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# Gender-Differentiated Determinants of Rice Farmers' Choice of Strategies to Adapt to Salinity Intrusion in the Mekong Delta, Vietnam

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**Keywords**: adaptation, farmers, gender, Mekong Delta, salinity intrusion, Vietnam

**JEL Codes**: Q15,  Q54

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The study investigates gender-differentiated determinants of rice farm households’ adaptive measures to salinity intrusion in three rice-producing provinces in the Mekong Delta, Vietnam. The sample covered 430 farm households (274 male-headed and 156 female-headed). A multivariate probit model was used to identify factors affecting male and female farmers’ choices of adaptive measures. The six adaptive measures most commonly used by these households were: changing from rice to other crops, saving rainwater for daily use, digging ponds for water storage in the garden, reducing the number of rice crops per year, seeking other income sources, and purchasing agricultural inputs on credit. We found that demographic, socioeconomic, and farming characteristics, as well as institutional conditions and salinity-related variables, influenced female farmers’ adaptation choices. Female farmers have to overcome more barriers to undertaking adaptive measures than male farmers. They are also less likely to seek other income sources due to limited access to education and training. Attending agricultural extension services increases the probability that female farmers will change from rice to other crops or will seek other income sources. Therefore, extension services, educational opportunities, training on adaptation strategies, and income-generating opportunities should be made accessible for all farmers, especially women, to increase their resilience to climate change and salinity intrusion.

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## 1. Introduction

The effects of climate change have been observed to be especially severe amongst the rural poor and women in developing economies. Female farmers are commonly associated with food production and adaptation to climate change (Carvajal-Escobar et al., 2008). However, they are often poor and vulnerable, with limited access to a variety of resources that would help them adapt to climate-related risks in agricultural production (Jost et al., 2016; Mitchell et al., 2007). In rural areas, there are major disparities in education, land ownership, access to credit and other services between male and female farmers, resulting in different adaptive responses to climate change (Bayard et al., 2007). Off-farm job opportunities are also limited for female farmers (McKinley et al., 2016). The inequality of access to agricultural resources between male and female farmers could affect crop yields and poverty (FAO, 2011). In fact, the impacts of climate change are exacerbated by women’s responsibilities in the households (Dankelman, 2008).

Previous studies have investigated gender-differentiated impacts of climate change and adaptation, including but not limited to aspects such as agricultural production, access to resources, livelihood, food security, migration, health, income, and decision-making (Arora-Jonsson, 2011; Carr & Thompson, 2014; Goh, 2012; Huynh & Resurreccion, 2014; Pham et al., 2016). However, such research has focused on women’s vulnerability, rather than on the processes underlying this vulnerability (Arora-Jonsson, 2011). Studies regarding gender-differentiated impacts of climate change and adaptation strategies in agriculture typically disregard other and intersecting dimensions of inequality (Almaden et al., 2020; Aryal et al., 2020; Khong et al., 2020; Ojo & Baiyegunhi, 2020). While gender differentiation in adaptation strategies has been studied (Jin et al., 2015; Mishra & Pede, 2017), such studies have not been attempted in the Mekong Delta, Vietnam, with respect to salinity intrusion.

One of the most significant impacts of climate change in the Mekong Delta is sea level rise and salinity intrusion. The degree of salinity has been increasing and saltwater has intruded further in the Delta (Khong et al., 2020). In response, there have been various adaptation strategies at local levels. In a study conducted in the Lower Mekong River basin, the authors argued that adaptation strategies have focused on coping with short-term rather than long-term risks. Adaptation strategies such as crop insurance and regulatory measures are absent at the local level in some areas in Vietnam (Bastakoti et al., 2014). A recent study regarding sea level rise in the Mekong Delta emphasised the effectiveness of the combination of hard (e.g., large-scale sea-dykes, sluice gates) and soft (e.g. salinity-tolerant varieties and crops) adaptation strategies (Smajgl et al., 2015). Some public adaptation strategies to salinity intrusion that have been used in the Mekong Delta include the construction of embankments and dykes (Smajgl et al., 2015), switching cropping systems (Bergqvist et al., 2012), regeneration of coastal ecosystems, agronomic measures, upstream flow control and shifts in agro-ecosystems (Renaud et al., 2015). Farm households have also employed a wide range of adaptive measures to salinity intrusion such as converting paddy land into aquaculture, rice-shrimp production, mixed cropping, restructuring crops and cultivation models, using salt-tolerant rice varieties, growing alternative cash crops, and innovative water management practices (Nhung et al., 2019; Tran et al., 2019). However, these studies have not included gender differentiation when investigating the determinants of farmers' choices of adaptation strategies to salinity intrusion.

This study identifies determinants of rice farmers' adaptation to salinity intrusion; analyzes gender differences in how these determinants affect the adaptive measures chosen; suggests mechanisms for both male and female farmers to enhance their adaptive capacities in the context of multiple stressors; and contributes to policy formulations regarding adaptation to salinity intrusion in the Delta.

## 2. Materials and methods

### 2.1 Study site, sampling and data collection

The Mekong Delta, the major agricultural region of Vietnam, is one of the areas most vulnerable to climate change in Southeast Asia (Yusuf & Francisco, 2009). The Mekong Delta has 13 provinces with a population of around 17.8 million (GSO, 2019). Rice cultivation occupies about 80% of this population. The Delta has provided 50% of rice production since 1997 (Wassmann et al., 2004), and 90% of rice exports in Vietnam (Yen et al., 2019). The Delta has a complex system of canals and rivers (Nguyen et al., 2007). It is roughly two metres above the mean sea level (Wassmann et al., 2004). Compared with other regions in Vietnam, the Mekong Delta is the most vulnerable area to sea level rise and salinity intrusion (Nachmany et al., 2015; Smajgl et al., 2015). Over 30% of the Delta is expected to be inundated as a result of a one-metre projected sea level rise by 2100. Nine of the 10 provinces with the highest expected percentage of inundation are located in the Delta (Carew-Reid, 2008). There has been an increase in the frequency and magnitude of salinity intrusion (Nguyen et al., 2019). The level of salinity has been increasing and saltwater has intruded further inland (Bergqvist et al., 2012). In 2016, drought and salinity intrusion were severe in most provinces of the Delta, seriously influencing agricultural production, farm income and rural lives.

**Insert Figure 1 here**

Three rice-producing provinces in the Mekong Delta, including Tien Giang, Ben Tre and Soc Trang, were selected for the research. Salinity intrusion has significantly affected these three coastal provinces, especially their agricultural production. One district was chosen in each province, then one commune was selected in each district (see Table 1). Those districts and communes are rice-producing areas and have recently been seriously affected by salinity intrusion. Rice farm households have been selected randomly in each commune for the survey.

**Insert Table 1 here**

Interviews with rice farmers were conducted in September and October 2020 by 10 interviewers who had been intensively trained after a pre-test of the questionnaire. The interviewees were household heads. Both male-headed and female-headed farm households were involved in the face-to-face interviews. To be eligible for the interviews, households had to have been influenced by salinity intrusion. Local authorities arranged the times and places for the interviews with rice farmers in their communes. The interviews took place in the meeting rooms of each selected commune. The final sample size was 430, including 274 male-headed households and 156 female-headed households. Each completed interview took approximately one hour.

A structured questionnaire was used in the interviews. Farmers were asked several questions regarding their experience and awareness of salinity intrusion, public adaptive measures and households' adaptive measures to salinity intrusion, information on salinity intrusion and adaptive measures, and local supporting activities for agricultural production. Information was also requested regarding agricultural production and household characteristics including details of income and expenditure. We also undertook three expert interviews with agricultural officers from Go Cong Tay, Ba Tri and Long Phu districts, and pre-tested 10 randomly selected households. The information from expert interviews helped refine and finalise the questionnaire and the pre-tests helped ensure its clarity and relevance.

## 2.2 Theoretical background

Farmers have employed a number of adaptive measures in response to the impacts of salinity intrusion on their livelihoods (Aryal et al., 2020; Johnson et al., 2016; Le et al., 2015; Nhung et al., 2019; Paik et al., 2020; SeinnSeinn et al., 2015; Szabo et al., 2016; Tran et al., 2019; Trang et al., 2018). Literature has shown that the risks regarding extreme climate events tend to be highly context-specific. The decisions to choose particular adaptive measures can be influenced by how farmers perceive the risks and their impacts on livelihoods and family life, as well as by their private adaptive ability, which is affected by their financial condition, education level, access to credit, extension services, training, technology, etc. (Dang et al., 2014; Deressa et al., 2011; Mertz et al., 2009; Patt & Schröter, 2008). The way farmers perceive and interpret their risks is likely to affect the adaptive measures they take. Therefore, the farmers' perceptions regarding salinity intrusion in their areas have been included in the research model. Farm households' adaptive ability greatly depends on their socio-economic characteristics, existing resources and support (Aryal et al., 2020; Berman et al., 2015). Those groups of factors are, therefore, incorporated in this study to examine the determinants of farmers' adaptations to salinity intrusion.

Previous studies have shown that increased climate variability reduces agricultural production, and that its impacts on natural, physical, social and financial capital differ between women and men. Women are particularly exposed since they spend a great amount of time and labour in agricultural production. In some developing economies, gender inequality and discrimination further increase women's vulnerability to extreme climate events (Aryal et al., 2020; Jordan, 2019). Women and men also differ in their access to the information and agricultural inputs needed to address climate variability (Bayard et al., 2007). A negative climate shock is more likely to induce men to migrate; women are more likely to stay (Goh, 2012). The variations in choices of adaptation strategies between male and female farmers have been attributed to gender differences in social capital, perspective and experience (Akter et al., 2016). In one study, a majority of wives had adopted crop-related strategies, whereas husbands had chosen livestock-related and agroforestry-related strategies (Ngigi et al., 2017). Male-headed households have been more likely to adopt new water conservation technology and investment in irrigation infrastructure (Jin et al., 2015).

## 2.3 Empirical model

Most studies of gender differentiation in the context of climate change and adaptation have applied qualitative methods (Abbasi et al., 2019; Acosta et al., 2019; Ahmed et al., 2016; Bhattarai et al., 2015; Goodrich et al., 2019; Huynh & Resurreccion, 2014; Pham et al., 2016). Studies using quantitative methods have been limited (Jin et al., 2015; Ngigi et al., 2017). Multinomial logit, multinomial probit and multivariate probit are among the empirical techniques commonly used to identify factors affecting farmers' choice of adaptation measures (Aryal et al., 2020; Esfandiari et al., 2020; Le et al., 2015; SeinnSeinn et al., 2015; Trinh et al., 2018). The assumed independence of error terms with respect to different adaptive measures means that univariate models may produce biased and inefficient estimates. Greene (2019) warns that important information about the interdependence and simultaneity of farmers' adaptive decisions can be excluded when these techniques are used. Farmers may choose more than one adaptive measure at the same time; therefore, the choice of one measure would possibly influence the decisions regarding others (see, e.g., Teklewold et al. 2013). When the defined adaptation strategies are not mutually exclusive, multivariate probit models (MVPs) should be employed. The MVP model offers a simultaneous analysis of the effects of explanatory variables on each of the different adaptation options, while allowing interdependence between adaptive options (Greene, 2003; Wooldridge, 2012).

A number of studies have used MVP models to investigate farmers' decisions regarding adaptation to climate change and other extreme climate events. For example, Pham et al. (2019) examined farmers' adaptive responses to flash floods and landslides in the northern mountainous regions of Vietnam. Aryal et al. (2021) studied climate risks and farmers' adaptation strategies in East Africa and South Asia. Bahinipati and Venkatachalam (2015) examined drivers of farmers' adoption of adaptation practices to climate extremes in India. The determinants of farmers' adaptation to climate change were also investigated by Amir et al. (2020) in Pakistan and by Trinh et al. (2018) in the central region of Vietnam. Feleke et al. (2016) have focused on climate change adaptation of sheep and goat farmers in Northern Ethiopia.

The MVP model is employed to estimate the contribution of farm household characteristics to their choices of adaptation options using the Simulated Maximum Likelihood Method. The simulation-based methods have been shown to provide much better properties than standard linear numerical approximations, which are relatively inefficient in multivariate estimations (Cappellari & Jenkins, 2003). In this study, the MVP model is characterized by a set of n binary dependent variables $Y_i$, and a set of characteristics of farm households, including demographic variables, socioeconomic characteristics, farming characteristics, institutional conditions, and salinity-related variables.

$$Y_i = \alpha_0 + \sum_j \beta_j x_{ij} + e_i \qquad (1)$$

where $\alpha_0$ is the intercept; $e_i$ is the error term; $\beta_j$ are the estimated coefficients; $x_{ij}$ are the characteristics of j farm households.

In this study, the adaptation choices of farm households to salinity intrusion were modelled in terms of discrete dependent variables. Twelve adaptive measures have been categorised into five groups: changing farming practices, water use and management, the choice of rice varieties, planting calendar, and other measures. Farm households were asked if they had been using any or all of the adaptive measures in the list in response to salinity intrusion in their areas. Since the extent to which a farm household has implemented a particular adaptive measure is not available, binary scales are used for the dependent variable. Since the surveyed farm households have used multiple adaptive measures simultaneously, the MVP model includes different simultaneous models. Among the adaptive measures farm households have used, six commonly used ones were selected to proceed with the MVP model. They include (1) changing from rice to other crops, (2) saving rainwater for daily use, (3) digging ponds for water storage (in the garden), (4) reducing the number of rice crops per year, (5) seeking other income sources, and (6) purchasing agricultural inputs on credit (where payment is due at harvest time). Whether farm households have applied each adaptive measure or not is a discrete choice. Hence, the MVP model is specified as follows:

$$Y_{ni} = \begin{cases} 1 \ if \ Y_{ni} = \alpha_n + \sum_j \beta_{nj} x_{ij} + e_{ni} \\ 0 \qquad\qquad\qquad\qquad otherwise \end{cases} \qquad (2)$$

where n is the number of observations (n = 430 farm households); i is the number of adaptive measures; $\alpha$ is the constant term; $\beta$ is the estimated coefficient; and $e_n$ is the error term.

## 2.4 Explanatory variables

The literature offers a number of variables that have influenced the adaptive decisions of farmers in response to climate change and extreme climate events. These variables include socioeconomic and demographic variables (e.g., age, gender, education level, household size, income), access to different resources (e.g., credit, extension, information), and perceptions regarding extreme climate events (Bryan et al., 2009; Deressa et al., 2009; Esham & Garforth, 2013; Hisali et al., 2011; Pham et al., 2019; Vincent, 2007). There are some similarities in the variables that contribute to farmers' adaptive options to salinity intrusion. Those variables cover age, gender, ethnicity, education, number of children, family agricultural labor, off-farm work, diversified crops, farm size, experience, land ownership, irrigation, community meetings, credit, salinity, yield, revenue, extension, training, institutions (Paik et al., 2020; SeinnSeinn et al., 2015; Szabo et al., 2016; Trang et al., 2018), household resources and household dependents (Almaden et al., 2020).

The five groups of independent variables employed in the MVP model include demographic variables, socioeconomic characteristics, farming characteristics, institutional conditions, and salinity-related variables. Table 2 presents the names, descriptions and measurements of all explanatory variables.

Demographic variables (e.g., age, marital status, gender, education) have been discussed substantially in previous empirical studies regarding the factors influencing farmers' adaptive behaviours in response to climate change, extreme climate events and salinity intrusion. The age of the farm household head is probably connected to his/her farming experience, which may, to some extent, affect the adaptation decisions of farm households. Farm household heads with a high education level may spend time looking for relevant information and seeking help to make the most suitable adaptive decisions. The differences between the adaptive responses of male and female farmers may be accounted for by disparities in their land ownership, off-farm job opportunities, health and welfare, education, socio-cultural context, access to credit, information and other resources (Bayard et al., 2007; Chaudhury et al., 2012; Goh, 2012; Huynh & Resurreccion, 2014; McKinley et al., 2016; Pham et al., 2016).

Socioeconomic and farming characteristics such as household size, farm income, farming experience, rice farm size, and land tenure have been included in investigations into farmers' adaptations to salinity intrusion (Almaden et al., 2020; Paik et al., 2020; SeinnSeinn et al., 2015; Szabo et al., 2016; Trang et al., 2018). In this study, the average annual farm income in million VND was employed. The number of years farm households have been growing rice represents farming experience. Rice farm size is the area that a household is planting with rice. Land tenure is a dummy variable for the state of land ownership. Its purpose is to explore whether there are differences between farmers who are only using their own land and farmers who are using both their own land and rented land.

Some institutional conditions have been incorporated in the model, including the status of farm households' participation in agricultural extension services and training on adaptation to salinity intrusion, as well as farm households' access to formal credit. The three variables are all dummies and have been employed in previous studies regarding adaptation to salinity intrusion (Paik et al., 2020; SeinnSeinn et al., 2015; Trang et al., 2018).

We use three salinity-related variables as proxies for the status of salinity intrusion in the study site. These are the distance from the respondent's rice farm to the nearest saltwater prevention sluice, the farm household's perceptions regarding salinity intrusion in their area, and the percentage of rice yield loss due to salinity in 2019. For farm households' perception about salinity intrusion, the households were asked to what extent they agree with five different statements based on a seven-point Likert scale. These were: (1) Saltwater is increasingly encroaching on rivers, creeks and land; (2) The time the water gets salty during the year is getting longer and longer; (3) The time when the water is salty is increasingly erratic and difficult to predict; (4) The salinity of river water and creeks is increasing; (5) The salinity intrusion is getting worse. The average number was calculated to represent each farmer's perceptions of salinity intrusion.

**Insert Table 2 here**

## 3. Results and discussion

### 3.1 Farm household characteristics

Table 2 presents some descriptive statistics of the explanatory variables used in the MVP model. Male-headed farm households account for roughly 64% of total farm households in the sample. This is common in rural Vietnam and the Mekong Delta. About 87% of respondents are married. The age of the household heads is from 18 to 81 with the average at 52. Most of the respondents have been involved in rice farming since childhood, and rice cultivation is the major family tradition. However, most of the young people in the family have found other off-farm jobs while the older people remain with farming. The mean education level of respondents is grade 7, which is relatively low. Although public education services have been available in the study areas, access to education is still limited.

The average number of members per household is four to five people. However, there are farm households with as many as 11. This was common for rural areas and farming communities in the past, when rice farming was more labour-intensive. Technical improvements and mechanization have contributed significantly to agricultural production. The average annual farm income of households sampled was 54 million VND; the maximum observed was 836 million VND. Farm households in the sample have around 29 years of rice farming experience. The average rice farm size was relatively small, approximately 0.8 hectares. The largest rice farm in the sample was approximately 17 hectares. Around 30% of the farm households reported using rented land for rice cultivation.

Approximately 36% of farm households have attended training sessions for adaptation to salinity intrusion. This proportion is relatively low. However, more than 74% of farm household heads have participated in extension services (e.g., training activities and workshops related to agricultural production). Among the remaining 26%, most farmers said they had no access to those services or did not have the time. The services tended to be well received; over 90% of the farmers who had used them evaluated the benefit of extension services at between 5 and 7 on a 7-point Likert scale. Around 50% of farm households had accessed either formal or informal credit; the most commonly used service was formal credit (i.e. Vietnam Bank for Agriculture and Rural Development and Vietnam Bank for Social Policies). The primary difficulties mentioned in relation to borrowing money were the paperwork and the lack of support.

For salinity-related variables, the average distance from a respondent’s rice farm to the nearest saltwater prevention sluice is around 4.6 km, with the maximum distance being 40 km. Most farm households perceive salinity intrusion to be worsening in their areas. The percentage of rice yield lost to salinity intrusion in 2019 averaged 48%, with some farm households having lost their entire rice crop.

### 3.2 Farmers’ adaptation strategies to salinity intrusion and gender issues

The difficulties faced by farm households trying to adapt to salinity intrusion include lack of capital (80.23%), lack of labor (56.98%), lack of access to technology (49.3%), difficulties in selling rice (e.g., low prices offered by traders) (50.47%), lack of information about adaptive measures (41.16%), and other reasons (3.72%) (see Table 3). These figures indicate that farm households have faced many obstacles in adapting to salinity intrusion. Female farmers face particular difficulties with respect to capital, labor and information access. Therefore, timely and efficient support from local authorities is necessary.

**Insert Table 3 here**

From the 12 adaptive measures initially included in the questionnaire, six commonly used measures were selected to put into the MVP model. Table 4 shows the percentage of farm households that have applied each adaptive measure in the full model (n = 430) and the other two models: male-headed households (n = 270) and female-headed households (n = 156). The adaptive measure preferred tended to differ between male-headed and female-headed households, with the exception of reducing the number of rice crops per year, which was quite similar between male and female groups.

In Tien Giang province, to help farmers adapt to salinity intrusion, the authorities offered three financial support options: (1) 2 million VND/ha/year within 3 years to reduce the number of rice crops from three to two by cutting out the Autumn-Winter crop; (2) 3 million VND/ha for cutting out the Autumn-Winter crop and implementing rice-vegetable rotation or conversion to other crops and livestock production; (3) An additional 2 million VND/ha for cutting out both the Winter-Spring crop and the Summer-Autumn crop, on the recommendation of the People's Committee of Tien Giang province in the event of erratic climate. This payment policy generally encourages farmers to reduce the number of rice crops per year. The three most widely used measures for all three models are saving rainwater for daily use, reducing the number of rice crops per year, and purchasing agricultural inputs on credit (post-harvest payment).

**Insert Table 4 here**

### 3.3 Multivariate probit adaptation models

An MVP model was used to examine factors affecting rice farm households' choice of adaptive measures in response to salinity intrusion. The dependent variable included six different adaptive measures that received a value of 1 if farm households used a specific adaptive measure, and 0 otherwise. Table 5 presents the correlation coefficients of the outcome variables. The figures show that $\chi^2$ (15) is highly significant (Prob > $\chi^2$ = 0.001) for the full model, and also significant for male (Prob > $\chi^2$ = 0.065) and female (Prob > $\chi^2$ = 0.042) models. There is, therefore, a correlation between the six adaptive measures in response to salinity intrusion. A correlation matrix for explanatory variables was used to test for multicollinearity. Most correlation coefficients were less than 0.3, implying no multicollinearity. The model has also been tested for heteroskedasticity using the robust standard error procedure, which shows no heteroskedasticity problem (Wooldridge, 2012).

**Insert Table 5 here**

Table 6, Table 7 and Table 8 presents the results of MVP models for the full model (n = 430), the male-headed household model (n = 274) and the female-headed household model (n = 156), respectively. The results indicate that the overall relationship between the explanatory variables and the probability that a farm household will use specific adaptive measures in response to salinity intrusion is highly significant in all three models (Wald $\chi^2(90)$ = 273.870, Prob > $\chi^2$ = 0.000 for the full model; Wald $\chi^2(84)$ = 623.040, Prob > $\chi^2$ = 0.000 for the male model; Wald $\chi^2(84)$ = 453.580, Prob > $\chi^2$ = 0.000 for the female model).

**Insert Table 6 here**

In the full model, the results in Table 6 show that all explanatory variables, except marital status, land tenure and rice farm size, significantly affect farm households' choice of at least one or more than one adaptive measure. Older farmers have lower probabilities of seeking other income sources as an adaptive option to salinity intrusion. The fact that some off-farm jobs require good health or formal training limits accessibility to older farmers. Male farmers are more likely to seek other income sources. A climate change study in the Mekong Delta showed that off-farm job opportunities were limited for female farmers (McKinley et al., 2016). This is consistent with Buechler's (2009) study in Mexico which showed women's household responsibilities were as caregivers in the family, while men migrated to look for employment. The results in Table 6 also show that male farmers are less likely than female farmers to save water for daily use. Similarly, Reyes (2002) noted that women in Peru played more important roles in obtaining water sources for households, and had a burdensome responsibility when water was polluted by flooding. Education level significantly affected farmers' choice of crop conversion. Farm households with higher education level are more likely to convert part of their rice farm to other crops. Those with a large household size are more likely to save rainwater for daily use. They also are more likely to dig water storage ponds in their gardens in order to meet their family water needs.

Farm income is significant in four of the six models; households with higher farm income are more likely to change part of their rice farm to other crops, but less likely to purchase agricultural inputs on credit. Crop rotation and conversion practices have been encouraged in the study sites as highly recommended responses to salinity intrusion. For example, in Tien Giang, local authorities have provided financial support for farmers to reduce the number of rice crops per year and shift from rice to other crops. Our findings show that farm households who have access to credit have higher probabilities of crop conversion and of purchasing agricultural inputs on credit than those who have not borrowed money for rice farming. It can be inferred that households that have limited access to credit may find it difficult to invest in other crops. Farm households that have access to credit may also have access to information on the status of salinity in local areas as well as technical knowledge on adaptation, and thus are ready for the conversion from rice to other crops. The households with higher farm income are less likely to save rainwater for daily use, though they do dig garden ponds to store water for household production activities.

Extension services significantly affect farm households' decisions regarding crop conversion and reduction. Households that have joined extension services, including training activities and workshops related to agricultural production, are more likely to diversify away from rice, but less likely to reduce the number of rice crops per year. Those attending the training sessions on salinity intrusion and adaptation to salinity intrusion were more likely to reduce the number of rice crops per year as an adaptive measure to salinity intrusion. Such trainings in the research sites provide farmers with significant information regarding efficient adaptation to salinity intrusion, and strongly recommend cutting one of the three annual rice crops. Indeed, households that have attended training on salinity intrusion and adaptation are less likely to be those that purchased agricultural inputs on credit. This probably reflects the vulnerability of farmers who have to purchase agricultural inputs on credit, including less flexibility with their time and limited access to such trainings.

Experienced rice farm households are less likely to seek other income sources. Experienced farmers are mostly old farmers who have significantly been involved in rice farming. They are also unskilled with respect to off-farm jobs. This is in line with the findings of Aryal et al. (2020) that experienced farmers often lacked the skills needed to find alternative employment.

The distance from a rice farm to the nearest saltwater prevention sluice, the perception of salinity intrusion seriousness, and yield lost to salinity intrusion are also significantly related to some choices of adaptation measures. Farm households with a greater distance from their rice farm to the nearest saltwater prevention sluice are more likely to save rainwater for daily use, but less likely to dig garden ponds for water storage. Farm households that perceive salinity intrusion as serious have higher probabilities of changing part of their land use from rice to other crops. The change from rice to other crops would help to diversify farmers' income sources. Farmers would not depend only on income from rice, which may be uncertain under the impacts of salinity intrusion. Farm households with a high percentage of yield lost due to salinity in 2019 were more likely to partly change to other crops, reduce the number of rice crops per year, and purchase agricultural inputs on credit. Those adaptive measures help farmers to maintain rice production as their major activity, but limit the possible loss that may occur.

**Insert Table 7 here**

In the male-headed household model, household size, extension, and rice farm size do not significantly affect male farmers' choice of adaptive measures. Older male farmers are less likely to seek other income sources as an adaptive option to salinity intrusion. Marital status has been shown to significantly affect male farmers' choice of two adaptive measures: reducing the number of rice crops per year and purchasing agricultural inputs on credit. Married male farmers are less likely to reduce the number of rice crops per year, but more likely to purchase agricultural inputs on credit. Male-headed farm households with higher education level have higher probabilities of changing in part from rice to other crops.

Farm income is significant in three of the six models, in which male farmers with higher farm income are more likely to partly diversify from rice to other crops and to dig ponds for water storage in the garden, but less likely to save rainwater for daily use. While land tenure is not significant in the full model, with the male model, male farmers who have used rented land have a high probability of saving rainwater for daily use. Male farmers who have accessed credit in the past are more likely to partly diversify their crops and to purchase agricultural inputs on credit than those who have not previously borrowed money for rice farming.

Male farmers who have attended the training courses on salinity intrusion and adaptation to salinity intrusion are more likely to reduce the number of rice crops per year and to seek other income sources to cope with salinity intrusion than those with no such training. They are also less likely to purchase their agricultural inputs on credit as an adaptive measure. Experienced male farmers have lower probabilities of seeking other income sources. The farther male-headed farm households are from the nearest saltwater prevention sluice, the more likely they are to save rainwater for daily use, but the less likely to dig garden ponds for water storage. The more seriously they perceived the problem of salinity intrusions, the more likely they are to change from rice to other crops. Male farmers who experienced high percentages of yield loss due to salinity in 2019 are more likely to reduce the number of rice crops per year.

**Insert Table 8 here**

There were some differences in the female-headed household model. All explanatory variables, except rice farm size, influenced female farmers' adaptive responses to salinity intrusion. Older female farmers were more likely to save rainwater for daily use, to reduce the number of rice crops per year, and to purchase their agricultural inputs on credit as adaptive measures. Married female farmers were less likely to partly change rice to other crops and to dig ponds for water storage in the garden. Female farmers with higher education levels were highly likely to partly diversify from rice to other crops, and to dig ponds for water storage in the garden. This differs from the male model, in which education level had no impact on the decision to dig ponds for water storage. These findings probably imply the important roles of females in housework and family responsibilities.

The larger the size of a female-headed household, the more likely they are to save rainwater for daily use, to reduce the number of rice crops per year, and to seek other income sources. One possible reason is that, following extreme climate events, men are more likely to migrate in search of work. When men migrate, women become responsible for all aspects of the family (i.e., housework, health, food, and agricultural production). They would apply different adaptive measures to minimize the potential impacts of salinity intrusion that may affect their farming and lives.

Female-headed farm households with higher farm income are more likely to diversify away from rice, and are less likely to purchase their agricultural inputs on credit. Female farmers who have used rented land for rice cultivation have a higher probability of reducing the number of rice crops per year. This is different from the male model. Female farmers may be more aware of the potential yield loss under the salinity impact; therefore, they might choose to reduce the number of rice crops per year. Female farmers who have accessed credit in the past are more likely to seek other income sources and to purchase their agricultural inputs on credit.

Female farmers who have accessed extension services in local areas are more likely to diversify their crops and to seek other income sources, but less likely to reduce the number of rice crops per year. Extension services in the research sites have been seen as useful by 92% of farmers who have used them. This may explain female farmers' confidence in crop conversion and rice cultivation. Due to the erratic patterns of salinity intrusion, seeking alternative income sources can be another adaptive measure of female farmers. However, it is interesting that female farmers who have attended training courses on salinity intrusion and adaptation to salinity intrusion are less likely to seek other income sources. There may be two possibilities. First, those who have attended such trainings found the adaptation measures efficient, reducing the need for other income sources. Second, potential earnings from other off-farm jobs may be constrained if those jobs require specialised training and education that they lack. Experienced female farmers are less likely to seek other income sources and to purchase their agricultural inputs on credit.

The distance from household rice field to the nearest saltwater prevention sluice adversely affects female-headed farm households' choice of digging ponds for water storage in the garden. Female farmers who perceive the seriousness of salinity intrusion are more likely to diversify their crops; however, there is a lower probability that they will reduce the number of rice crops they plant per year. Female-headed farm households with a high percentage of yield loss due to salinity in 2019 are more likely to dig garden ponds for water storage, to reduce the number of rice crops per year, and to purchase agricultural inputs on credit.

The three models indicate that, following salinity intrusion, male-headed and female-headed households differ substantially in the factors affecting their choices of adaptive measures. Almost all factors (except rice farm size), including demographic variables, socioeconomic characteristics, farming characteristics, institutional conditions, and salinity-related variables, have influenced female farmers' choice of adaptive measure(s). Among male farmers, rice farm size, the number of family members and the farmer's participation in extension services have not affected the choice of any adaptive measures. It seems that female farmers are more responsive to changes in influential social and natural factors, while male farmers display greater inertia. However, limited access to different resources prevents female farmers from taking adaptive measures, while male farmers have better opportunities for adaptation (Asfaw & Admassie, 2004; Bayard et al., 2007; Temesgen et al., 2014).

From the results of the full model, male farmers are more likely to seek other income sources as an adaptive response to salinity intrusion. In fact, it seems to be easier for male farmers to find off-farm jobs as alternative income sources. Female farmers have tended rather to engage in housework and agricultural activities, and have typically had limited opportunities for education and training (Pham et al., 2016). Limitations in educational attainment have often prevented female farmers in the research sites from accessing off-farm jobs. Among surveyed farm households, the percentage of female farmers who only had primary education as their highest level of education was much higher than it was for male farmers, 50.6% and 30.7%, respectively. Meanwhile, more male farmers have attained at least secondary education (69.3%) than female farmers (49.4%). Only 5.1% of female farmers have attained college or university education, while this rate is 7.7% for male farmers. It has also been shown in a climate change study in the Mekong Delta that off-farm job opportunities are limited for female farmers (McKinley et al., 2016). In addition, education has been found to influence the crop diversification decisions made by both male and female farmers in response to salinity intrusions. Female farmers' ability to diversify their income sources appears to be curtailed when their education is limited.

**Insert Table 9 here**

Table 9 presents the marginal predicted probability that any particular adaptive measure will be chosen by farm households following a salinity intrusion. The figures show that partly changing from rice to other crops, digging garden ponds for water storage, reducing the number of rice crops per year, and seeking other income sources, are more favoured by male than female farmers. Saving rainwater for daily use and purchasing agricultural inputs on credit are more favoured by female farmers.

## 4. Conclusions and policy implications

This study investigates the gender-differentiated determinants of rice farmers' choice of adaptation measures to salinity intrusion in the Mekong Delta, Vietnam. The six adaptive measures most commonly used by rice farm households in the research sites are: (1) Changing from rice farming alone to other crops (partly); (2) Saving rainwater for daily use; (3) Digging garden ponds for water storage; (4) Reducing the number of rice crops per year; (5) Seeking other income sources; and (6) Purchasing agricultural inputs on credit.

Many factors, including demographic variables, socioeconomic characteristics, farming characteristics, institutional conditions, and salinity-related variables, have influenced female farmers' choice of at least one of six adaptive measures. Female farmers were more responsive to changes in influential factors; limited access to resources, however, prevents them from taking adaptive measures. Limited education and training opportunities also leave them less likely to seek other income sources such as off-farm jobs. Therefore, training activities on adaptation strategies to salinity intrusion and educational opportunities should be made more accessible for female farmers. In addition to ensuring equal learning opportunities for farmers, local authorities should encourage farmers to join local networks and associations for information and support in adaptation to salinity intrusion.

Participating in farm field schools and demonstration farms can enhance farmers' knowledge of farm management and access to information and resources. Attending extension services has been found to increase the probabilities that female farmers will diversify their cropping and will seek other income sources. Thus, extension activities should be widened and made more accessible for female farmers. Those activities are vital in promoting new technologies and upgrading the skills of farmers, thereby speeding the implementation of adaptation measures.

Female farmers often have limited access to resources, education and training that would help them adapt to climate-related risks in agricultural production. Therefore, female farmers' rights in accessing technical supports and implementing adaptation strategies should be guaranteed. They should have equal access to credit facilities and adaptation funds. Income-generating activities for farm households should be promoted by local authorities to increase farmers' resilience to the impacts of climate change and salinity intrusion.

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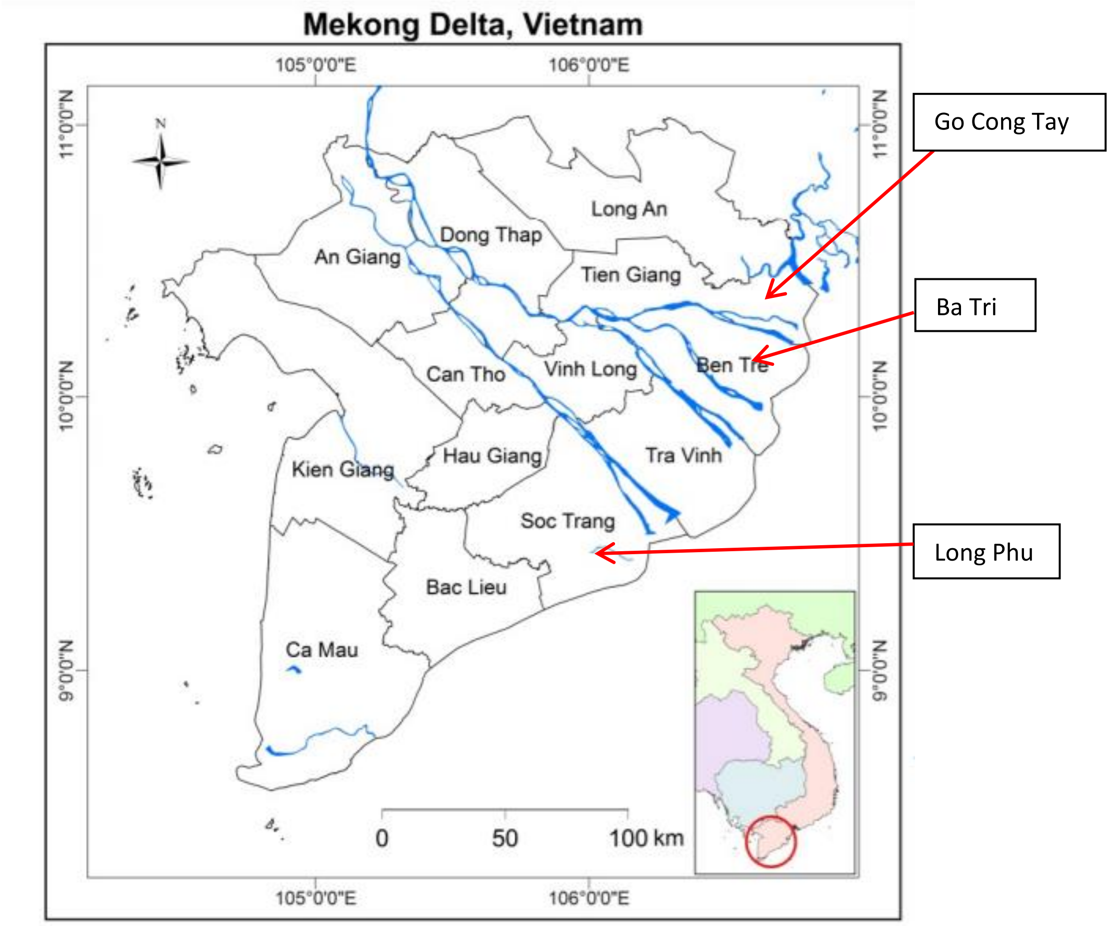
**Figure 1. Map of the research sites**



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 research sites in the Mekong Delta, Vietnam**

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

## Table 2. The details of explanatory variables used in the adaptation model

| Variables | Descriptive | Percentage (%) | Mean | St.dev | Min. | Max. |
|---|---|---|---|---|---|---|
| ***Demographics*** | | | | | | |
| Age | Age of respondents | | 52.598 | 11.534 | 18 | 81 |
| Gender | Gender of respondents | | 0.637 | 0.481 | 0 | 1 |
| | 1 = Male | 63.72 | | | | |
| | 0 = Female | 36.28 | | | | |
| Marital | Marital status of respondents | | 0.872 | 0.334 | 0 | 1 |
| | 1 = Married | 87.21 | | | | |
| | 0 = Others (single/widowed/divorced) | 12.79 | | | | |
| Education | Number of schooling years of respondents | | 7.377 | 3.892 | 0 | 18 |
| ***Socioeconomic characteristics*** | | | | | | |
| Hhsize | Number of household members | | 4.226 | 1.592 | 1 | 11 |
| Farm_income | Total annual farm income (million VND/year) | | 54.283 | 69.752 | 0 | 836 |
| ***Farming characteristics*** | | | | | | |
| Experience | Number of years farm households have been growing rice | | 28.840 | 13.085 | 2 | 66 |
| Rice_farmsize | 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 | | | | |
| Access_Credit | Accessing credit | | 0.493 | 0.501 | 0 | 1 |
| | 1 = Yes | 49.30 | | | | |
| | 0 = No | 50.70 | | | | |
| Training_salinity | Attending the training of responding to salinity intrusion | | 0.358 | 0.480 | 0 | 1 |
| | 1 = Yes | 35.81 | | | | |
| | 0 = No | 64.19 | | | | |
| **Salinity degree** | | | | | | |
| Distance | Distance from respondents‘ 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 | Respondents were asked to identify the extent they agree with the corresponding statements about perception on salinity intrusion based on seven-point Likert scale (from 1—strongly disagree to 7—strongly agree) | | 6.136 | 0.810 | 1.6 | 7 |
| Loss_yield | Percentage of yield was lost due to salinity in 2019 (%) | | 48.280 | 20.559 | 0 | 100 |

Note: Percentage in case of qualitative (dummy) variables; Mean and Standard deviation in case of quantitative (continuous) variables

**Table 3. The difficulties of farm households in using adaptive measures to salinity intrusion**

| No. | Difficulties | Percentage of households facing the difficulties (%) | | |
|---|---|---|---|---|
| | | Full (n = 430) | Male (n = 274) | Female (n = 156) |
| 1 | Lack of capital | 80.23 | 77.74 | 84.62 |
| 2 | Lack of labor | 56.98 | 54.01 | 62.18 |
| 3 | Accessibility to technology | 49.30 | 48.54 | 50.64 |
| 4 | Selling | 50.47 | 50.36 | 50.64 |
| 5 | No or lack information about adaptive measures | 41.16 | 37.23 | 48.08 |
| 6 | Other reasons | 3.72 | 4.74 | 1.92 |

**Table 4. Household adaptation practices in the research regions**

| No. | Adaptation practices | Percentage of households used (%) | | |
|---|---|---|---|---|
| | | Full (n = 430) | Male (n = 274) | Female (n = 156) |
| 1 | Changing rice farm to other crops (partly) | 38.37 | 43.43 | 29.49 |
| 2 | Saving rainwater for daily use | 83.02 | 79.56 | 89.10 |
| 3 | Digging ponds for water storage (in the garden) | 30.47 | 32.48 | 26.92 |
| 4 | Reducing the number of rice crops per year | 87.91 | 87.96 | 87.82 |
| 5 | Seeking other income sources | 57.67 | 59.49 | 54.49 |
| 6 | Purchasing the agricultural inputs (payment when harvesting) | 81.16 | 79.20 | 84.62 |

**Table 5. Correlation coefficients of outcome variables**

| Rho | Total sample (n = 430) | | Male adaptation (n = 274) | | Female adaptation (n = 156) | |
|---|---|---|---|---|---|---|
| | Coefficient | P > z | Coefficient | P > z | Coefficient | P > z |
| rho21 | *-0.166 (0.091) | 0.066 | -0.137 (0.118) | 0.245 | -0.105 (0.182) | 0.565 |
| rho31 | ***0.214 (0.081) | 0.008 | *0.167 (0.099) | 0.092 | *0.250 (0.139) | 0.072 |
| rho41 | ***-0.336 (0.089) | 0.000 | ***-0.348 (0.113) | 0.002 | -0.292 (0.218) | 0.181 |
| rho51 | -0.056 (0.083) | 0.505 | -0.065 (0.113) | 0.563 | -0.079 (0.144) | 0.586 |
| rho61 | **0.187 (0.095) | 0.048 | *0.204 (0.116) | 0.078 | -0.093 (0.139) | 0.504 |
| rho32 | 0.070 (0.083) | 0.402 | 0.018 (0.109) | 0.871 | *0.410 (0.224) | 0.067 |
| rho42 | -0.003 (0.117) | 0.982 | 0.148 (0.163) | 0.364 | -0.6140 (0.580) | 0.290 |
| rho52 | **-0.167 (0.082) | 0.041 | *-0.225 (0.123) | 0.067 | -0.0860 (0.190) | 0.651 |
| rho62 | 0.118 (0.098) | 0.228 | 0.079 (0.125) | 0.526 | 0.0340 (0.127) | 0.651 |
| rho43 | -0.048 (0.117) | 0.681 | -0.131 (0.129) | 0.311 | -0.026 (0.470) | 0.956 |
| rho53 | 0.128 (0.080) | 0.110 | 0.055 (0.098) | 0.572 | *0.286 (0.150) | 0.056 |
| rho63 | -0.078 (0.098) | 0.427 | -0.031 (0.117) | 0.789 | *-0.389 (0.203) | 0.055 |
| rho54 | 0.018 (0.092) | 0.840 | 0.093 (0.144) | 0.516 | 0.009 (0.245) | 0.971 |
| rho64 | -0.070 (0.115) | 0.542 | 0.092 (0.139) | 0.508 | -0.035 (0.222) | 0.876 |
| rho65 | -0.025 (0.088) | 0.773 | -0.099 (0.115) | 0.390 | -0.016 (0.336) | 0.963 |
| $\chi^2$ (15) | 36.624 | | 24.007 | | 25.611 | |
| Prob > $\chi^2$ | 0.001 | | 0.065 | | 0.042 | |

Likelihood ration test of: rho21 = rho31 = rho41 = rho51 = rho61 = rho32 = rho42 = rho52 = rho62 = rho43 = rho53 = rho63 = rho54 = rho64 = rho65 = 0

Note: The values in the brackets are Robust Standard Errors; *; **; *** indicate significance at 10%; 5%; and 1%, respectively.

## Table 6. Multivariate probit model of determinants of farmers’ adaptation options (n = 430)

| **Variables** | **Changing rice farm to other crops (partly) ($Y_1$)** | | **Saving rainwater for daily use ($Y_2$)** | | **Digging ponds for water storage (in the garden) ($Y_3$)** | | **Reducing the number of rice crops per year ($Y_4$)** | | **Seeking other income sources ($Y_5$)** | | **Purchasing the agricultural inputs (payment when harvesting) ($Y_6$)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z |
| Age | -0.005 ((0.009) | 0.588 | 0.007 (0.011) | 0.488 | -0.008 (0.009) | 0.346 | 0.013 (0.010) | 0.206 | **-0.019 (0.009) | 0.027 | -0.002 (0.009) | 0.864 |
| Gender | 0.241 (0.158) | 0.127 | *-0.342 (0.181) | 0.059 | 0.056 (0.157) | 0.719 | -0.005 (0.203) | 0.982 | **0.328 (0.157) | 0.037 | -0.048 (0.188) | 0.801 |
| Marital | -0.374 (0.232) | 0.106 | 0.005 (0.245) | 0.984 | -0.282 (0.218) | 0.295 | -0.104 (0.259) | 0.688 | -0.261 (0.248) | 0.292 | 0.084 (0.246) | 0.733 |
| Education | ***0.056 (0.019) | 0.004 | 0.018 (0.023) | 0.431 | 0.020 (0.019) | 0.293 | 0.016 (0.024) | 0.506 | 0.007 (0.018) | 0.689 | -0.020 (0.021) | 0.353 |
| Hhsize | 0.043 (0.046) | 0.353 | *0.085 (0.048) | 0.078 | **0.927 (0.043) | 0.031 | 0.049 (0.054) | 0.363 | 0.056 (0.047) | 0.237 | 0.013 (0.047) | 0.776 |
| Farm_income | ***0.006 (0.002) | 0.000 | **-0.002 (0.001) | 0.045 | *0.002 (0.001) | 0.063 | -0.001 (0.001) | 0.265 | -0.002 (0.001) | 0.138 | **-0.003 (0.001) | 0.037 |
| Land_tenure | 0.006 (0.150) | 0.966 | 0.203 (0.173) | 0.242 | 0.112 (0.152) | 0.463 | 0.250 (0.181) | 0.168 | -0.212 (0.147) | 0.148 | 0.017 (0.174) | 0.921 |
| Access_Credit | **0.320 (0.135) | 0.017 | -0.242 (0.153) | 0.115 | 0.008 (0.134) | 0.952 | 0.050 (0.160) | 0.758 | 0.099 (0.131) | 0.450 | ***0.671 (0.155) | 0.000 |
| Extension | *0.320 (0.165) | 0.052 | -0.104 (0.207) | 0.616 | 0.046 (0.166) | 0.782 | **-0.412 (0.196) | 0.036 | 0.237 (0.159) | 0.135 | 0.225 (0.192) | 0.241 |
| Training_salinity | -0.077 (0.150) | 0.609 | -0.278 (0.173) | 0.109 | 0.019 (0.147) | 0.898 | ***0.952 (0.218) | 0.000 | 0.011 (0.149) | 0.942 | ***-0.442 (0.162) | 0.006 |
| Experience | -0.001 (0.007) | 0.946 | 0.004 (0.009) | 0.642 | 0.007 (0.008) | 0.347 | -0.008 (0.010) | 0.457 | **-0.019 (0.007) | 0.010 | -0.005 (0.007) | 0.504 |
| Rice_farmsize | -0.160 (0.106) | 0.131 | -0.051 (0.067) | 0.453 | -0.033 (0.052) | 0.518 | 0.028 (0.074) | 0.706 | -0.076 (0.070) | 0.282 | 0.179 (0.133) | 0.117 |
| Distance | 0.001 (0.011) | 0.927 | **0.050 (0.019) | 0.010 | ***-0.054 (0.018) | 0.003 | 0.018 (0.016) | 0.255 | -0.004 (0.013) | 0.784 | 0.011 (0.014) | 0.416 |
| Per_salinity | **0.206 (0.085) | 0.015 | 0.145 (0.090) | 0.109 | 0.045 (0.081) | 0.581 | -0.181 (0.114) | 0.113 | -0.021 (0.082) | 0.799 | 0.117 (0.088) | 0.181 |
| Loss_yield | *0.006 (0.003) | 0.096 | 0.001 (0.004) | 0.770 | 0.001 (0.003) | 0.742 | ***0.018 (0.005) | 0.001 | 0.003 (0.003) | 0.300 | *0.006 (0.004) | 0.078 |
| Constant | -2.630 (0.717) | 0.000 | -0.484 (0.849) | 0.569 | -0.955 (0.672) | 0.156 | 0.760 (0.852) | 0.373 | 1.474 (0.708) | 0.037 | -0.176 (0.737) | 0.812 |
| Model summary | | | | | | | /atrho | | Coef. | P > z | | |
| Log likelihood | -1235.738 | | | | | | /atrho21 | | *-0.168 (0.093) | 0.072 | | |
| Wald $\chi^2$ (90) | 273.870 | | | | | | /atrho31 | | **0.217 (0.085) | 0.010 | | |
| Prob > $\chi^2$ | 0.000 | | | | | | /atrho41 | | ***-0.350 (0.110) | 0.000 | | |
| Pr ($Y_1$) = 1 | 38.022 | | | | | | /atrho51 | | -0.056 (0.084) | 0.505 | | |
| Pr ($Y_2$) = 1 | 83.088 | | | | | | /atrho61 | | *0.189 (0.098) | 0.054 | | |
| Pr ($Y_3$) = 1 | 30.329 | | | | | | /atrho32 | | 0.070 (0.083) | 0.404 | | |
| Pr ($Y_4$) = 1 | 88.024 | | | | | | /atrho42 | | -0.003 (0.117) | 0.982 | | |
| Pr ($Y_5$) = 1 | 57.785 | | | | | | /atrho52 | | **-0.168 (0.084) | 0.045 | | |
| Pr ($Y_6$) = 1 | 81.061 | | | | | | /atrho62 | | 0.119 (0.099) | 0.232 | | |
| | | | | | | | /atrho43 | | -0.048 (0.117) | 0.681 | | |
| | | | | | | | /atrho53 | | 0.129 (0.082) | 0.114 | | |
| | | | | | | | /atrho63 | | -0.078 (0.099) | 0.428 | | |
| | | | | | | | /atrho54 | | 0.019 (0.092) | 0.840 | | |
| | | | | | | | /atrho64 | | -0.070 (0.115) | 0.543 | | |
| | | | | | | | /atrho65 | | -0.025 (0.088) | 0.773 | | |

Note: The values in the brackets are Robust Standard Errors; *; **; *** indicate significance at 10%; 5%; and 1%, respectively.

## Table 7. Multivariate probit model of determinants of male farmers' adaptation options (n = 274)

| Variables | Changing rice farm to other crops (partly) ($Y_1$) | | Saving rainwater for daily use ($Y_2$) | | Digging ponds for water storage (in the garden) ($Y_3$) | | Reducing the number of rice crops per year ($Y_4$) | | Seeking other income sources ($Y_5$) | | Purchasing the agricultural inputs (payment when harvesting) ($Y_6$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z |
| Age | -0.002 (0.011) | 0.851 | 0.001 (0.013) | 0.929 | -0.010 (0.011) | 0.361 | 0.006 (0.014) | 0.669 | ***-0.049 (0.012) | 0.000 | -0.0182 (0.011) | 0.114 |
| Marital | -0.031 (0.406) | 0.938 | -0.096 (0.436) | 0.825 | 0.130 (0.413) | 0.753 | ***-3.910 (0.391) | 0.000 | 0.223 (0.506) | 0.659 | *0.735 (0.413) | 0.076 |
| Education | *0.043 (0.023) | 0.066 | 0.018 (0.256) | 0.521 | -0.008 (0.023) | 0.742 | 0.038 (0.032) | 0.234 | -0.013 (0.024) | 0.592 | -0.010 (0.028) | 0.718 |
| Hhsize | 0.058 (0.057) | 0.311 | 0.027 (0.058) | 0.643 | 0.068 (0.054) | 0.206 | 0.001 (0.071) | 1.000 | -0.003 (0.059) | 0.963 | -0.019 (0.062) | 0.765 |
| Farm_income | ***0.006 (0.002) | 0.001 | *-0.002 (0.001) | 0.053 | *0.002 (0.001) | 0.090 | -0.001 (0.001) | 0.262 | -0.003 (0.002) | 0.126 | -0.002 (0.001) | 0.139 |
| Land_tenure | -0.027 (0.185) | 0.884 | *0.368 (0.200) | 0.066 | 0.173 (0.190) | 0.364 | 0.187 (0.236) | 0.429 | -0.248 (0.193) | 0.198 | (0.142) (0.223) | 0.526 |
| Access_Credit | **0.378 (0.166) | 0.023 | -0.270 (0.181) | 0.137 | 0.174 (0.168) | 0.298 | -0.018 (0.215) | 0.932 | -0.038 (0.174) | 0.827 | ***0.682 (0.190) | 0.000 |
| Extension | 0.138 (0.222) | 0.534 | -0.074 (0.275) | 0.788 | -0.090 (0.232) | 0.699 | -0.318 (0.272) | 0.243 | -0.125 (0.236) | 0.597 | 0.183 (0.256) | 0.474 |
| Training_salinity | -0.238 (0.176) | 0.178 | -0.327 (0.205) | 0.111 | 0.102 (0.175) | 0.559 | ***1.309 (0.262) | 0.000 | *0.320 (0.183) | 0.080 | **-0.497 (0.195) | 0.011 |
| Experience | 0.004 (0.009) | 0.626 | 0.010 (0.010) | 0.341 | 0.015 (0.010) | 0.120 | 0.001 (0.013) | 0.975 | *-0.018 (0.010) | 0.063 | 0.011 (0.010) | 0.283 |
| Rice_farmsize | -0.177 (0.124) | 0.155 | -0.032 (0.068) | 0.633 | -0.044 (0.056) | 0.433 | -0.006 (0.071) | 0.933 | -0.097 (0.085) | 0.249 | 0.164 (0.163) | 0.315 |
| Distance | 0.004 (0.019) | 0.842 | *0.046 (0.025) | 0.065 | **-0.061 (0.024) | 0.010 | 0.016 (0.029) | 0.581 | -0.025 (0.018) | 0.178 | 0.012 (0.021) | 0.564 |
| Per_salinity | **0.226 (0.103) | 0.029 | 0.153 (0.105) | 0.144 | 0.036 (0.091) | 0.692 | -0.160 (0.122) | 0.188 | -0.072 (0.109) | 0.513 | 0.141 (0.105) | 0.179 |
| Loss_yield | 0.004 (0.004) | 0.294 | -0.001 (0.005) | 0.942 | -0.004 (0.004) | 0.318 | ***0.019 (0.006) | 0.003 | 0.006 (0.004) | 0.149 | 0.005 (0.005) | 0.280 |
| Constant | -2.788 (0.951) | 0.003 | -0.309 (1.060) | 0.771 | -0.712 (0.890) | 0.424 | 4.516 (1.124) | 0.000 | 3.904 (1.033) | 0.000 | -0.460 (0.996) | 0.644 |
| Model summary | | | | | | | /atrho | | Coef | P > z | | |
| Log likelihood | -794.570 | | | | | | /atrho21 | | -0.138 (0.120) | 0.251 | | |
| Wald $\chi^2$ (84) | 623.040 | | | | | | /atrho31 | | *0.169 (0.102) | 0.099 | | |
| Prob > $\chi^2$ | 0.000 | | | | | | /atrho41 | | ***-0.363 (0.128) | 0.005 | | |
| Pr ($Y_1$) = 1 | 43.340 | | | | | | /atrho51 | | -0.065 (0.113) | 0.564 | | |
| Pr ($Y_2$) = 1 | 79.658 | | | | | | /atrho61 | | *0.207 (0.121) | 0.086 | | |
| Pr ($Y_3$) = 1 | 32.501 | | | | | | /atrho32 | | 0.018 (0.110) | 0.871 | | |
| Pr ($Y_4$) = 1 | 88.172 | | | | | | /atrho42 | | 0.149 (0.166) | 0.371 | | |
| Pr ($Y_5$) = 1 | 58.972 | | | | | | /atrho52 | | *-0.229 (0.129) | 0.077 | | |
| Pr ($Y_6$) = 1 | 79.178 | | | | | | /atrho62 | | 0.079 (0.126) | 0.528 | | |
| | | | | | | | /atrho43 | | -0.131 (0.131) | 0.316 | | |
| | | | | | | | /atrho53 | | 0.055 (0.098) | 0.573 | | |
| | | | | | | | /atrho63 | | -0.031 (0.117) | 0.790 | | |
| | | | | | | | /atrho54 | | 0.093 (0.145) | 0.519 | | |
| | | | | | | | /atrho64 | | 0.092 (0.140) | 0.245 | | |
| | | | | | | | /atrho65 | | *-0.099 (0.099) | 0.092 | | |

Note: The values in the brackets are Robust Standard Errors; *; **; *** indicate significance at 10%; 5%; and 1%, respectively.

## Table 8. Multivariate probit model of determinants of female farmers' adaptation options (n = 156)

| Variables | Changing rice farm to other crops (partly) ($Y_1$) | | Saving rainwater for daily use ($Y_2$) | | Digging ponds for water storage (in the garden) ($Y_3$) | | Reducing the number of rice crops per year ($Y_4$) | | Seeking other income sources ($Y_5$) | | Purchasing the agricultural inputs (payment when harvesting) ($Y_6$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z | Coef. | P > z |
| Age | -0.022 (0.017) | 0.201 | **0.038 (0.015) | 0.015 | -0.014 (0.014) | 0.301 | **0.033 (0.017) | 0.045 | 0.017 (0.014) | 0.218 | *0.029 (0.015) | 0.055 |
| Marital | ***-0.845 (0.304) | 0.005 | -0.081 (0.328) | 0.805 | **-0.573 (0.281) | 0.041 | -0.460 (0.327) | 0.160 | -0.400 (0.260) | 0.123 | -0.508 (0.348) | 0.144 |
| Education | **0.088 (0.039) | 0.025 | 0.005 (0.048) | 0.912 | *0.073 (0.039) | 0.062 | -0.048 (0.042) | 0.250 | 0.051 (0.041) | 0.212 | -0.057 (0.039) | 0.138 |
| Hhsize | 0.023 (0.077) | 0.768 | **0.330 (0.137) | 0.016 | 0.111 (0.070) | 0.115 | **0.259 (0.121) | 0.033 | *0.123 (0.067) | 0.067 | 0.102 (0.093) | 0.272 |
| Farm_income | **0.008 (0.003) | 0.015 | -0.001 (0.005) | 0.958 | 0.005 (0.003) | 0.148 | 0.080 (0.006) | 0.199 | 0.001 (0.003) | 0.955 | ***-0.009 (0.003) | 0.004 |
| Land_tenure | 0.195 (0.303) | 0.519 | -0.276 (0.413) | 0.504 | -0.246 (0.294) | 0.403 | *0.719 (0.383) | 0.061 | -0.337 (0.257) | 0.190 | -0.321 (0.332) | 0.334 |
| Access_Credit | 0.184 (0.251) | 0.463 | -0.195 (0.303) | 0.518 | -0.387 (0.239) | 0.106 | 0.458 (0.298) | 0.125 | **0.412 (0.246) | 0.018 | **0.595 (0.292) | 0.042 |
| Extension | **0.753 (0.293) | 0.010 | -0.335 (0.332) | 0.314 | 0.362 (0.271) | 0.181 | **-0.575 (0.279) | 0.039 | **0.599 (0.302) | 0.048 | 0.436 (0.308) | 0.157 |
| Training_salinity | 0.470 (0.313) | 0.133 | -0.018 (0.346) | 0.959 | -0.207 (0.292) | 0.478 | 0.165 (0.494) | 0.739 | **-0.596 (0.289) | 0.039 | -0.211 (0.337) | 0.532 |
| Experience | -0.009 (0.014) | 0.516 | -0.010 (0.016) | 0.550 | -0.009 (0.012) | 0.455 | -0.031 (0.023) | 0.175 | **-0.028 (0.012) | 0.020 | ***-0.044 (0.015) | 0.004 |
| Rice_farmsize | -0.047 (0.231) | 0.839 | -0.209 (0.237) | 0.377 | -0.067 (0.194) | 0.730 | -0.112 (0.232) | 0.630 | 0.002 (0.239) | 0.994 | 0.337 (0.317) | 0.287 |
| Distance | -0.003 (0.016) | 0.846 | 0.050 (0.038) | 0.181 | *-0.056 (0.031) | 0.069 | 0.061 (0.048) | 0.203 | 0.011 (0.016) | 0.494 | 0.021 (0.021) | 0.319 |
| Per_salinity | *0.301 (0.175) | 0.085 | 0.280 (0.225) | 0.213 | 0.064 (0.180) | 0.722 | *-0.461 (0.265) | 0.082 | 0.034 (0.158) | 0.831 | 0.243 (0.207) | 0.240 |
| Loss_yield | 0.008 (0.006) | 0.198 | 0.006 (0.009) | 0.535 | ***0.018 (0.006) | 0.003 | **0.025 (0.011) | 0.024 | 0.003 (0.007) | 0.701 | *0.013 (0.007) | 0.065 |
| Constant | -2.630 (1.386) | 0.058 | -3.186 (1.704) | 0.062 | -1.259 (1.382) | 0.362 | 1.210 (2.019) | 0.549 | -1.274 (1.2001) | 0.289 | -1.316 (1.427) | 0.357 |
| Model summary | | | | | | | /atrho | | Coef | P > z | | |
| Log likelihood | -368.933 | | | | | | /atrho21 | | -0.105 (0.185) | 0.568 | | |
| Wald $\chi^2$ (84) | 453.580 | | | | | | /atrho31 | | *0.256 (0.148) | 0.085 | | |
| Prob > $\chi^2$ | 0.000 | | | | | | /atrho41 | | -0.301 (0.239) | 0.208 | | |
| Pr ($Y_1$) = 1 | 29.235 | | | | | | /atrho51 | | -0.079 (0.145) | 0.588 | | |
| Pr ($Y_2$) = 1 | 88.968 | | | | | | /atrho61 | | -0.093 (0.139) | 0.506 | | |
| Pr ($Y_3$) = 1 | 27.707 | | | | | | /atrho32 | | 0.436 (0.269) | 0.105 | | |
| Pr ($Y_4$) = 1 | 86.514 | | | | | | /atrho42 | | -0.716 (0.932) | 0.443 | | |
| Pr ($Y_5$) = 1 | 54.185 | | | | | | /atrho52 | | -0.086 (0.191) | 0.653 | | |
| Pr ($Y_6$) = 1 | 83.973 | | | | | | /atrho62 | | 0.034 (0.127) | 0.788 | | |
| | | | | | | | /atrho43 | | -0.026 (0.470) | 0.956 | | |
| | | | | | | | /atrho53 | | *0.294 (0.163) | 0.071 | | |
| | | | | | | | /atrho63 | | *-0.410 (0.239) | 0.085 | | |
| | | | | | | | /atrho54 | | 0.009 (0.245) | 0.971 | | |
| | | | | | | | /atrho64 | | -0.035 (0.222) | 0.876 | | |
| | | | | | | | /atrho65 | | -0.016 (0.336) | 0.963 | | |

Note: The values in the brackets are Robust Standard Errors; *; **; *** indicate significance at 10%; 5%; and 1%, respectively.

**Table 9. The marginal predicted probability of success for each outcome**

| No. | Adaptation practices | Predicted Probabilities (%) (Pr ($Y_i$) = 1) (i = 1, 2, ..., 6) | | |
|---|---|---|---|---|
| | | **Full (n = 430)** | **Male (n = 274)** | **Female (n = 156)** |
| 1 | Changing rice farm to other crops (partly) | 38.022 | 43.340 | 29.235 |
| 2 | Saving rainwater for daily use | 83.088 | 79.658 | 88.968 |
| 3 | Digging ponds for water storage (in the garden) | 30.329 | 32.501 | 27.707 |
| 4 | Reducing the number of rice crops per year | 88.024 | 88.172 | 86.514 |
| 5 | Seeking other income sources | 57.785 | 58.972 | 54.185 |
| 6 | Purchasing the agricultural inputs (payment when harvesting) | 81.061 | 79.178 | 83.973 |