

## ADAPTATION TO SALINITY IMPACTS IN THE VIETNAMESE MEKONG DELTA'S COASTAL AREAS

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### Abstract

The paper aims to understand the recent trends of saline intrusion in the Vietnamese Mekong Delta's coastal areas, and how this process negatively affects local rice farmers. Ways that rice farmers have learned elsewhere to adapt to the detrimental effects of salinity are also the main theme under study. This paper integrated both qualitative and quantitative field data that collected from 390 surveyed samples and four focus group discussions and sixteen interviews with key informants in the research areas. The quantitative analysis explores the correlation between salinity level and rice yield. Meanwhile, the qualitative analysis suggests that rice farmers have enhanced their awareness of salinity impacts on their crops, but only a few has prepared adequately to adapt to change. In absence of information and policy guidance, their decisions do not pertinently correspond to long-term adaptation responses, but tend to tackle emerging contingencies. The study indicates the implications of structural systems for local rice production, which, to some extent, is more likely to aggravate salinity conditions and cause water pollution in protected areas. The study contributes to reframing water management policies relevant to saline intrusion and water quality in the coastal zones of the Vietnamese Mekong Delta. It draws the particular attention to strengthening further collaboration between local governments and rice farmers in dealing with increasing impacts of salinity in the future.

**Keywords:** Adaptation, Irrigation Water, Salinity Impacts, Salinity Intrusion, Vietnamese Mekong Delta.

### A. INTRODUCTION

The Vietnamese Mekong Delta (VMD) is the last part of the country where the Mekong River reaches out into the East Sea. The VMD located in an important areaspecial on socio-economics development in Vietnam. It is a vast wetland of 40.604,7 km<sup>2</sup>, accounting for 12% of the country area, approximately 27% of the agricultural land of Vietnam (MONRE, 2019). Endowed with rich natural assets, its coastal areas possess favorable conditions and competitive opportunities to develop the economy and provide livelihoods for local people (Michel and Pandya, 2010), approximately 58% of livelihoods in coastal areas are based on agriculture, fishing and aquaculture (Chaudhry and Ruyschaert, 2007). Nevertheless, these regions are frequently being at risk of salinity intrusion (IPSARD, 2016; Nguyen et al., 2019; Thong et al., 2021). The continual acceleration of salinity has obviously caused considerable impacts on the livelihood of poor population. Salinity impacts in Vietnam are mainly manifested through sea level rise which leads to increase of flood risk from the ocean, particularly during water shortage in recent years (Le et al, 2007; Estellès et al., 2012). The saline intrusion in the Mekong Delta was influenced by the mainstream reverse flow and tides (Thanh & Toan, 2009; Thong et al., 2019; Thong et al., 2021). In dry season from December to June, the average discharge of the Mekong River is about 6,000 m<sup>3</sup>/s. From March to April, it is at its lowest, at approximately 2,000 m<sup>3</sup>/s; this leads to saline intrusion far inland (Tri, 2016). The increasing

sea level rise contributes considerably to the prevalence of saline intrusion in the VMD (see Figure 1).



**Figure 1: The Severity of Saline Intrusion in the VMD; 4mg/L Calculated from the Red-line to the Sea (SIWRR, 2021)**

In 1990s of the last century, at the national level the government had put massive investment into the development of salinity control structure to control a region (Tran, 2009; Nguyen, 2016). By doing this, the government expected that households in the saline zones could intensify rice farming and other freshwater upland crop to improve their livelihood (World Bank, 2015; Dang et al., 2012; Van, 2019), however saline intrusion still exists that requested the coastal farmers to adapt to overcome the impact of saline intrusion. Therefore, they have applied new varieties of salt tolerant rice or shift from rice to shirmp farming (IPSARD, 2016; Nguyen et al., 2019). Supporting from the government brings economics benefits but weakness exist requesting more on strategy, money and technique supply (Van, 2019). However, adaptation is a process by which communities and households seek to confront with consequences brought by the impacts of saline intrusion. To understand how rice-farming households responded to impacts of saline intrusion in the Vietnamese Mekong Delta, this

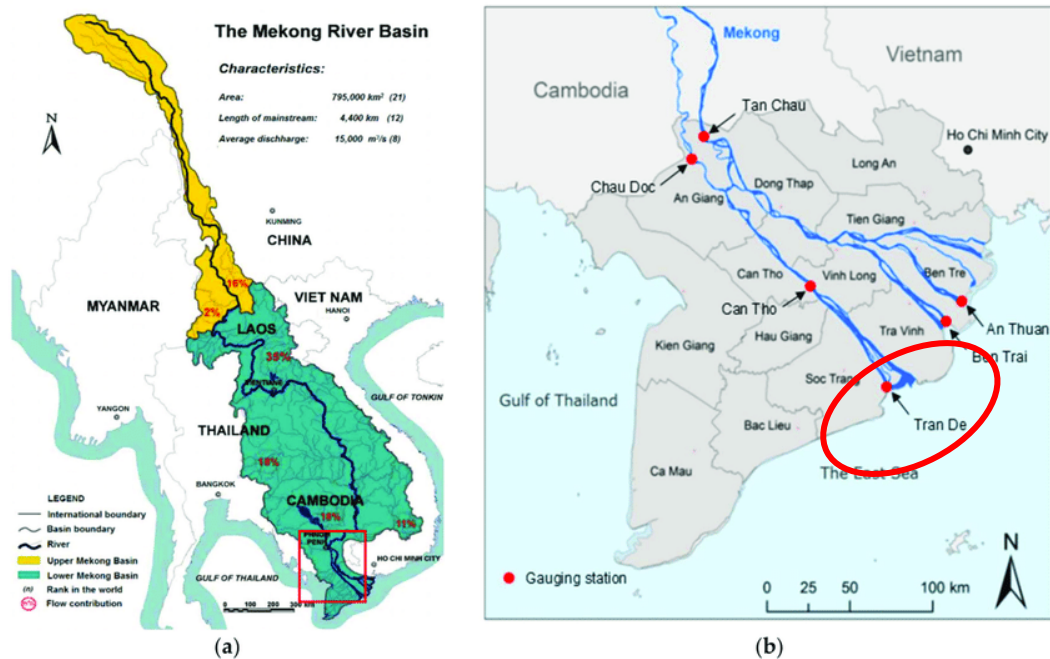
paper focused on the adaptive capacity and adaptation to saline intrusion, especially at the household level. The specific objectives were to:

- (1) Analyze the coping capacity of farming households;
- (2) Evaluate the adaptive capacity of rice farming households; and
- (3) Reveal how rice-farming households adapted their livelihood to saline intrusion.

## B. METHODOLOGY

### 1. Study Area

The research took place in Soc Trang and Tra Vinh province (see Figure 2) where is a coastal areas of the VMD, and is also the Mekong River branch is influenced strongly by the irregular semi-diurnal tides of the East Sea with large tide amplitude of 3,0 - 4,0m (SIWRR, 2019) in order to better understand how rice farmers can adapt under the impacts of salinity intrusion.



**Figure 2: Locations of the Research Sites; Red Dots are Gauging Station (SIWRR, 2022)**

### 2. Data Collection

Household survey were conducted in order to collect data on household daily life and production activities, perceptions and conditions of households, impacts of saline intrusion, and adaptive capacity, making a total of 390 household. Household survey was carried out to get information of households using the structured questionnaires.

Questionnaire was structured into five major parts as:

- [1] Household background information included place of origin; length of settlement; number of household members; gender, age, and education level of household heads; major livelihood activity; major household occupation; and household income;
- [2] Livelihood activities facing saline intrusion included farming patterns and practices, seasonal calendar, farming income and loss, response and adaptive capacity;
- [3] Coping behavior and adaptation to saline intrusion, livelihood changed to respond and adapt to the adverse effects of saline intrusion in their daily life and production; and
- [4] Limitations, constraints and needs for household adaptation.

In-depth interviews with key informants at all levels (e.g. province, district, and community) were carried out in order to understand the situation of saline intrusion and the impacts on household livelihoods. Different stakeholders were selected for in-depth interviews. They were key leaders of the local government and competent agencies which included Farmer's Associations of districts (2 leaders), Sub-DARD and Sub-DNRE of districts (4 leaders), Agricultural Extension Division of districts (2 leaders), agriculture staff of communes (4 staff), and head of communes (4 leaders), making a total of 16 key informants at the communal and district levels. They had profound understanding of socio-economic and environmental situation associated with saline intrusion. Their leadership and roles, vision and views in the context of saline intrusion were explored.

### **3. Data Analysis**

The household's coping and adaptive capacity was determined by the level of government support, accessibility to financial support, experience from adaptation training, availability of insurance for crop damage and loss, policy support at all levels, rice farming practices and how an individual households has been affected by salinity intrusion and what has been done to adapt to environment changes. Data is analyzed using descriptive analysis to indicate perception of household, patterns of adaptation and economic and social impacts, so forth. Data coming from in-depth interview is analyzed via an inductive approach as described by Thomas (2003). The extensive and raw data are condensed into a brief and categorized into different categories. They were then selected corresponding to research objectives. The findings are grouped into four group: resource system, resource unit, resource users and governance system. Causal loop analysis is applied to analyse the relation between factors to get insights in how ecological ad social factors influence research site.

## **C. FINDING AND DISCUSSION**

### **1. Saline Intrusion Impacts and Farming System Change**

The impacts of saline intrusion on rice farming have been reported in the VMD coastal areas, especially in April of 2020. Because rice in the main crop in the Delta, data of crop lost by saline intrusion is clearly in case of rice than other crops. They are estimated both in areas and financial loss (see Table 1).

**Table 1: Areas and Loss of Rice Due to Salt Water in the VMD Coastal Areas**

Province	Area (ha)	Loss (million USD)
Ben Tre	5,100	0.61
Tra Vinh	23,747	4.82
Soc Trang	12,160	1.12
Bac Lieu	3,400	0.54
Ca Mau	20,500	3.19
<b>Total</b>	<b>64,907</b>	<b>10.28</b>

Source: Estimated from the report of the Department of Agriculture and Rural Development in the VMD provinces (2023).

Saline intrusion highly affected rice farming productivity. Households stated that the yield of rice farming was decreasing. In the research sites, total of 48.1% of rice farming households indicated that rice yield was lower despite the increase of production cost in their farmlands. The number of households facing with losses of rice yield varied according to different provinces in the research sites. Result from the regression linear between salinity level and rice yield confirmed the degree of saline intrusion significantly influenced the yield of rice farming. Table 2 explained that the rice yield, in Soc Trang, were significantly affected by the degree of saline intrusion. In specific, if the salinity increased one level, the rice yield would be decreased 0.53 ton/ha.

**Table 2: The Regression Linear between Salinity Level and Rice Yield in the Research Sites**

Variables	Estimated coefficient	t stat	Significant
Constant (Soc Trang)	5.74	3.51	0.00
Constant (Tra Vinh)	3.28	2.07	0.13
Rice yield in Soc Trang (ton/ha) <sup>1</sup>	- 0.53*	2.53	0.02
Rice yield in Tra Vinh (ton/ha) <sup>2</sup>	- 0.14*	2.61	0.05
Number of samples (n) = 134; <sup>1</sup> R square = 0.39; <sup>2</sup> R square = 0.49			
* = confident level at 95%			

Futhermore, the saline intrusion impacts affected to change famring system, the results from household surveys in Tra Vinh and Soc Trang confirmed that rice farming households shifted a part of farmlands (accounting for 214.7 ha) from rice farming to shrimp farming. Seriously, in Soc Trang, 31.8% of surveyed households left their crop or fallow in duration of saline intrusion impacts. Although the agriculture production areas were protected by the system of dykes and sluice gates, but saltwater could infiltrate into farmlands when opened sluice gates for irrigation.

## 2. Coping Capacity of Rice Farming Household

Facing with saline intrusion, coping capacity of rice farming households was influenced by three factors. The first factor was the government decisions on building irrigation, canals, sluice gates and dyke systems to help prevent damage and provide better conditions for people livelihood activities. The second factor was household's characteristics (perception and scale of household farming activities) which made rice farming households at the research sites chose

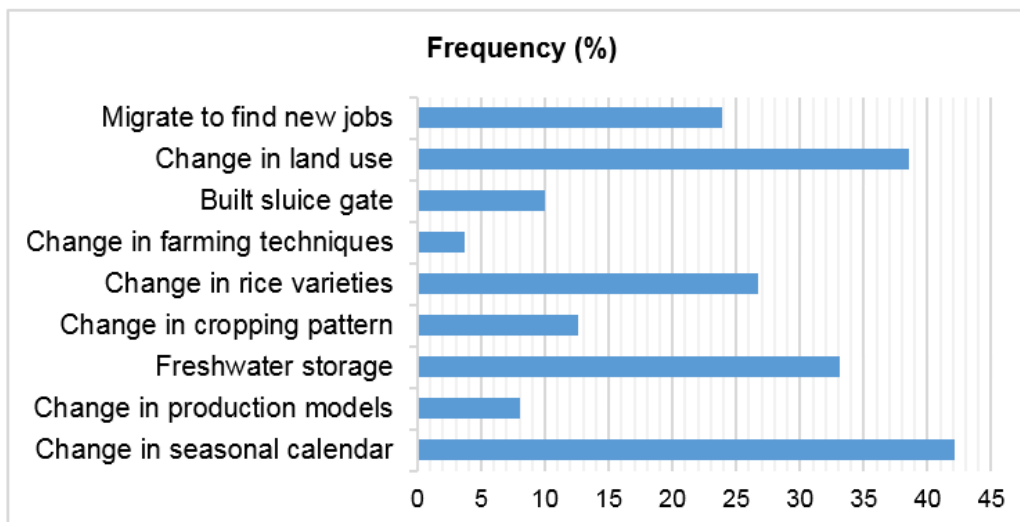
various ways to decrease impacts of saline intrusion. The third factor was the experience of households and communities with saline intrusion impacts.

Results from household surveys confirmed that the coping capacity depended completely on the characteristics of households. Household labors, education of household heads, farming techniques and land holding were four factors indicated the level of coping capacity. Rice farming households in the research sites had less coping capacity to saline intrusion because they had not enough labors, land holding, experience and farming technique.

The coping capacity of rice farming households was still affected by their perception, ability, and experience. The percentage of rice farming households having capacity to cope with saline intrusion differed in research sites. Results from household surveys indicated that, on average, approximately 53.2% of surveyed households had different ways to deal with saline intrusion in their production and livelihood.

### 3. Adaptation Methods of Rice Farming Household

Rice farming households in the research sites still had limited adaptation methods to saline intrusion. They had limited ways to deal with saline intrusion, including change in seasonal calendar, change in production models, freshwater storage, change in cropping patterns, use of tolerant rice varieties and fish species, change in farming techniques, change in land use, and built sluice gate. Change in seasonal calendar and change in land use were the prioritized adaptation methods indicated by the sampled households, meanwhile change in production models and change in farming techniques were the least applied adaptation methods of rice farming households to deal with saline intrusion (see Figure 3).



**Figure 3: Adaptation Methods to Saline Intrusion in the Research Sites**

Adaptation methods of rice farming households can be summarized into four groups as water management, cropping pattern, land use change and migration follows.

- *Water management (canals, sluice gates, fresh water stored for irrigation):* In term of irrigation, the interviews with communal and district leaders presented multiple initiatives in the way households used and managed water for crop irrigation. According to the results of in-depth interview, in response to saline intrusion that occurred extensively between March and April, rice-farming households dug internal ditch systems across their rice field to function as both water drainage in case of inundation by saltwater and freshwater storage to maintain soil moisture and prevent salt deposition in soil. With this initiative, freshwater was pumped into ditch systems and small ponds which canvases were stretched in the farming areas. Supported by this method, freshwater can be stored and used for crop irrigation during hot days or in case of water shortage. This way was very effective in case of water shortage during hot days. However, this was only a temporary measure since the volume of stored water in the pond was not always available.
- *Cropping patterns:* To deal with saline intrusion, surveyed households actively changed their seasonal calendar, types of crop and crop varieties. Rice farming households grew rice earlier to ensure that they could harvest before the saltwater infiltrated into canal systems. This transformation helped them reduce economic loss, compared to the original model. Importantly, the crop transformation contributed to diversify the local agriculture production activities that brought more income for rice farming households. Results from in-depth interview with key informants showed that the provincial government implemented many projects for testing new rice varieties and other crops to adapt to high salinity, but the adaptive capacity was low and could not survive in the salinity at 4ppt. Only sugarcane was well-adapted to the salinity-affected soil within rice areas from 3ppt to 4ppt due to its higher drought resistant capacity, compared to rice, and gave higher economic return. Given this initial success, government department encouraged rice farming households to capture this model instead of growing rice. At the beginning, there were only 100 ha, but the areas of sugarcane soon grew rapidly up to 450 ha in 2020.
- *Land use change:* Results from in-depth interview confirmed that rice farming households shifted parts of their land from rice farming to fruit trees and vegetable crops because household's locations were not suitable for rice farming. Moreover, rice framing households reduced to one rice crop, compared to the past because the duration of saline intrusion was longer.
- *Migration:* Shifting employments into non-farm activities was encouraged to bring more income for rice farming households and reduced the human pressure on declining natural resources. Off-farm activities were the main adaptation method to increase income of rice farming households during saline intrusion duration. Results from from in-depth interview with key informants with households showed that off-farm activities included collecting crab, small business within community, picking coffee, bricklayers and carpenter outside community. Main labor of rice farming households migrated to big cities for seeking jobs during saline intrusion duration and their remittance supported farm production activities.

#### D. CONCLUSION AND RECOMMENDATION

Rice farming households had low coping capacity and adaption methods to saline intrusion. Change in water management, change in cropping patterns, change in land use, and migrate to seek new jobs were practiced in the context of saline intrusion. Despite of the government policies support to deal with saline intrusion, rice-farming households still had low adaption.

The application of salt-tolerant rice varieties with high productivity should be widely promoted for the long-term adaptation to saline intrusion. In short-term, varieties and implementation of minimal use of water for upland crops are especially needed while the freshwater resource is being seriously threatened. Besides, finding alternative livelihood during saline intrusion duration should be encouraged to bring more income for local people and reduce the human pressure on declining natural resources.

The planning of irrigation systems should be implemented immediately to ensure the sustainable freshwater crop production. The ecological zones can be maintained as long as the irrigation system is well constructed and managed. This balance helps the effective planning of crop system across the area.

Trainings on negative implications of saline intrusion to rice farming households are needed to improve their awareness and ways to respond to the situation on a long-term basis. There is a critical need to focus on formulating the policy of long-term response to saline intrusion in the harmony of the provincial and local levels. Authorities at different levels should formulate sound policies that can strengthen capacity of all households.

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