Economic Analysis and Policy 73 (2022) 639–652

Contents lists available at ScienceDirect

Economic Analysis and Policy

journal homepage: www.elsevier.com/locate/eap

Analyses of topical policy issues

The impact of an adjusted cropping calendar on the welfare of rice farming households in the Mekong River Delta, Vietnam

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A R T I C L E   I N F O

Article history:
Received 29 July 2021
Received in revised form 26 December 2021
Accepted 26 December 2021
Available online 1 January 2022

JEL classification:
Q12
Q18

Keywords:
Early planting
Welfare
Farmer
Mekong River Delta
PSM

A B S T R A C T

The study assessed the impacts of an adjusted cropping calendar on the welfare of rice farming households in the Mekong River Delta (MRD) of Vietnam in the 2019/20 Winter–Spring (W-S) crop season. Some farmers in the study area practiced early planting as an adaptation strategy to avoid the risk of saline intrusion during the 2019–2020 El Niño. The study randomly surveyed 1,176 rice farmers in three MRD provinces, namely, Long An, Kien Giang, and Soc Trang, of which 412 were early planters and 764 were non-early planters. Propensity score matching was applied to explore the effects of early planting on the rice yield and rice farming income. Early planting during the 2019/20 W-S season produced (i) an increase in rice farming income of VND 22.8–24.6 million per farmer or VND 8.62–8.77 million per hectare; (ii) an increase in the annual rice farming income of VND 13.7–17.1 million per farmer or VND 3.2–4.3 million per hectare; and (iii) an increase in rice yield by 5.29–5.67 tons per farmer or 2.51–2.59 tons per hectare. The findings confirm that adjusting the rice cropping calendar as an adaptation strategy against salinity can improve rice farmers' production and income.

1. Introduction

Vietnam is among the most vulnerable countries in the world in regard to climate change. Its agricultural sector is particularly susceptible to various damages caused by climate change (World Bank, 2010). Close to 40 percent of the country's total land area is agricultural land. The agriculture sector accounts for 24 percent of Vietnam's GDP, 20 percent of total exports, and over 70 percent of total employment (Maitah et al., 2020). Using integrated or multi-sector modeling, Arndt et al. (2015) estimated the economic cost of climate change in Vietnam and concluded that the annual GDP growth rate would decline by about 1%–2%. Even so, they found that the negative impacts on agriculture and roads would be

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https://doi.org/10.1016/j.eap.2021.12.018

modest by 2050. They further showed that adopting appropriate preemptive actions to climate change would bring positive results.

Agriculture is an important pillar of the Vietnamese economy. Rice farming, which uses two-thirds of the country's rural labor, produces 30 percent of the country's total agricultural production value (Diallo et al., 2019). Vietnam is also one of the largest rice exporters in the world (Maitah et al., 2020).

More than half of Vietnam's rice production (GSO, 2019) and about 90 percent of the rice exports come from the Mekong River Delta (MRD) (Yen et al., 2019a,b). However, this low-lying area faces some of the worst impacts of climate change (Chi et al., 2017; SRD, 2016) and is therefore seen to "severely compromise" the country's future rice production (Yu et al., 2010). Recent studies have shown that ongoing climate change has had significant impacts on rice production and the livelihoods of farmers in the region. The most serious effect is caused by saltwater intrusion during the Winter–Spring (W-S) crop season (Nguyen et al., 2020; Yen et al., 2019a,b; Tivet and Boulakia, 2017; Le, 2016; CCAFS-SEA, 2016; Le et al., 2015; Vo, 2015; Tran, 2013; World Bank, 2010; Kotera et al., 2008). In the 2015/16 W-S crop season, MRD farmers suffered great losses from saltwater intrusion as rice paddy production fell by 11.2 percent in comparison with the 2014/15 W-S crop season (GSO, 2016). The problem is likely to continue in the future. The sea level in 2050 is projected to be between 25 cm and 30 cm higher than the 2000 level, which will likely result in salinity intrusion of >4g/l up to 50–60 km from the mouths of the Mekong River affecting about 30,000 hectares of agricultural area (Vu et al., 2018).

Local authorities have intervened to protect MRD farmers against drought and salinity intrusion. Assistance includes adjusting seasonal schedules, managing water resources, adjusting cultivation techniques, diversifying and changing crops, applying new varieties, and self-learning to protect crops and cut economic losses (Duffy et al., 2020; Nguyen et al., 2020; Nguyen and Nguyen, 2019; Nhung et al., 2019; Yen et al., 2019a; Trinh et al., 2018; Chi et al., 2017; Le et al., 2015, 2014; Vo et al., 2014). Previous studies provided empirical evidence on the effectiveness of adaptation strategies (e.g., Nguyen et al., 2020; Chi et al., 2017; CCAFS-SEA, 2016) as well as the factors that influence the rice farmers' choice among various adaptation strategies (e.g., Nguyen and Nguyen, 2019; Le et al., 2014). However, the benefits of such solutions were not properly controlled in the past comparative studies.

Specifically, the following problems can be cited. First, studies that used a binary indicator to measure the cope-with-climate-change solutions failed to quantify the costs or control the farmer's response process. Second, the impact of each strategy on income and productivity could not be separated as the studies aggregated many coping solutions. Third, the use of annual outcome indicators such as costs, profits, and productivity could not identify the effect of a single-response strategy in each crop season since the seasonal weather factor is not controlled.

To avoid these problems, we investigate the role of an adjusted cropping calendar in the rice production of MRD farmers facing saltwater intrusion. We focused on the relationship between early planting and the production and welfare of MRD rice farmers during the 2019/20 W-S crop season. This strategy is based on the following considerations. First, Nguyen and Ho (2021), Nguyen et al. (2020), and Nguyen and Nguyen (2019) found that farmers' adaptation strategies against climate change significantly affect their farm income. Because farmers are highly resource conscious when making climate adaptation decisions, a comparative study is required to gauge the change in farmers' welfare under different adaptation strategies. Second, Lu et al. (2017) argued that the timing of sowing needs to be predicted appropriately to avoid risks and achieve maximum yields.

In 2018, the Ministry of Agriculture and Rural Development of Vietnam instructed the provinces in the MRD coastal areas to apply Climate-Smart Maps and Adaptation Plans (CS-MAP)[1] to adjust the rice planting calendar during the 2019/20 W-S crop season to minimize saltwater intrusion brought by the 2019 El Niño (CCAFS-SEA and DCP-MARD, 2018).

In 2019, experts predicted that saltwater intrusion in the MRD would start earlier and that the salinity level would be higher than those in the 2015/16 dry season. The Department of Crop Production (DCP) issued Official Document No. 1252/TT-VPNN directing the MRD to adjust its planting calendar in the 2019/20 W-S crop season. Coastal areas of the MRD, including Long An, Kien Giang, and Soc Trang provinces, were advised to plant rice from early October to early November in 2019.

This created an opportunity for a natural experiment for the current study. To the best of our knowledge, this is the first study to examine the impacts of the adjusted cropping calendar on the welfare of rice farming households in the 2019/20 W-S crop season. To determine the effect of early planting in response to saltwater intrusion, a total of 1176 rice farmers in three MRD provinces (Long An, Kien Giang, and Soc Trang) were randomly selected as research participants. Then propensity score matching (PSM) was applied to match 412 early-planter farmers (treatment group) with 764 non-early planters (control group),comparing the rice farming income and rice yield of the two groups. We found that early planting increased rice farming income by VND 8.62–8.77 million per hectare and rice production by 2.51–2.59 tons per hectare during the 2019/20 W-S crop season.

Our findings suggest that during salinity years, advancing the rice cropping calendar to early planting can increase the production and income of rice farmers. This confirms the significant benefits of crop calendar adjustment in areas

[1] In 2017, the Department of Crop Production (DCP) collaborated with the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) to implement Climate-Smart Maps and Adaptation Plans (CS-MAP) in the MRD (Yen et al., 2019b). The CS-MAP is a participatory approach for mapping climate risks and adaptive interventions to recognize climate-related risks, identify potentially affected areas, and develop regional and provincial adaptation plans for rice production.

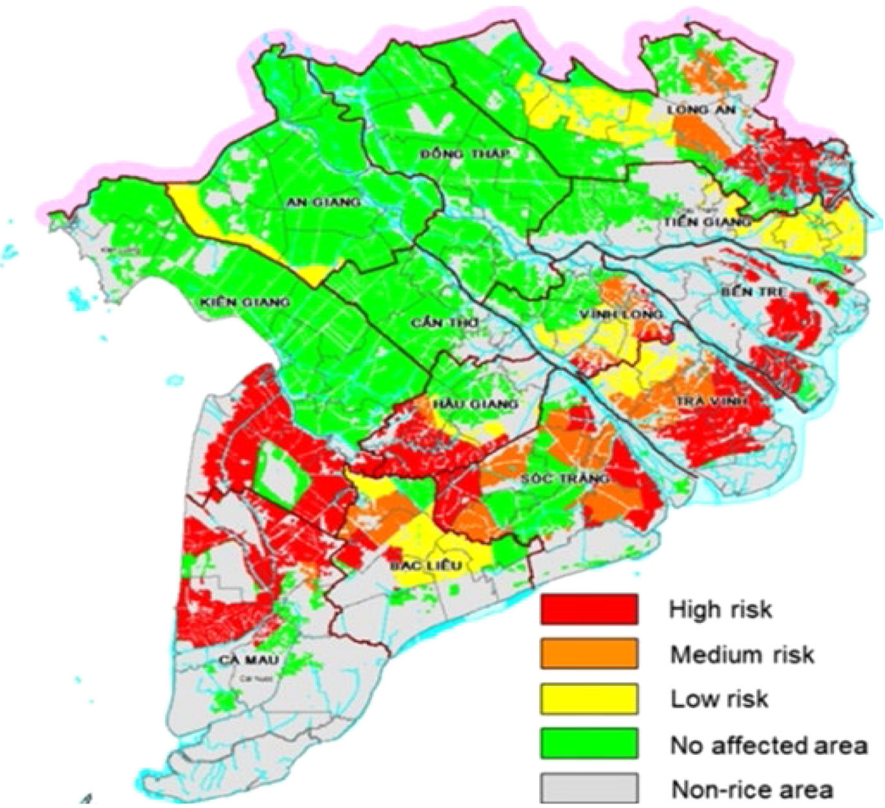

Fig. 1. CS-MAP saltwater intrusion risk in the MRD and the study area.
Source: Son et al. (2018).

exposed to the risk of saltwater intrusion. The result also corroborates the robustness of a "planned" response to climate change risks in agricultural production (World Bank, 2010). It is also consistent with the framework for agricultural climate change adaptation advocated by Ozor et al. (2012) and the process model of private proactive climate change adaptation presented by Grothmann and Patt (2005).

The paper proceeds as follows. Section 2 presents an overview of the study site and rice cropping practice in the MRD. Section 3 describes the sample and the methodology. Section 4 reports and discusses the results. Section 5 concludes the paper.

2. The study area and the rice cropping system in the Mekong river delta

2.1. The study area

Three provinces in the MRD, namely, Kien Giang, Long An, and Soc Trang, were selected as study areas based on the three criteria: the risk level of saltwater intrusion, contribution to rice production in the MRD, and the number of areas that adopted early planting during the 2019/20 W-S crop season.

The MRD saltwater intrusion risk map indicates that eight provinces are considered high-risk areas for saltwater intrusion: Long An, Ben Tre, Tra Vinh, Kien Giang, Hau Giang, Soc Trang, Bac Lieu, and Ca Mau (Fig. 1). Among these provinces, Kien Giang was the biggest rice-planting and producing province in the MRD in 2018 accounting for 17.7 percent of the total area of rice paddy planted (4,107,400 ha) and 17.4 percent of total rice production (24,441,900 tons). This was followed by Long An (12.5% and 11.5%, respectively), and Soc Trang (8.6% and 8.8%, respectively) (GSO, 2018).

These three provinces are among those in the southern coastal region that were advised by the DCP to plant early. About 227,630 hectares (53 percent of the total rice production area of the three provinces) practiced early planting during the 2019/20 W-S season, of which Soc Trang accounted for 22.6 percent, Kien Giang - 16.4%, and Long An - 13.9%. The combined number of farm households of the three provinces was one-third of the total number of farm households in the MRD (GSO, 2016).

2.2. The rice cropping system in the MRD and early planting

MRD farmers practice either two (Summer–Autumn and Winter–Spring) or three (Summer–Autumn, Autumn–Winter, and Winter–Spring) rice cropping systems. Normally, the Winter–Spring crop season is from November to February, the Summer–Autumn rice season is from April to July, and the Autumn–Winter rice season is from August to November. In normal years with no drought or high salinity, MRD rice farmers start planting in middle to late December for the W-S crop season. Rice farmers can move the planting calendar forward, particularly for the W-S season, whenever unfavorable environmental conditions such as drought and high salinity necessitate it Nguyen (2020).

For early planting, the DCP calendar recommends planting within the month of October during the W-S season, which is the season most affected by drought and salinity. Nguyen (2020) found that rice farmers in Long An, Kien Giang, and Soc Trang, especially those practicing the two-cropping system, define "early planting" as starting the planting period by mid-November. Considering this, we define early planting for the 2019/20W-Scrop season as planting rice by 15 November 2019 at the latest provided that this is the last cropping of the 2019/20 crop year. If the farmer planted before 15 November 2019 but had another cropping extending from late November to February 2020, he or she was considered a non-early planter for the 2019/20 W-S crop season.

3. Methodology

3.1. Study participants and the sampling method

The target sample size of the treatment group was 384.[2] The number of participants in the control group should be twice as many as that of the treatment group to ensure a higher number of matched samples. Consequently, the target number of study participants was 1152. Data from the DCP and the Department of Agriculture and Rural Development (DARD) were used during the pilot testing of the interview schedule and the sampling of survey participants. As a result, 5 districts and 15 communes were selected from Kien Giang, Soc Trang, and Long An provinces, with three communes being selected from each district.

The districts of each province were selected based on the data of the area planted before and after 15 November 2019 and on the ratio of salinity-affected area to total salinity area in the province. Thus, the selected districts have the following characteristics: (i) they are more heavily damaged by salinity relative to other districts in terms of the proportion of affected areas to the total area, and (ii) they have farmers who adopt early planting.

Within each district, the three most salinity-affected communes were chosen as study sites. Within each commune, the sampling distribution was determined by the proportion of salinity-affected areas to the total salinity-affected area. The sample households were chosen using a two-stage sampling strategy. The first stage involved dividing the households into two groups, namely, early planter households and non-early planter households. In the second stage, sample households from each group were selected by simple random sampling. The survey yielded slightly more study participants than the initial target: 412 early planters and 764 non-early planters.

3.2. Data collection methods

We conducted across-sectional survey among the early planters and non-early planters. Focus group discussions (FGD) and key informant interviews were also conducted to supplement the survey data. The data collection instruments included the interview schedule for the survey, the FGD guide, and consent forms. The interview schedule was mostly composed of closed questions and covered the basic profile of the farmers and their households; the profile of farm and farming activities; production, sales, and costs; and the perceptions regarding water salinity and early planting, among others.

We collected data as follows:

Step 1. The interview schedule was pilot-tested with 25 households in Soc Trang Province to check the clarity and appropriateness of the questions, possible alternatives to the questions, the difficulty of the questions, the probability that a large number of questions would go unanswered, and the length of the interview.

Step 2. The interview schedule was revised and finalized to address the concerns raised by the pilot testing participants. It also became an opportunity for the data collection team to gain experience in working with the farm households and to find the best interview strategy.

Step 3. A team of trained data collectors conducted the survey from September to October 2020. The team was composed of three researchers from Hanoi and 15 people from Can Tho University.

2 We calculated the sample size using a formula for an unknown population (of early planters) at the 95 percent level of confidence. The same number is arrived at when we alternatively used the existing population of 362,833 as the total number of rice farming households in the three provinces (GSO, 2016).

3.3. Data analysis methods

3.3.1. Measuring the impact of early planting through the propensity score matching approach

PSM was used to assess the effects of early planting on rice farming income and the quantity of rice produced. Although the difference-in-difference research design is ideal, this approach posed a problem due to the absence of the baseline data on MRD rice farmers' income during a drought year when no intervention was applied (i.e., 2015–2016). It was too difficult for farmer participants to recall their rice production and nonfarm income in 2015–2016. Even if some data had been collected for this purpose, they would have been highly unreliable.

We also considered the possibility of using spatial discontinuity for this study. This requires a continuous assignment variable and cut-off point, which gives the basis for grouping farmer participants. However, there was no reliable data for this method such as the actual salinity level of farm areas. Although the distance of the farm area from the shoreline is a good proxyvariable, using this would infringe data privacy and generate sensitive issues in the cultural context of the MRD. Given these limitations, we consider PSM as the next best design for comparing the outcome indicators of the early planters and their matching non-early planters.

We estimated the effects of the adaptation decision on farmers' welfare by comparing the outcomes of the treatment and control groups. The average treatment on the treated (ATT) was calculated based on the matched samples of the early and non-early planters. The fundamental assumptions of PSM are conditional independence and the presence of common support. These assumptions imply that outcomes are independent of treatment assignment and are instead conditioned based on the explanatory variables. They also imply that there is sufficient overlap in the propensity scores such that both groups have an equal probability of >0 and <1 to adjust their cropping calendar. The ATT is specified as the average difference in the outcomes across the two groups and can be written as follows:

$$\mathrm{ATT} = \mathrm{E}(\mathrm{Y}_1 - \mathrm{Y}_0|\mathrm{D} = 1) = \mathrm{E}(\mathrm{Y}_1|\mathrm{D} = 1) - \mathrm{E}(\mathrm{Y}_0|\mathrm{D} = 1) \tag{1}$$

where ATT is the average treatment effect on the treated group and $\mathrm{Y_i}$ is the observed average households' welfare, with a value of 1 for early adopters and 0 for non-early adopters.

We used four PSM matching methods – nearest neighbor, kernel, radius, and stratification – to analyze the impacts of early planting on the welfare of farm households.

After the matching analysis, we ran a sensitivity analysis to check the robustness of the treatment effects (Becker and Caliendo, 2007). The result of this analysis will indicate how the conclusions of the study may change with respect to the small deviations in the propensity scores and will determine whether the results of the study are sensitive to any hidden biases (Rosenbaum, 2002).

To account for selection biases, we employed an endogenous switching regression (ESR)model to control for unobserved heterogeneity due to self-selection in the treatment and control groups. Following the method of Di Falco et al. (2011) and Khanal et al. (2018), rice farmers face two regimes: (1) $A_1 =$ to adopt early planting and (2) $A_0 =$ not to adopt early planting. This can be expressed as follows:

$$\text{Regime 1:} \quad y_{1i} = \mathbf{X_{1i}\beta_1} + \varepsilon_{1i} \textit{ if } A_i = 1, \text{ and} \tag{2a}$$

$$\text{Regime 0:} \quad y_{0i} = \mathbf{X_{0i}\beta_0} + \varepsilon_{0i} \textit{ if } A_i = 0, \tag{2b}$$

where y_i is the output of the W-S crop produced by the farmers corresponding to regime 1 or 0, X_i are the control factor variables in the model, and ε_{1i} and ε_{0i} are the model errors (2a) and (2b), respectively, with an assumption that ε_i has a normal distribution.

The ESR results allow us to compare the quantity of rice production and income between early planting farmers (3a) and non-early planting farmers (3b). The results can be used to investigate the expected outcomes (rice production and income) in the counterfactual hypothetical cases (3c) that early planters did not adopt an early cropping schedule (counterfactual) and (3d) that non-early planters adopted the measure(counterfactual).

$$\mathrm{E}(\mathrm{y_{1i}}|\mathrm{A_i} = 1) = \mathrm{X_{1i}}\beta_1 + \sigma_{1\eta}\lambda_{1\mathrm{i}} \tag{3a}$$

$$\mathrm{E}(\mathrm{y_{0i}}|\mathrm{A_i} = 0) = \mathrm{X_{0i}}\beta_0 + \sigma_{0\eta}\lambda_{0\mathrm{i}} \tag{3b}$$

$$\mathrm{E}(\mathrm{y_{0i}}|\mathrm{A_i} = 1) = \mathrm{X_{1i}}\beta_0 + \sigma_{0\eta}\lambda_{1\mathrm{i}} \tag{3c}$$

$$\mathrm{E}(\mathrm{y_{1i}}|\mathrm{A_i} = 0) = \mathrm{X_{0i}}\beta_1 + \sigma_{1\eta}\lambda_{0\mathrm{i}} \tag{3d}$$

We estimated again the average effect of the treatment of "early planting" on the treated (ATT) as the difference between (3a) and (3c) using the following formula:

$$\mathrm{ATT}^* = \mathrm{E}(\mathrm{y_{1i}}|\mathrm{A_i} = 1) - \mathrm{E}(\mathrm{y_{0i}}|\mathrm{A_i} = 1) = \mathrm{X_{1i}}(\beta_1 - \beta_0) + (\sigma_{1\eta} - \sigma_{0\eta})\lambda_{1\mathrm{i}} \tag{4}$$

This represents the effect of early planting on the rice production and income of the early planters. Similarly, the effect of the treatment on the untreated (ATU) of the non-early planters is expressed as the difference between (3b) and (3d), which can be computed as:

$$\mathrm{ATU} = \mathrm{E}(\mathrm{y_{1i}}|\mathrm{A_i} = 0) - \mathrm{E}(\mathrm{y_{0i}}|\mathrm{A_i} = 0) = \mathrm{X_{0i}}(\beta_1 - \beta_0) + (\sigma_{1\eta} - \sigma_{0\eta})\lambda_{0\mathrm{i}} \tag{5}$$

Table 1
Variables used in the PSM analysis.

Variable category	Definition
Dependent variable	
Early planter	1 if the farmer started planting by 15 November during the 2019/20 W-S crop season; 0 otherwise
Outcome Variables	
Rice farming income	Estimated financial profit from rice farming during the 2019/20 W-S crop season (per farmer, per hectare)
	Estimated annual financial profit from rice farming (per farmer, per hectare)
Quantity of production	Estimated quantity of production during the 2019/20 W-S crop season (per farmer, per hectare)
Matching Variables	
Age of farmer	Age (in years) of the farmer as of last birthday
Educational attainment	Number of years in school
Member of a community-based organization	1 if the farmer is a member of a community-based organization; 0 otherwise
Labor force - Male	Number of male household members within working age (15–60 years old)
Labor force - Female	Number of female household members within working age (15–55 years old)
Ownership of flat-screen TV	1 if the household of the farmer owns a flat-screen TV; 0 otherwise
Area of rice farm	Size of the rice farm (in hectares) cultivated during the 2019/20 W-S crop season
Farm's location in an irrigated lowland	1 if the farm is located in an irrigated lowland area; 0 otherwise

The expected outcomes in Eqs. (3a) and (3d), which are used to calculate the heterogeneity effects, can be expressed as the difference between (3a) and (3d):

$$H_1 = E(y_{1i}|A_i = 1) - E(y_{1i}|A_i = 0) = (X_{1i} - X_{0i})\beta_{1i} + \sigma_{1\eta}(\lambda_{1i} - \lambda_{0i}) \tag{6}$$

Similarly, for the group of farmers who decided not to adopt early planting, the effect of base heterogeneity is the difference between (3b) and (3c):

$$H_1 = E(y_{1i}|A_i = 1) - E(y_{1i}|A_i = 0) = (X_{1i} - X_{0i})\beta_{1i} + \sigma_{1\eta}(\lambda_{1i} - \lambda_{0i}) \tag{7}$$

Finally, we calculated the transitional heterogeneity (H3). It represents the effect of adopting early planting for the early planters or for the non-early farmers in the counterfactual situation that they did adopt. H3 is by nature the difference between Eqs. (4) and (5).

$$H3 = ATT^{*} - ATU \tag{8}$$

3.3.2. Outcome indicators and descriptions of variables

Outcome Indicators

The outcome variables in the study are rice farming income and the quantity of rice production. We estimated rice farming income as the financial profit from rice farming during the 2019/20 W-S crop season and the whole year per farmer and per hectare. Meanwhile, rice production was estimated through the quantity of rice produced (tons per hectare) during the 2019/20 W-S crop season.

Independent Variables

Eight independent variables are used including the farmer participants' personal characteristics (i.e., age, educational attainment, membership in an organization); household variables (i.e., number of household members with work-male, number of household members with work-female, and ownership of a flat-screen TV); and farming information (i.e., farm size and farm location). Table 1 shows the definition of the outcomes and matching variables used in this study.

4. Result and discussion

4.1. Profile of study participants

The early and non-early planters did not differ much in terms of their basic personal and household characteristics. There were more men than women among the study participants. On average, they were in their mid-50s with most above 45 years old. This may signify that farming is seen to be less attractive to young people, which is worrisome for the future of MRD as a rice granary of Vietnam. The sample households had an average of four members with most households having both men and women in the labor force. Television and more personalized sources of information (e.g., government technicians or fellow farmers) were the main sources of farming information. The use of modern ICT tools such as smartphones and the internet was not prevalent among the study participants.

Both early and non-early planters considered farming to be an important livelihood. They were introduced to it at a young age. Although a few had left for nonfarm work, they returned to farming after some time. The farms were small and mostly used for rice production. Some farmer participants practiced crop diversification mixing rice production with vegetable or fruit production. More than half of the sample households' income comes from rice farming.

Table 2
MRD farmers: Rice production in the 2019/20 W-S crop season.

Parameter	Early n = 412	Non-early n = 764	All N = 1176
Size of land area used for production (ha)	2.02	1.96	1.99
Target total quantity produced (ton)	10.78	9.29	9.81
Target total quantity produced per hectare (ton/ha)	5.29	4.81	4.98
Actual total quantity produced (ton)	11.76	6.24	8.17
Actual total quantity produced per hectare (ton/ha)	5.89	3.30	4.21

Table 3
Revenue, costs, and profit from rice production in the 2019/20 W-S crop season.

Variables	Unit	Early n = 412	Non-early n = 764	All N = 1176
Total quantity sold	Ton/ha	5.51	3.09	3.94
Price received	VND/kg	5,352	5,337	5,343
Total revenue	Million VND/ha	29.65	16.91	21.38
Total operating cost	Million VND/ha	17.65	13.66	15.06
Total operating profit	Million VND/ha	11.99	3.26	6.32

Note: The exchange rate of USD 1 = VND23,000 is used.

The early and non-early planters more or less had similar farming practices. These included the method of planting; planting density; and the use of fertilizer, pesticides, and other chemicals, among others. Every crop takes 18 days for the rice to emerge, about 60 days to reach the flowering stage, and about 97 days to harvest.

4.2. Rice production in the 2019/20 W-S crop season

The total rice production during the 2019/20 W-S crop season was 8.17 tons or 4.21 tons/ha (Table 2). The early planters produced more rice than the non-early planters (on average, 11.76 tons or 5.89 tons/ha vs. 6.24 tons or 3.30 tons/ha). The early planters exceeded their target rice production of 10.78 tons or 5.29 tons/ha. Conversely, the non-early planters failed to reach their target of 9.29 tons or 4.81 tons/ha.

4.3. Revenue, costs, and profit of rice production

MRD rice farmers generally sell their rice at VND 5343/kg (Table 3). As expected, the price was almost identical for the early planters (VND 5352) and non-early planters (VND 5337). The early planters were able to produce and sell more (5.51 tons/ha) than the non-early planters during the crop season and generated a total revenue of VND 29.65 million. The non-early planters, with the quantity produced and sold amounting to 3.09 tons/ha, generated VND 16.91 million in revenues, or only 57 percent of what the early planters. Early planters incurred VND 17.65 million per hectare in operating cost, which was higher than that of the non-early planters at VND 13.66 million. The profit earned by the early planters (VND 11.99 million) was 3.68 times that earned by the non-early planters (VND 3.26 million).

4.4. Annual revenue, costs, and profits

The non-early planters' annual revenue per hectare was higher than that of the early planters (VND 72.02 million vs. VND 64.08 million). However, the operating cost of the former was higher than that of the latter (VND 48.71 million vs. VND 37.04 million) as shown in Table 4. Almost half of the annual operating cost was spent on labor and pesticides and other chemicals. The cost of these items for the early planters accounted for 33 percent (labor cost) and 23 percent (pesticides)of the total annual costs, while it was 31 percent and 24 percent, respectively, for the non-early planters. Fertilizer was the next biggest item comprising 18 percent (early planters) and 21 percent (non-early planters) of the operating costs. The cost of seeds was 14 percent of the total. The remaining costs included rental costs, water, other farm supplies, and fuel.

As previously discussed, several early planters practiced two rice cropping but some of them did not produce additional crops during the Autumn–Winter season. This explains the lower revenue and cost per hectare and the higher annual profit (VND 27.04 million vs. VND 23.35 million) of the early planters as compared to those of the non-early planters.

4.5. Impacts of early planting

4.5.1. Outcome variables

Table 5 shows a summary of the statistics of the outcome variables. The mean income of the early planters during the 2019/20 W-S crop season was significantly higher, both per individual and per hectare, than that of the non-early

Table 4
Annual revenue, costs, and profit.

Variable	Unit	Early n = 412	Non-early n = 764	All N = 1176
Total revenue	Million VND/ha	64.08	72.02	69.24
Total operating cost	Million VND/ha	37.04	48.71	44.62
Labor		12.16	14.90	13.94
Pesticide and other chemicals		8.49	11.46	10.42
Fertilizer		6.77	10.49	9.15
Seeds		5.41	7.23	6.59
Rental		2.39	2.91	2.71
Water costs		0.79	0.61	0.67
Other farm supplies		0.85	0.83	0.84
Fuel/Petrol/Diesel		0.22	0.32	0.28
Total operating profit	Million VND/ha	27.04	23.35	24.64

Table 5
Summary statistics of the outcome variables.

Statistics	W-S2019/20 production	W-S2019/20 production	Annual rice farming income (profit/farmer)	Annual rice farming income (profit/ha)	W-S2019/20 rice income (profit/kg)	W-S2019/20 Rice income (profit/ha)
Unit	Tons/farmer	Tons/ha	Million VND	Million VND/ha	VND/kg	Million VND/ha
Treatment group: Early rice planters (n = 412)						
Mean	11.76	5.89	62.12	27.04	994.44	10.30
SD	12.00	2.71	93.60	29.70	4,509.51	17.70
Min	0.00	0.00	−129.00	−122.00	−33,328.53	−104.00
Max	126.00	40.99	706.00	142.00	6,177.50	82.50
Control group: Non-early rice planters (n = 764)						
Mean	6.24	3.30	46.33	23.35	−2,520.73	2.00
SD	8.29	2.76	86.50	54.50	14,714.70	14.10
Min	0.00	0.00	−748.00	−1,100.00	−314,106.70	−118.00
Max	75.00	26.78	781.00	301.00	5,958.67	51.40

Note: The exchange rate of USD 1 = VND23,000 is used.

planters. In terms of annual rice farming income, the early planters earned more than the non-early planters both on a per farmer basis (VND 62.12 million vs. VND 46.33 million) and on a per hectare basis (VND 27.04 million vs. VND23.35 million). More than three-fourths of the early planters practiced two rice cropping whereas most of the non-early planters practiced three rice crops per year. The rice production of the early planters during the 2019/20 W-S crop season (11.76 tons or 5.89 tons/ha) was significantly higher than that of the non-early planters (6.24 tons or 3.30 tons/ha).

4.5.2. Experience with salinity coping strategies

Almost all study participants (98%) recognized salinity as a problem in their farms. In the last decade, the salinity problem was the most serious in 2016 (the 2015/16 W-S crop season) and 2019 (the 2019/20W-S crop season). Although salinity is experienced in all seasons, many study participants (84%) stated that it was most serious during the W-S season. This issue was more prevalent among the non-early planters (93%) than among the early planters (68%).

Aside from early planting, most of the farmer study participants said that they had other ways to adapt to the salinity problem in the MRD (Table 6). These included using salt-tolerant varieties (41%), alternate wetting and drying (17%), short-cycle varieties (15%), organic fertilizer or own farmyard (8%), and practicing rainwater harvesting (11%). About 12 percent of the farmer study participants applied none of these alternative strategies, and a few did not respond.

It should be noted that farmers practiced similar farming methods (other than early planting) during the 2019/20 W-S crop season (Table 7). All farmers reported that they had used high-yielding varieties and practiced broadcasting in rice planting. Almost all of the early planters and non-early planters used inorganic fertilizer (95% and 94%, respectively) and pesticides (both 99.5%). Their main source of water was surface water which included water from rivers, canals, lakes, and irrigation ditches (96%). About half of the early planters (44%) and non-early planters (48%) practiced an alternative wetting and drying method and re-flooded farms about four times (early planters) or five times (non-early planters).

4.5.3. Matching

The early planters were only slightly older than the non-early planters (53.21 years old and 52.69 years old, respectively) and the two groups had an almost identical number of schooling years (6.86 and 6.45, respectively) (Table 8). Both groups had similar tendencies to own a flat-screen TV (77%). The number of household members who were men or women in the labor force was also similar between the two groups. The percentage of having farms located in irrigated lowland was 14 percent and 15 percent for the early and non-early planter groups, respectively.

Table 6
Farmers' adaptation strategies other than early planting to cope with salinity.

Adaptation strategy	Early n = 412		Non-early n = 764		All N = 1176	
	No.	%	No.	%	No.	%
Use salt-tolerant varieties	166	41.71	303	40.29	469	40.78
Use alternate wetting and drying method	71	17.84	128	17.02	199	17.30
Use short-cycle rice varieties	55	13.82	120	15.96	175	15.22
Do nothing (Cannot do anything)	49	12.31	84	11.17	133	11.57
Practice rainwater harvesting	59	14.82	73	9.71	132	11.48
Use of organic fertilizer/use of farmyard	24	6.03	67	8.91	91	7.91
Others	87	21.86	178	23.67	265	23.04
No answer	14	3.39	12	1.57	26	2.21

Table 7
Farm practices in the 2019/20 W-S crop season.

Farm practice	Early n = 412		Non-early n = 764		All N = 1176	
	No.	%	No.	%	No.	%
Use high yielding rice variety	412	100.00	764	100.00	1176	100.00
Use broadcast planting method	412	100.00	764	100.00	1176	100.00
Use inorganic fertilizer[a]	384	95.29	713	94.44	1097	94.73
Use pesticide[b]	402	99.50	748	99.47	1150	99.48
Use surface water (as the main source of water)	375	93.28	732	96.95	1107	95.68
Use alternate wetting and drying method only	168	44.09	338	47.67	506	46.42

Note:
[a] n = 403, n = 755, N = 1158.
[b] n = 404, n = 752, N = 1156.

Table 8
Summary statistics of the independent variables that characterize early and non-early rice planters in the MRD.

Variables	Treatment group: Early rice planters n = 412				Control group: Non-early rice planters n = 764			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Age of farmer	53.21	11.83	21.0	85	52.69	12.16	25.00	84
No. of years in school	6.86	3.55	0.0	16	6.45	3.55	0.00	16
Member of a community-based organization	0.51	0.50	0.0	1	0.45	0.50	0.00	1
No. of male household members aged 15–60 years old	1.59	0.95	0.0	5	1.59	0.91	0.00	6
No. of female household members aged 15–60 years old	1.57	0.95	0.0	6	1.49	0.92	0.00	6
Ownership of flat-screen TV	0.77	0.42	0.0	1	0.77	0.42	0.00	1
Area of rice farm (ha)	2.02	1.88	0.1	18	1.96	1.76	0.07	12
Farm location in an irrigated lowland	0.14	0.35	0.0	1	0.15	0.35	0.00	1

More than half of the early planters (51%) were members of community-based organizations, whereas 45 percent of the non-early planters were members. On average, the early planters had a slightly larger area dedicated to rice planting compared to the non-early planters (2.02 ha vs. 1.96 ha). These matching variables were chosen as they are related to the outcome variables, and thus must be controlled, regardless of which group had the higher value.

4.5.4. Effects of early planting on rice farming income

To realize the impacts of early planting on rice farming households' welfare, PSM analysis with four different matching methods (i.e., nearest neighbor, kernel, radius, and stratification) was carried out. Table 9 describes the ATTs of the PSM model. ATTs show the additional income for the adopters when they implemented an adjusted early cropping calendar. The impacts of early planting on rice farming household's income during W-S season were VND 24.60 million per farmer or VND 8.77 million per hectare by the nearest neighbor method, VND 22.90 million per farmer or VND 8.65 million per hectare by radius matching, and VND 22.80 million per farmer or VND 8.62 million per hectare and VND 22.80 million per farmer or VND 8.66 million per hectare by kernel and stratification matching, respectively. The total returns to rice income in the 2019/20 W-S crops season thus ranged from VND 22.80 to 24.60 million. In terms of income per hectare, the early planters earned more than the non-early planters by VND 8.62–8.77 million. Early planting also increased the total annual rice income earned during the same crop year by VND 13.70–17.10 million per farmer or VND 3.21–4.27 million per hectare. The ATT results from the four matching methods are consistent and indicate that adopting early planting as an adaptation strategy has a positive impact on rice farmers' welfare. The t-values of all the matching algorithms are high (>1.96), which signifies that additional income from early planting in the 2019/20 W-S crop season was statistically

Table 9
Average treatment effect on the treated (ATT): Early planting on rice farming income.

Matching method	2019/20 W-S rice farming income	2019/20 W-S rice farming income	Annual rice farming income	Annual rice farming income
	Million VND per farmer	Million VND per hectare	Million VND per farmer	Million VND per hectare
	N = 1176	N = 1176	N = 1176	N = 1176
t-test				
Coefficient	22.90	8.74	15.80	3.70
t-value	9.49	9.62	2.90	1.28
Regression				
Coefficient	22.30	8.55	13.20	2.96
t-value	9.50	9.46	2.68	1.02
Nearest Neighbor				
Matched control	287.00	287.00	287.00	287.00
ATT	24.60	8.77	17.10	4.27
t-result	6.72	7.36	2.24	0.82
t-result (bootstrapped)	7.78	6.40	2.42	1.28
Radius				
Matched control	757.00	757.00	757.00	757.00
ATT	22.90	8.65	15.10	3.36
t-result	8.83	8.92	2.69	1.35
t-result (bootstrapped)	9.00	9.74	2.84	1.34
Kernel				
Matched control	757.00	757.00	757.00	757.00
ATT	22.80	8.62	14.50	3.21
t-result (bootstrapped)	8.48	9.54	2.69	1.24
Stratification				
Matched control	757.00	757.00	757.00	757.00
ATT	22.80	8.66	13.70	3.20
t-result	8.66	8.93	2.41	1.28
t-result (bootstrapped)	9.24	8.20	2.56	1.14

Note: Treatment variable: Planting strategy (1 = Early planting, 0 = Non-early planting)
Independent variables: Age of farmer
No. of years in school
Member of a community-based organization
No. of male household members aged 15–60
No. of female household members aged 15–55
Ownership of flat-screen TV
Area of rice farm
Farm's location in an irrigated lowland.

significant. The results thus confirm the positive impacts of cropping calendar adjustment among farming households in MRD of Vietnam.

4.5.5. Effects of early planting on rice production

Table 10 presents the ATTs of the adoption of early planting in the study site. The estimates of ATTs indicate that adopters of early planting produced significantly more rice and had higher productivity than the non-adopters. Specifically, the rice yield of early planters increased by 5.67 tons per farmer and 2.51 tons per hectare under the nearest neighbor matching method. With radius matching, similar positive impacts were found: the adopter farmers additionally gained 5.59 tons per farmer and 2.61 tons per hectare. By kernel matching, gains were 5.54 tons per farmer and 2.61 tons per hectare. By stratification matching, there were 5.29 tons per farmer and 2.59 tons per hectare. By all methods, positive and significant impacts of early planting were detected in rice yield.

4.5.6. Robustness check and validation of the results

Following Becker and Caliendo (2007), we perform sensitivity tests on the estimated ATTs. Table 11 shows that the significance levels of the estimates are unaffected even if gamma increases threefold. This shows that the estimated treatment effects are reliable. The positive impact of early planting found by this research is consistent with the result of Lu et al. (2017), where the authors studied the effect of early planting of maize by farmers in China.

Apart from the sensitivity test, we also adopted ESR to further account for endogeneity problems (Table 12). The ESR results suggest that heterogeneity occurs in rice production and income between the two farmer groups. The estimated results show that the models fit the data reasonably well.

Lastly, Table 13 presents the actual and counterfactual outcomes of adopting or not adopting early planting and the average treatment effects. The estimated results of ATT (the last column) are positive and statistically significant, showing the positive impact of early planting on the adopters. The ATT results show that the annual effect of early planting on rice

Table 10
Average treatment effect on the treated (ATT): Early planting on production, 2019/20 W-S crop season.

Matching methods	Rice production (tons/farmer) N = 1176	Rice production (tons/ha) N = 1176
t-test		
Coefficient	5.52	2.59
t-value	9.26	15.46
Regression		
Coefficient	5.20	2.56
t-value	12.96	15.32
Nearest Neighbor		
Matched control	287.00	287.00
ATT	5.67	2.51
t-result	6.77	10.23
Radius		
Matched control	757.00	757.00
ATT	5.59	2.61
t-result	8.40	15.55
t-result (bootstrapped)	8.63	14.60
Kernel		
Matched control	757.00	757.00
ATT	5.54	2.61
t-result (bootstrapped)	8.48	14.60
Stratification		
Matched control	757.00	757.00
ATT	5.29	2.59
t-result	7.86	15.35
t-result (bootstrapped)	8.51	15.16

Note: Treatment variable = Planting strategy (1 = Early planting, 0 = Non-early planting)
Independent variable = Age of farmer
No. of years in school
Member of a community-based organization
No. of male household members aged 15–60
No. of female household members aged 15–55
Ownership of flat-screen TV
Area of rice farm
Farm's location in an irrigated lowland.

Table 11
Sensitivity analysis with Rosenbaum bounds.

Gamma	Sig+	Sig−
1.0	0.7604	0.7604
1.5	0.6679	0.6679
2.0	0.5992	0.5992
2.5	0.5451	0.5451
3.0	0.5006	0.5006

production in MRD is equal to 5.12 tons per farmer. A comparison of ATTs also shows that the adoption of early planting generated higher income per farmer along with a larger quantity of rice production compared with non-early planters. The ESR estimated result is consistent with the PSM analysis that early planting can increase rice farmers' production and income.

5. Conclusion

The foremost objective of the paper is to evaluate the impact of an adjusted cropping calendar implemented in the 2019/20 W-S season on the rice income of MRD farmers. Early planting was recommended to cope with the saltwater intrusion caused by the 2019/20 El Niño phenomenon. We used propensity score matching (PSM) to assess the effects of early planting on the impact (treatment) variables. The matching methods used were nearest neighbor, radius, kernel, and stratification. After matching the early planters (treatment group) and the non-early planters (control group), the results showed that early planting(i) increased rice farming income by about VND 22.80–24.60 million per farmer or VND 8.62–8.77 million per hectare, (ii) increased annual rice farming income by about VND 13.7–17.1 million per farmer or VND 3.2–4.27 million per hectare, and (iii) increased rice production by about 5.29–5.67 tons per farmer or 2.51–2.59 tons per hectare.

The results provide important empirical evidence of the benefits of adjusting the crop calendar in rice production in response to saltwater intrusion in the MRD. The current paper also contributes methodologically to the literature by showing that the PSM method can strictly control the level of heterogeneity between the two groups treatment and

Table 12
Endogenous switching regression results.

Variable	2019/20W-S crop season Total quantity of production (tons/farmer)			2019/20W-S crop season Rice farming income (VND million/farmer)		
	All	Early	Non-early	All	Early	Non-early
Age of farmer	0.0049 (0.0031)	0.0061 (0.0259)	0.0572*** (0.0197)	0.0055* (0.0032)	291,613 (191,270)	209,440** (105,592)
No. of male household members (15–60 years old)	−0.0319 (0.0414)	0.0752 (0.3472)	0.4165 (0.2693)	−0.0295 (0.0416)	5,610,140** (2,574,855)	−55,074 (1,440,152)
No. of female household members (15–55 years old)	0.0628 (0.04156)	−0.4027 (0.3487)	0.8000*** (0.2686)	0.0601 (0.04152)	−8,210,592*** (2,577,070)	3,713,257** (1,434,359)
Farm location is in an irrigated lowland	−0.0161 (0.1058)	−0.4001 (0.8901)	2.1405*** (0.6664)	−0.0403 (0.1064)	5,583,594 (6,620,910)	11,600,000*** (3,566,172)
Own flat-screen TV	−0.0061 (0.0889)	0.5424 (0.7421)	0.4754 (0.5648)	−0.0088 (0.0893)	280,538 (5,501,575)	3,080,115 (3,566,172)
Area of the farm planted with rice (ha)	0.0740 (0.0425)	6.9807*** (0.3607)	3.0300*** (0.3714)	0.0875** (0.0430)	25,500,000*** (2,753,617)	10,400,000*** (1,987,767)
Square area of the farm planted with rice (ha^2)	0.0025 (0.0039)	−0.0571* (0.0315)	−0.0217 (0.0446)	0.0017 (0.0040)	−687,658*** (234,629)	−1,572,472*** (238,443)
No. of years in school	0.0229*** (0.0072)	– –	– –	0.0237*** (0.0073)	– –	– –
Member of a community-based organization	0.0072 (0.0477)	– –	– –	0.0224 (0.0486)	– –	– –
_cons	−1.0400*** (0.2250)	6.0391*** (1.8370)	−5.2191*** (1.3912)	−1.0894*** (0.2248)	29,400,000*** (13,500,000)	−25,000,000*** (7,390,798)
/lns1		2.1056*** (0.0494)	– –		17.9181*** (0.0540)	– –
/lns0		– –	1.8666***) (0.0257)		– –	17.3591*** (0.0256)
rho_1		−0.9741	–		−0.9721	–
rho_0			−0.0274			0.0034
LR chi^2(1)		116.2 (p < 0.000)***			89.32 (p < 0.000)***	
Observations (N)	1176	412	764	1176	412	764

Notes:
(1) Standard errors are in parentheses.
*Significance level: 10 percent.
**Significance level: 5 percent.
***Significance level: 1 percent.

Table 13
ESR Results: Counterfactual Conditions Estimation and Average Treatment Effects.

Variable		Decision stages				Average treatment effects
		Adopt early planting		Not adopt early planting		
Early planters	Production Income	(a) $E(Y_{1i}\|A_i = 1) =$	11.356 25.400	(c) $E(Y_{0i}\|A_i = 1) =$	6.232 5.060	$ATT_{production} = 5.124$*** $ATT_{income} = 20.300$***
Non-early planters	Production Income	(d) $E(Y_{1i}\|A_i = 0) =$	10.919 29.500	(b) $E(Y_{0i}\|A_i = 0) =$	9.733 20.500	$ATU_{production} = 1.186$** $ATU_{income} = 9.020$***
Heterogeneity	Production Income	$H_1 =$ $H_1 =$	0.437 −4.100*	$H_2 =$ $H_2 =$	−3.500*** −15.430***	$H3_{production} = 3.938$*** $H3_{income} = 11.290$***
Observations (N)			412		764	

Notes:
(1) Quantity of production = tons per farmer.
(2) Income = VND million per farmer.
*Significance level: 10 percent.
**Significance level: 5 percent.
***Significance level: 10 percent.

control, before applying comparison techniques. This significantly reduces estimation errors and permits a more accurate interpretation of previous studies (Nguyen et al., 2020; Nguyen and Nguyen, 2019; Le et al., 2015).

Based on the results of this study, the Vietnamese government in general and the leaders responsible for the agriculture sector in particular should engage in intensive research on the large-scale implementation of CS-MAP not only in rice farming but also in the production of other crops. This would enable both the central and local governments to effectively mobilize available resources and improve risk management modalities in adapting to climate change (IPCC, 2014). In addition, local leaders need to actively inform farmers of the benefits of crop calendar adjustment so the adoption of this strategy is accelerated.

Acknowledgments

This work was implemented as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is carried out with support from CGIAR Fund Donors and through bilateral funding agreements. For details, please visit https://ccafs.cgiar.org/donors. The views expressed in this document cannot be taken to reflect the official opinions of these organizations.

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