Alternative cropping adoption in Thailand: A case study of rice and sugarcane production

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Abstract
This research analyzed farmers' acceptance to switch from rice to sugarcane farming and their support preferences in this regard using choice models. The results showed that farm size, crop conversion experience, sugarcane price, household asset and sugarcane price guarantee significantly influenced the farmers' land-use decisions in this regard. Farmers' concerns over cash flow and ability to access the sugarcane market critically decreased their likelihood to switch to sugarcane production. They were also less inclined to grow sugarcane when climatic conditions and soil fertility were favorable. Loan burden and unclear support policies were also a major hindrance. However, attractive sugarcane price along with price guarantee policy had a positive influence on the farmers' willingness to cultivate sugarcane. Farmers mostly prioritized sugarcane price guarantees in the first year, followed by low-interest credit support for production costs and harvesting and logistic services. This shows that effective policy solutions to encourage farmers to switch from rice to sugarcane production should incorporate capacity building, improve credit access, and implement price controls, particularly in the early stages of the transition.

1. Introduction

Rice farming substantially contributes to the economy of Thailand, which had a total cultivation area of roughly 9.4 million ha in 2018 and 2019. Paddy production is widespread across Thailand, with the northeast and central regions accounting for over 60% of the total production in 2020 (Office of Agricultural Economics, 2021). However, data from the Land Development Department show that 9% of the paddy fields (1.072 million ha) are unsuitable for rice production, and 0.022 million ha of these are better suited for sugarcane production (Land Development Department, 2020). The average rice yield in the unsuitable areas is around 2,187.5 kg per ha compared to 4,687.5 kg per ha for suitable areas (Office of Agricultural Economics, 2017). Bamrungrai et al. (2014) reported that farmers earned higher income from sugarcane cultivation in the unsuitable areas than from paddy production. Also, Khansila et al. (2014) showed that in the unsuitable areas, farmers earned net incomes of 29,362.5 and -3,568.75 baht per ha from sugarcane and rice farming, respectively. Thus, farmers whose land was not suitable for paddy production but suited to sugarcane could increase their incomes by opting to cultivate sugarcane instead, which would also help stabilize the rice market by preventing an oversupply.

At a projected annual growth of 1.4%, sugar consumption would reach 202 million tons globally and 105 million tons in Asia by 2028, with annual import volumes of 63 and 33 million tons, respectively (OECD/FAO, 2019), representing large market opportunities for sugarcane, including in the food and bioenergy industries. Thailand had 57 sugar factories with a daily production capacity of 1.3 million tons each while the total sugarcane production was 116.78 million tons in 2019. In the five-year period from 2014 to 2019, sugarcane production increased from 1.68 million ha to 1.79 million ha. Thus, the industry has enough capacity to support a further increase in sugarcane production and also the opportunity to export more sugar. Rice farmers whose fields are particularly unsuitable for rice production should be encouraged to cultivate sugarcane instead to make the most of their resources and enhance their income. Previous studies identified insufficient capital, lack of knowledge about production and market, limited labor, and unsupportive family as obstacles to farmers adoption of sugarcane cultivation (Bamrungrai et al. (2014), Meesungnoen and Taweekul (2019)). Overcoming these would require the implementation of policies acceptable to farmers to effectively persuade them to switch to sugarcane. Therefore, this study investigated factors that influence farmers'
decisions to change from rice to sugarcane farming and proposed effective supportive measures.

2. Literature review

Several studies have identified key factors central to farmers' decision-making regarding adopting sugarcane cultivation. Khansila, Mongkonthum and Phetcharaburarin (2014) stated that sugarcane production accounted for about 25 percent of the agricultural area in Nam Phong District, KhonKaen province. They identified land suitability, water availability, productivity per unit cost, price, ease of cultivation, decreasing prices of original crops, and distance to sugar factories as important factors affecting farmers' willingness to switch to sugarcane cultivation. However, a drawback of sugarcane production was the negative environmental impact from sugarcane burning during harvesting; thus, the promotion of sugarcane cultivation should incorporate regulatory policies on sugarcane burning. Bamrungrai et al. (2014) also demonstrated that the willingness of farmers in Chiang Mai, Thailand to adopt sugarcane cultivation was influenced by higher income, land unsuitability for paddy production, and government promotion. The farmers were, however, faced with problems such as high production cost, insufficient market and labor and climate viability. Similar findings were made by Mee-sungnooen and Taweekul (2019) who stated that 48.2 percent of the sugarcane cultivation area in Khao Suan Kwang District, Khonkaen was converted from paddy fields. They identified suitable land, land fertility, soil characteristics, transportation and distance to market, support from family, labor force, advice from model farmers, higher income, household debt, and government support as factors influencing farmers' decisions to adopt sugarcane cultivation.

As for adopting other alternative crops, Duangpoch (1998) demonstrated that the willingness of farmers in Chiang Mai, Thailand to cultivate alternative crops in place of opium poppy was influenced mostly by their level of Thai language literacy, prices of alternative crops, number of years of experience in farming, and the frequency of staff contact. However, obstacles such as high input prices, marketing problems, insufficient capital and labor force hindered farmers from adopting alternative crops. Mialhe, Becu and Gunnell (2012) identified policy-related variables as important factors influencing farmers' decision-making on land utilization in Philippines. Similarly, Buntaotook (2014) found that political factors such as supportive government policy on oil palm, support from agricultural officers, and price guarantee policy influenced farmers' decision-making. In addition to policies, socioeconomic factors such as the age of breadwinners, water use in the area, household asset value, household average income per capita, and size of arable land were found to be significant determinants. Similarly, Mishra et al. (2018) indicated that age, gender, irrigation, perception of climatic change, and location specific factors affected farmers' decision on land allocation to paddy cultivation in the Vietnam's delta region. Also, Embaye et al. (2018), using a probit model, demonstrated that farmer's experience, distance from crushing facility, use of no-till farming, and education had positive effects on western US farmers' decision to adopt oilseed crop. Farm income and gender also positively impacted farmer's decision on land allocation. Moreover, Osabuodhen et al. (2018) validated that high investment and operating cost, lack of capital and labor, and weak linkage to rice market prevented farmers in Ogun state, Nigeria from growing rice. Therefore, financial support and clusters formation for farmer to pool resources such as farm machineries, labor, and accessibility to market affected farmers' decision on adopting rice cultivation. Khanna et al. (2017) conducted a choice experiment to examine crop-contract attributes that influenced US farmers' adoption of energy crops. They found that contracts that provided lower upfront investment costs encouraged farmers to adopt and allocate more land to energy crops.

Thus, from our literature review, the factors influencing farmers' decision on adopting alternative crops are i) internal factors such as land suitability, farmer's age, farmer's education, labor force, family support

3. Methodology

In this study, two statistical models were applied for data analysis as follows.

First, a probit model was used to analyze the likelihood of farmers' decisions to adopt sugarcane production and factors that influence their decisions. The probit model was presented as following equation:

$$
\text{Prob}(Y_i = 1|X_i) = \frac{\exp^{\beta^T x_i}}{1 + \exp^{\beta^T x_i}} = \Phi(X_i^\beta)
$$

(1)

where $Y_i = 1$ when farmer $i$ decides to adopt sugarcane, otherwise $Y_i = 0$. $X_i$ is a vector of factors influencing farmers' adoption decisions namely i) socioeconomic variables — sex, age, level of education, number of household members working full-time on the farm, income earned growing rice (baht/ha), farm size, the experience of switching crops in the past five years, and number of problems (production, price, market, etc.) encountered growing rice; ii) basic knowledge of sugarcane production, based on aggregate scores; iii) risk-perception of sugarcane production (high capital investment, household cash flow, production risks, market access, price risks); and iv) perception of important factors on adopting alternative cropping were scored on a scale of 0–5 (the suitability of soil and weather conditions for sugarcane production, sugarcane price, rice price, household debt, household asset, government support policy for sugarcane production, sugarcane price guarantee).

Since the coefficients estimated from the probit model presented only the direction of relationship and not the magnitude of the effect between dependent and independent variables. Thus, the marginal effect was necessary to explain the effect of factor and was expressed as Eq. (2).

$$
\frac{d\text{Prob}(Y_i = 1|x_i; \beta)}{dx_j} = \frac{\exp^{\beta^T x_i}}{1 + \exp^{\beta^T x_i}} \beta_j
$$

(2)

Second, a choice experiment model\(^1\) was used to analyze the types of governmental support available to farmers as motivation to convert unsuitable rice farms to sugarcane plantations. Since the individual's preference on attribute $j$ was heterogeneous across farmers, the mixed logit model was employed in our estimation. The probability of farmer $i$ using a support package $j$ can be expressed as (Train, 2009):

$$
\text{Prob}(Y_i = j|J) = \int \frac{\exp(V_{ij})}{\sum_{j} \exp(V_{ij})} f(j) \, df
$$

(3)

where the $f(j)$ is the density function specifying distribution of $j$, and $V_{ij}$ is farmer $i$'s indirect utility from using support package $j$. The indirect utility function is generally defined as linear (Hojjati and Bockstael (1988) and Champ et al. (2002)) as:

$$
V_{ij} = \gamma_i Z_{ij}
$$

(4)

where $Z_{ij}$ is a vector of attributes of support package $j$ for farmer $i$. $\gamma_i$ is the coefficient associated with support package $j$. Attributes of the support packages are shown in Table 1. Orthogonal design\(^2\) was used to generate 16 alternatives (out of total 72 alternatives), then the alternatives were matched into 8 pairs which were divided into two choice sets. Each farmer was presented with a choice set which was randomly selected. Farmers were asked to choose the most preferred choices with the possibility of not choosing any (opt-out option).

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\(^1\) The choice experiment model was derived from two theories which were Lancaster's characteristic theory of value (Lancaster, 1966) and Random utility theory (McFadden, 1973).

\(^2\) The orthogonal design was generated by using SPSSv.21 package.
Harvesting and logistics service provided Harvesting and logistic services are
price guarantee Minimum price guarantee for within 50 km of the study area. Then, we randomly selected farmers as they had large numbers of rice farmers, and there was a sugar factory random sampling as follows. First, we purposively selected representa-
who were cultivating paddy in our study area. A total of 233 participants were interviewed with rice growers in areas considered unsuitable for rice
production (N) but suitable for sugarcane plantations (S1–S3) within a 50 km distance to a sugar factory. The samples were selected by stratified random sampling as follows. First, we purposively selected representa-
tive provinces in each region. The representative provinces were chosen as they had large numbers of rice farmers, and there was a sugar factory within 50 km of the study area. Then, we randomly selected farmers who were cultivating paddy in our study area. A total of 233 participants were selected as shown in Table 2.

The variable description and descriptive statistics from the sample are shown in Table 3.

### 4. Data collection

Primary data were obtained from field surveys during 2016 and interviewed with rice growers in areas considered unsuitable for rice production (N) but suitable for sugarcane plantations (S1–S3) within a 50 km distance to a sugar factory. The samples were selected by stratified random sampling as follows. First, we purposively selected representative provinces in each region. The representative provinces were chosen as they had large numbers of rice farmers, and there was a sugar factory within 50 km of the study area. Then, we randomly selected farmers who were cultivating paddy in our study area. A total of 233 participants were selected as shown in Table 2.

The variable description and descriptive statistics from the sample are shown in Table 3.

#### Table 1. Attributes and levels used in the choice models.

| Attributes                          | level | Details of the incentives                                                                 |
|-------------------------------------|-------|------------------------------------------------------------------------------------------|
| Compensation for farmers to quit rice production | Subsidy | THB 6,250 per ha
| Financial assistance (Low interest rate credit support) | 1-time_payment | Pay all the money once after planting the sugarcane cuttings
| | 2-time_payment | Payment in two installments: 50% in the 1st month after planting the sugarcane cuttings and 50% in the 7th month
| | 3-time_payment | Payment in three installments: 50% in the 1st month, 30% in the 5th month, and 20% in the 9th month after planting the sugarcane cuttings
| Production cost support | credit_support | Low-interest credit support
| | input_support | Provide inputs at lower prices than the market
| Price guarantee | price_guarantee | Minimum price guarantee for sugarcane in the first year of cultivation
| | no_price_guarantee | No price guarantee for sugarcane in the first year of cultivation
| Harvesting and logistics | service_provided | Harvesting and logistic services are available at the farmers’ expense
| | self_management | Farmers are fully responsible for harvesting and logistic operations

The probit and mixed logit models were estimated by STATA13 software.

#### Table 2. Number of participants in each studied province.

| Provinces                      | Number of participants |
|--------------------------------|------------------------|
| Northern region                | 62                     |
| Kampaengphet                   | 32                     |
| Nakonsawan                     | 30                     |
| Central and western region     | 115                    |
| Kanchanaburi                   | 22                     |
| Lopburi                        | 17                     |
| Ratchaburi                     | 20                     |
| Supanburi                      | 22                     |
| Chachoengsao                   | 17                     |
| Prachubkirikhan                | 17                     |
| Northeastern region            | 56                     |
| Khonkhan                       | 25                     |
| Chaiyapoom                     | 31                     |
| total                          | 233                    |

#### Table 3. Variable description and descriptive statistics.

| Variables                                      | Denoted | Mean/ ratio |
|------------------------------------------------|---------|-------------|
| Sex (1 = female, 0 = male)                     | female  | 0.3734      |
| Age (years)                                    | age     | 51.75       |
| Level of education (1 = lower than high school, 0 = otherwise) | edu | 0.7425 |
| Number of household member working full-time (head) | member_full | 2 |
| Income from rice cultivation (baht/ha)         | income_rice | 27,709.27 |
| Farm size (ha)                                 | farm size | 12.6 |
| Experience of switching crop during past 5 years (1 = yes, 0 = no) | exp | 0.1853 |
| Number of problems encountered growing rice    | rice_problems | 2.57 |
| Basic knowledge of sugarcane production (score 0 to 6) | sugar_knowledge | 3.85 |
| Risk-perception of sugarcane cultivation (1 = agree, 0 = disagree) | high_cap | 0.7639 |
| Household cash flow                           | cash_flow | 0.3348 |
| Production risk                               | production_risk | 0.3777 |
| Market access                                 | market_access | 0.1073 |
| Price risk                                    | price_risk | 0.4163 |
| Perception of important factors influencing adoption alternative cropping (score 0 to 5) | suitability | 3.60 |
| Suitability of soil and weather                | suitability | 3.91 |
| Rice price                                    | rice_price | 3.82 |
| Household debt                                | debt | 3.29 |
| Household asset                               | household_asset | 2.93 |
| Government support policy for sugarcane production | gov_policy | 3.56 |
| Sugarcane price guarantee                      | price_guarantee | 4.21 |

Note:1) The basic knowledge of sugarcane production was measured by six questions related to sugarcane production. The Farmers’ scores were counted from their correct answers to the questions.
2) The descriptive statistic of dummy variables were expressed in ratio.

The majority of farmers had no experience of switching crop during past 5 years. Considering problems associated with rice cultivation, they had faced around 3 problems on average. The sample farmers had moderate basic knowledge of sugarcane production. The considering risk-perception of sugarcane production, most farmers concerned about high capital investment of sugarcane cultivation, 76.39%. The factors influencing adoption of sugarcane cultivation, the sugarcane price guarantee was the most important in farmers’ perspective.
5. Results

Table 4 presents the results of the probit regression analysis. Empirical evidence suggested that female farmers were 22% more likely to adopt sugarcane cultivation as compared to male farmers. The female farmers in our survey owned larger land sizes than male farmers; thus, they were more able to do crop diversification as their risk management strategy. Also, for every increase in farm size by 1 ha, there was 0.0039% more likely to increase in conversion to sugarcane farming. The reason for this is that growing sugarcane requires sufficient land to achieve the target return on investment. Rice farmers in the northeast, in particular, were mostly into subsistence production, and only those with fields to spare were likely to embrace sugarcane farming. Our results are consistent with Buntaoook (2014) and Mishra et al. (2018) who found that socioeconomics factors influenced farmers’ decisions to adopt alternative crops.

Furthermore, the farmers’ basic knowledge of sugarcane cultivation significantly affected their decision-making. Farmers who were knowledgeable about sugarcane farming were more inclined to allocate some parts of their land for sugarcane production, with likelihood of 11.2%. In particular, farmers were risk averse; having knowledge provided more confidence to farmers adopting new crops.

Also, considering farmers’ risk perception of sugarcane production, concerns over household cash flow and access to the sugarcane market had a significant effect on farmers' willingness to switch to sugarcane production. Farmers who were concerned about household cash flow and access to the sugarcane market were less likely to switch to sugarcane production compared to those who were not bothered in the least, by 16.7% and 21.1%, respectively. Because sugarcane takes a longer time to grow than rice, farmers who have insufficient assets or inadequate savings usually prefer to grow rice, which has a shorter turnaround, so as to earn some money to cover household expenses. Moreover, the farmers’ risk perception of accessibility to the sugarcane market, which is far more complex than other crops, also had a significant effect on their decisions. Khansila et al. (2014), Embaye et al. (2018), and Meesungnoen and Taweekul (2019) also found that the distance to market (factory) influenced farmers’ decisions to cultivate sugarcane or other crops.

Farmers’ opinions on the suitability of soil and weather conditions for sugarcane production also influenced their decisions to adopt sugarcane farming. The more favorable these opinions were, the lower the chance they would adopt sugarcane farming by 8.66%. From our interviews, farmers were unaware that their lands were suitable for sugarcane farming; thus, adoption of sugarcane farming was less likely based on their perception of the suitability of their lands. Furthermore, the price of sugarcane was another influential factor that increased the likelihood of farmers allocating parts of their land for sugarcane production, by 13%. This is because crop prices directly affect farmers' income. Likewise, farmers who owned more household assets were more 10.6% likely to grow sugarcane as they had the ability to invest in sugarcane cultivation which requires higher capital than paddy. In contrast, those who had liabilities were 13.4% less likely to allot parts of their land for sugarcane production. Sugarcane production involves high capital investment and takes a longer time compared to paddy. Therefore, farmers with liability tended to have little or no wiggle room to consider alternative crops.

Regarding the policy factors, the sugarcane promotion policy and price guarantee significantly influenced farmers’ decisions. Contrary to expectation, farmers who closely monitored the government's sugarcane promotion policy were 19.2% less likely to utilize their land for sugarcane production. This could be due to the policies' lack of concrete measures on ways to support the farmers, especially at the initial phase, as compared to the rice pledging scheme and rice insurance. In addition, farmers who had a positive opinion on the price guarantee were more likely to switch to sugarcane farming, by 22.3%, as they believed that the price guarantee program would resolve sugarcane price volatility. Similarly, Khansila et al. (2014), Bamrungrai et al. (2014), and Meesungnoen and Taweekul (2019) reported that land suitability and government policy had a sufficient impact on farmers' sugarcane cultivation decisions.

Table 5. Estimation of farmers’ support preferences using mixed logit models.

| Incentives                                      | (1)            | (2)            | Mean          | Standard deviation (SD) |
|-------------------------------------------------|----------------|----------------|---------------|-------------------------|
| subsidy                                         | 0.00121***     | 0.000651***    | (0.000320)    | (0.000235)              |
| 2-time payment                                  | -0.0749        | 0.651***       | (0.149)       | (0.237)                 |
| 3-time payment                                   | -0.562***      | 0.738**        | (0.185)       | (0.294)                 |
| input support                                   | -0.0688        | 0.863***       | (0.128)       | (0.152)                 |
| no_price_guarantee                               | -0.941***      | 0.740***       | (0.133)       | (0.179)                 |
| self_management                                 | -0.452***      | 0.586***       | (0.104)       | (0.164)                 |
| rice_preferred                                  | -2.595***      | 2.912***       | (0.616)       | (0.474)                 |
| Average utility value of each attribute         |                |                |               |                         |
| Amount of financial aid to quit rice farming     | 0.000598       |                |               |                         |
| Allocation of payment                            | 0.277529       |                |               |                         |
| Production cost support                          | 0.03975        |                |               |                         |
| First year price guarantee                       | 0.464689       |                |               |                         |
| Harvesting and logistic services                 | 0.223209       |                |               |                         |
| Observations                                     | 2.796          | 2.796          |               |                         |
| chi2                                            | 155.2          | 155.2          |               |                         |

Remark: The values in parentheses represent the standard errors. Significant at ***p < 0.01, **p < 0.05, *p < 0.1.
Farmers’ preferences for governmental incentives to convert unsuitable rice fields to sugarcane plantations are presented in Table 5. Farmers were mostly in favor of sugarcane price guarantee in the first year of production, as indicated by the highest estimated mean utility (0.4647), which is consistent with the result of the probit model. In the absence of price guarantees in the first year, the utility value would decrease by 0.941. This might be because farmers felt more confident to manage their production if they were certain about the revenue they would receive in the future. This is consistent with Buntaotook (2014), who showed that price guarantee supported farmers’ decisions on adopting alternative crops.

In addition, the low-interest credit support and sugarcane harvesting and logistic services significantly influenced farmers’ willingness to switch to sugarcane production. Khanna et al. (2017) also showed that farmers would adopt and allocate more land if they were offered a contract that lowers their investment costs. Similarly, Osabuohien et al. (2018) indicated that financial support had positive impact on farmers’ crop decision. Furthermore, production cost support and subsidies were less effective in motivating farmers to adopt sugarcane farming. Regarding the low-interest credit support, the farmers would rather choose a one-time payment than a two or three-time payment. Although a one-time payment involves a higher interest amount, the farmers are better able to manage their expenses as compared to periodic installment payments where farmers worry they might not have sufficient cash for the production. The multiple payment scheme posed more uncertainties to their expense management strategies, hence giving them less incentive to choose it.

Farmers also showed interest in the harvesting and logistics support. The absence of these support services reduced the utility value by 0.452 compared to self-management. This highlighted the problem of insufficient manpower in harvesting and transportation. Previous studies also stated that high production costs ( Bamrungrai et al., 2014) and indebtedness (Meesungnoen and Taweekul, 2019) would prohibit farmers from adopting sugarcane cultivation. Finally, when comparing the benefits of growing rice and sugarcane (rice preferred), rice farmers were interested in switching to sugarcane production as doing otherwise would decrease the utility by 2.595.

6. Conclusions and recommendations

Based on our findings on factors influencing the decisions of farmers in this study to switch from rice to sugarcane farming, it was evident that social-economic factors such as the gender of household heads, farm size and basic knowledge of sugarcane production significantly affected the likelihood of switching from rice to sugarcane cultivation. Farmers’ concerns over cash flow and ability to access the sugarcane market were critical factors that decreased their likelihood to switch to sugarcane production. Moreover, climatic conditions, soil fertility, loan burden and unclear support policies were barriers to farmers’ conversion from rice to sugarcane farming. On the other hand, attractive sugarcane price along with price guarantee policy had a positive influence on the farmers’ willingness to cultivate sugarcane. Several studies have demonstrated the importance of crop prices for farmers’ crop choice decisions and the direct effect on farmers’ incomes.

When considering the type of support farmers prefer, the results of the choice experiment model showed farmers mostly prioritized sugarcane price guarantees in the first year, followed by the low-interest credit support for production costs, and harvesting and logistic services. For the low-interest credit support, farmers preferred a one-time payment at the beginning of the cropping season over several installments to better manage their expenses. These findings highlight the importance of capital and labor in farmers’ decision-making regarding switching to sugarcane production.

Thus, an effective policy to encourage farmers to switch from rice cultivation to sugarcane production should consider participatory knowledge transfer schemes, especially on sugarcane cultivation techniques, quota systems and pricing mechanisms. In addition, incentives should be provided through sugarcane price guarantee and provision of low-interest credit support, particularly in the early stages of the shift from rice to sugarcane production.

Declarations

Author contribution statement

Atchara Patoommakul and Ravissa Suchato: Conceived and designed the experiments;Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Nuttapon Photchanaprasert: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

The authors do not have permission to share data.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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