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# Toward Sustainable Agriculture of Rice in Asia: Economic Challenges and Policy Implications

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Thanh Tam HO

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**AJI BOOKS**

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**Toward Sustainable Agriculture of Rice in Asia:**
**Economic Challenges and Policy Implications**

AJI Editorial Office
OIC Research Office,
Ritsumeikan University Osaka Ibaraki Campus (OIC)
2-150 Iwakura-cho, Ibaraki,
Osaka 567-8570 JAPAN
Email: aji-eb@st.ritsumei.ac.jp



Note:
Authors' names in this publication are ordered according to their preference and their surnames are capitalized.

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# Preface

This book, entitled "Toward Sustainable Agriculture of Rice in Asia: Economic Challenges and Policy Implications," is a record of the Asia-Japan Research Institute International Workshop held on July 14, 2022, which took place online amid pandemics. This workshop brought a number of young researchers together in an international scientific exchange with a focus on Asian rice production, innovations, and climate change adaptation toward sustainable agriculture.

Rice is the staple food for more than half of humanity — with 90% of the world's crop grown and consumed in Asia. It sustains lives and livelihoods. How the current level of annual production could be increased to meet the demand for rice — which is expected to grow faster than the production in most countries — in an environmentally and economically sustainable way is a challenging question.

The increasing scarcity of natural resources, environmental degradation, and ecosystem loss have already begun to limit the expansion of food production. More specifically, climate change affects agriculture and food systems adversely due to irregular weather patterns, droughts, floods, and natural disasters. Climate change and its impacts are becoming more severe, devastating rice farms and rural livelihoods, especially in Asia. Hence, it poses significant challenges to global food security and safety. On the other hand, recently, agriculture has been found to be an increasing contributor to greenhouse gas (GHG) emissions which may exacerbate global warming. Ten percent of global methane emissions come from rice production. Hence, strategic policies to mitigate food safety risks while minimizing environmental impacts in the era of climate change have become more important.

The good news is that sustainable agriculture can be a solution for climate change adaptation and mitigation, ensuring food security, and improving rural livelihoods and climate resilience. It is crucial for Asian countries, as the major rice producers, to develop sustainable agriculture. Sustainability is now widely accepted as a guiding concept and goal for our low-carbon economies, agriculture, and the food system. Some approaches are in practice already but conditions are still challenging.

This book gives an insight into the current economic and policy challenges for rice in the era of climate change and towards sustainable agriculture with case studies in China, Japan, India, Thailand, Indonesia, and Vietnam. In the first chapter, Dr. Qi Dong compares the differences in rice production and cost efficiency between China and Japan. In Chapter 2, Dr. Phuc Trong Ho introduces the benefits of high-quality rice varieties in the Mekong Delta of Vietnam, and in Chapter 3, Dr. Orawan Srisompun describes how drought affects Thai rice farmers and their adaptations. In Chapter 4, Dr. Thanh Tam Ho introduces rice production towards sustainable agriculture, an economic and policy challenge in Vietnam and Japan. Dr. Mohammad Rondhi, Suci Virgianti Diani, and Rizky Yanuarti introduce the effects of risk preferences and perceptions on Indonesian farmer participation in farm insurance in Chapter 5, and Dr. Melanie Connor shows the roadmap from science to policy for sustainable rice production in Southeast Asian countries, with a focus on Vietnam, in Chapter 6. The Concluding Chapter is a summary of the discussion on economic and policy challenges in developing Asia rice production. It is my hope that these chapters will provide meaningful suggestions for promoting sustainable agriculture and economic development in Asia.

Thanh Tam HO

# Acknowledgments

This work would not have been possible without the full support of the Asia Japan Research Institute of Ritsumeikan University and colleagues of the Institute who helped me prepare and organize the international workshop. My overwhelming debt is to Professor Yasushi Kosugi, Director of the Asia-Japan Research Institute, who has been supportive of my career goals and given precious encouragement and endless support during the planning and organizing of this workshop.

Also, I would like to express my deepest appreciation for the assistance and guidance of the special advisor, Professor Anthony Brewer. His dedicated support in shaping the outline, communicating with participants, and making this booklet the best possible was greatly appreciated.

Furthermore, I am very grateful to Professor Koji Shimada for his devotion and enormous support not only throughout the period of the workshop, but also throughout my years in academia.

My grateful thanks are also extended to my colleagues at the Institute for their kind support in running this workshop.

Furthermore, my special thanks should be given to the six guest presenters: Dr. Qi Dong from the Economic Research Institute for Northeast Asia – Japan, Dr. Phuc Trong Ho from the University of Economics, Hue University – Vietnam, Dr. Orawan Srisompun from Mahasarakham University – Thailand, Dr. Mohammad Rondhi from the University of Jember – Indonesia, and Dr. Melanie Connor from the International Rice Research Institute – Philippines and Institute for Development Studies – United Kingdom, for their participation in our workshop at the most inconvenient times due to the considerable time differences as well as their much appreciated efforts to contribute their

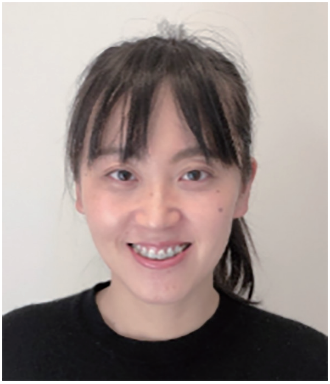
chapters to this book.

Finally, I am grateful to my partner and family, who patiently assisted and encouraged me to keep focused and patient in accomplishing my task.

Thanh Tam HO

# Contributors

**Dr. Qi DONG**



Chapter 1. Comparison of Rice Production in China and Japan: Evidence from a Panel Data Analysis

Dr. Qi Dong is an Associate Professor at the Economic and Social Research Institute for Northeast Asia of the University of Niigata Prefecture, Japan. She received her Ph.D. in Agricultural Economics from the University of Tokyo, Japan. Her research focuses on labor migration, agricultural capital investment, and food security. Her current research explores agricultural corporations and agricultural product exports in Japan.

**Dr. Phuc Trong HO**


Chapter 2. Impact of High-Quality Rice Variety on Profit and Profit Efficiency: Evidence from Vietnam

Dr. Phuc Trong Ho is a Lecturer at the Faculty of Economics and Development Studies, University of Economics, Hue University, Vietnam. He received his Ph.D. in Agricultural Economics from the School of Agriculture and Environment, University of Western Australia, Australia. His dissertation "Profit Efficiency and Rice Variety Choice in Rice Farming in Vietnam: A Stochastic Frontier Analysis Approach," explored the determinant of these inefficiencies and identified potential solutions to enhance farmers' incomes. His research interests include efficiency and productivity analysis, impact evaluation of technology adoption, production economics, and consumer behavior analysis.

**Dr. Orawan SRISOMPUN**

Chapter 3. Drought Effect and Adaptation of Farmers in Northeast Thailand

Dr. Orawan Srisompun is an Assistant Professor at the Department of Agricultural Technology, Faculty of Technology, Mahasarakham University, Thailand. She received her Ph.D. in Agricultural Economics at Kasetsart University, Thailand. Her research focuses on agricultural production economics and agricultural policy. In 2021, she was a leader of two projects, “Study on Economics and Social Effects of Drought and COVID-19 Pandemic on Farmers in the Northeast Thailand” (funded by the National Research Council of Thailand) and “iCCBA Pilot Project Consultant — Maha Sarakham” under the NDC Support Project — Delivering Sustainability through Climate Finance Actions in Thailand (funded by UNDP).

**Dr. Thanh Tam HO**

Chapter 4. Rice Production for Sustainable Agriculture: Case Studies in Vietnam and Japan

Dr. Thanh Tam Ho is a Senior Researcher at the Ritsumeikan Asia-Japan Research Organization. She received her Ph.D. in Economics at Ritsumeikan University. Her research focuses on climate change adaptation and mitigation, sustainable agriculture policies, and behavior analysis. Her dissertation, "An Economic Analysis of Climate Change Response and Rice Farmers' Behavior in the Mekong Delta of Vietnam," explored farmer's decision-making on multiple climate change responses and the economic performance in rice farming. Currently, she is conducting a research project related to sustainable agriculture and promotion policy in Japan.

**Dr. Mohammad RONDHI**

Chapter 5. The Effect of Risk Preference and Farmer Perception on Climate Change to Farmer Participation on Farm Insurances

Dr. Mohammad Rondhi is an Associate Professor at the Department of Agribusiness, Faculty of Agriculture, University of Jember, Indonesia. He obtained his Ph.D. at the Graduate School of Agriculture, Hokkaido University, Japan. His research interest is in agricultural economics including agricultural land economics, agricultural irrigation management, and agricultural institutions. He is a specialist in Computer-aided data analysis and has published several articles related to agricultural land conversion, climate change, and risk aversion level.

**Dr. Melanie CONNOR**

Chapter 6. From Science to Policy: Sustainable Rice Production in the Mekong Delta, Vietnam

Dr. Melanie Connor is a Senior Social Scientist researching behavior change in agriculture. Her research interests lie in investigating farmer adoption behavior and constraints, decision-making, and how these interlink with agricultural policymaking. She currently works at the International Rice Research Institute and is based in Nairobi, Kenya. She has published numerous articles on the impacts of climate change on food security and sustainable rice agriculture.

# Chapter 1
# Comparison of Rice Production in China and Japan: Evidence from A Panel Data Analysis

Qi DONG

**Abstract:** Rice is one of the most important staple foods in the world, especially in Asia. According to the data for 2020 from the Food and Agriculture Organization (FAO), Asia accounts for 89% of worldwide rice production and 88% of global rice consumption. Of Asian countries, China and Japan play significant roles in the production and consumption of rice. China produces and consumes approximately one-third of Asia's rice in terms of quantity. Although Japan's percentage is not as large as China's, their rice productivity and quality are notable. This study uses a provincial (regional) panel data set on China's and Japan's rice production (Japonica rice) to examine cost composition and variation in rice production in the two countries. The results indicate that the cost-revenue ratio of rice production in Japan ranges from 0.96 to 1.42, while in China, it ranges from 0.64 to 0.92, suggesting Japan's rice production is economically unprofitable, and China's rice production is about to face the same issue. Building on this, the study applies DEA (data envelopment analysis) to the data set to further analyze the differences in rice production efficiency between the two countries. The results reveal that the estimated efficiency score of rice production is greater in China (0.92) than that in Japan (0.66).

## 1. Introduction

Rice is one of the most important staple foods in the world, particularly in Asia. According to the data published by FAO (2020), Asia accounts for

89% of worldwide rice production and 88% of global rice consumption. While rice is mainly produced and consumed in Asia, its percentage has been declining in recent years. Of Asian countries, China and Japan are significant contributors to the production and consumption of Asia rice. China alone produces and consumes approximately one-third of Asia's rice. It is also the largest rice producer globally, accounting for about 30% of the world's total production, and is the largest rice consumer, representing about 30% of global demand in 2021. Although Japan's percentage is not as large as China's, its rice productivity and quality are impressive.

Figure 1.1 shows rice and other main staple crop production in China. We can see that rice was once the first staple crop in China, no matter whether in terms of sowing area or yield. In terms of sown area of rice, the total percentage increased from about 22% in 1960 to almost 30% in 1980 and then gradually declined in recent years. Since 2000, the sown area of maize in China has grown rapidly. This is probably because of an increase in the domestic need for forage. Similarly, it can be clearly seen that the yield of maize has had a rising trend in recent years while the rice yield has tended to flatten out. However, rice production occupies less land but yields a greater output, indicating the average productivity of rice is much higher than other staple crops.

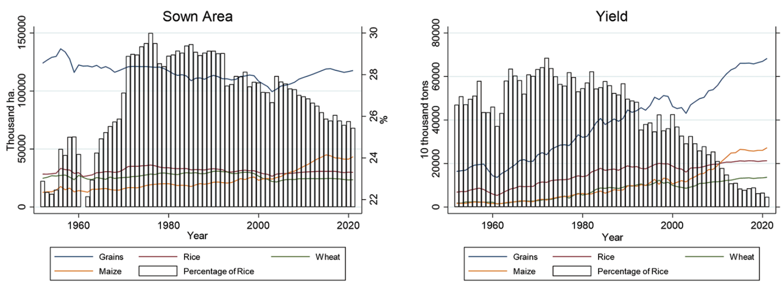



Figure 1.1 Rice production in China.
Source: The data are from the annual database of China's National Bureau of Statistics.

In fact, China's rice productivity has more than tripled in the past several decades as shown in Figure 1.2. Possible reasons are (1) the prevalence of household responsibility system and domestic market liberation (Lin 1992), (2) support of Government policy (Huang et al. 2006; Huang et al. 2013), (3) the development of high-yielding varieties (Peng et al. 2009), (4) improved crop management practices (Peng et al. 2009), and (5) increased demand for rice. However, China's rice production is currently facing several problems involving off-farm employment (Peng et al. 2009; Dong et al. 2018), such as labor transfer, a decline in arable land (Zhai and Ikeda 2000), a looming water crisis (Cai 2000; Li 2006; Li and Li 2011), and global climate change (Tao et al. 2003; Lyu et al. 2020). Consequently, Chinese rice is gradually losing its comparative advantages.

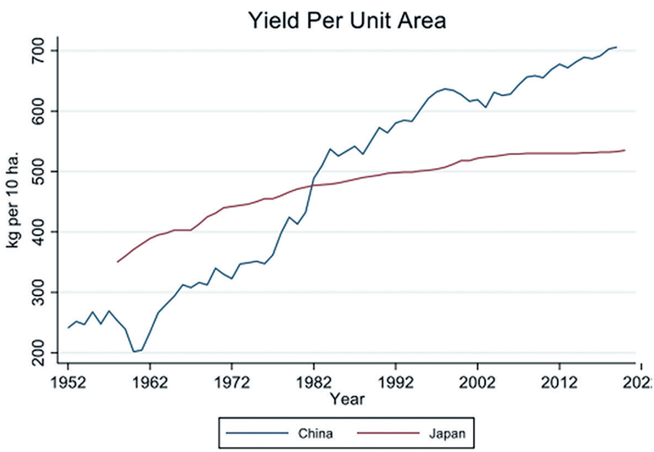



Figure 1.2 Rice productivity in China and Japan.
Source: The data are from the database of the Ministry of Agriculture, Forestry, and Fisheries of Japan.

Figure 1.3 shows the trends in the export and import of rice in China. Before 2010, China exported much more rice than it imported. Since the early 2010s, due to a slowdown in the growth of rice production and a rapid increase in rice consumption, China has changed from a net exporter of rice to a net importer. In recent decades, China has sustained a high level of rice self-sufficiency (above 97%) due to the low level of rice import in the past decades.

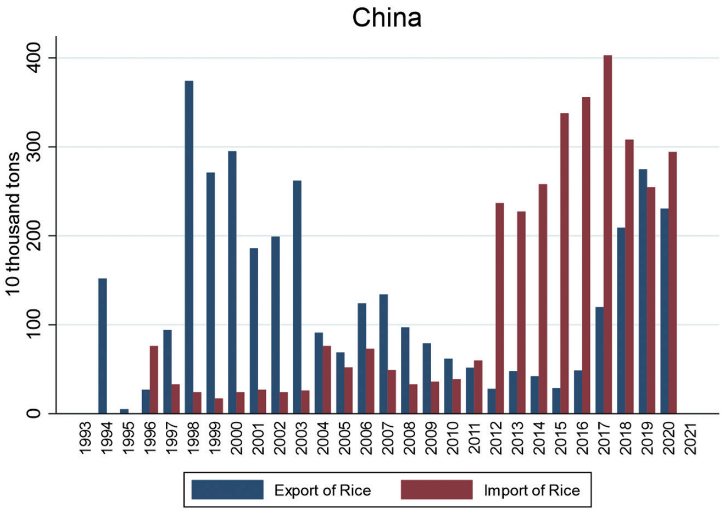



Figure 1.3 Export and import of rice in China.
Source: The data are from the annual database of China's National Bureau of Statistics.

Figure 1.4 shows rice production in Japan. We can see that both the sown area and the rice yield have declined since 1960. The percentage of rice in the total sown area declined from almost 50% in the late 1970s to about 37% recently. Meanwhile, the percentage of rice yield declined from 70% in total in the late 1970s and remains stable at 55%.

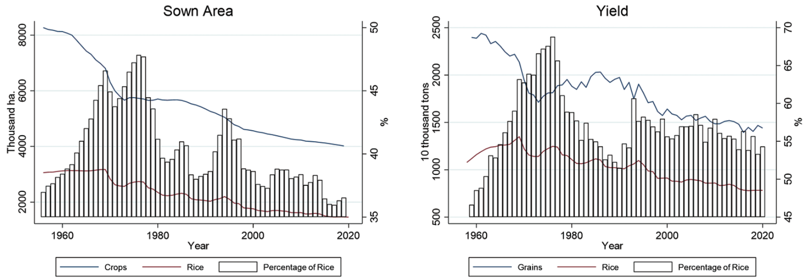



Figure 1.4 Rice production in Japan.
Source: The data are from the database of the Ministry of Agriculture, Forestry and Fisheries of Japan.

However, rice is still the most important staple food in Japan. About 20% of agricultural production is rice, and 70% of agricultural management entities grow rice. Japan's self-sufficiency rate for food is about 38% (calorie-based), but its rice is basically completely self-sufficient (98%, calorie-based). Japan implemented the Acreage Reduction Policy (Gentan Policy) since 1970, but it was abolished in 2018. Basically, it is a policy to control the amount of rice to prevent overproduction in Japan. In detail, it requires rice farmers to reduce their planted areas to avoid rice surplus and price concerns. Gradually, this may cause rice farmers to lose their enthusiasm for raising their rice productivity (See Figure 1.2). On the other hand, there are also several problems with Japan's rice production, including decreasing domestic demand and decreasing rice prices which can lead to an opportunity for exporting Japanese rice. In 2020, Japan exported $64.7 million in rice, making it the 29th largest rice exporter in the world. At the same time, Japan imported $463 million in rice, becoming the 15th largest importer of rice in the world in 2020 (OECD 2022) (See Figure 1.5). Moreover, aging agricultural labor forces, the Fukushima nuclear disaster (Shimokawa et al. 2018), global climate change (Horie et al. 1996; Nakagawa et al. 2003), and a shortage of forage rice are emerging issues in producing rice in Japan.

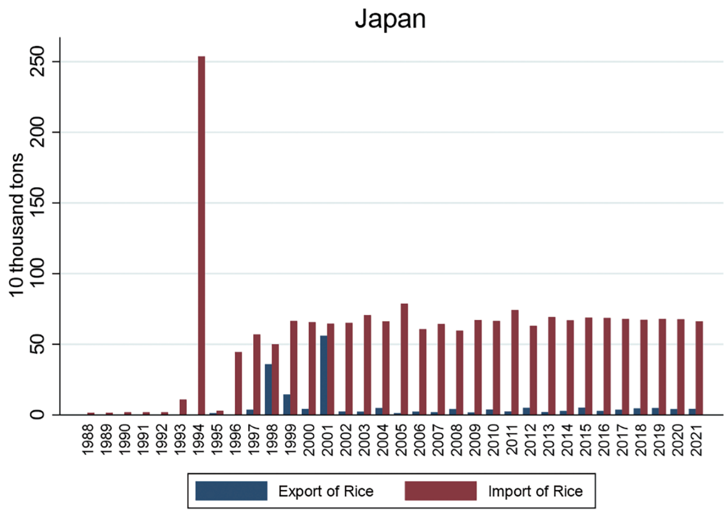



Figure 1.5 Rice import and export in Japan.
Source: The data are from the database of the Ministry of Agriculture, Forestry and Fisheries of Japan.

There is no shortage of relevant studies on the conditions and problems of rice production in China and Japan. As for China's rice production, some studies have researched conventional and hybrid rice (Xu and Jeffrey 1998; Ma and Yuan 2003), fertilizers used in rice production (Sun et al. 2019), and farm size and production cost of rice (Zhang et al. 2019). Regarding Japanese rice production, the existing literature has been mainly concerned with the effects of the Gentan policy and the production cost of rice (Kusakari 1989), farm size and the production cost of rice (Matsukura et al. 2015), and production cost and forage rice (Senda and Tsunekawa 2015; Tsunekawa 2016). But there are two questions that remain unanswered, namely: (1) How does the production cost of rice change in China and Japan, respectively? and (2) Which country is more efficient in rice production, China or Japan?

The significance of this research can be addressed as follows: first, from the perspective of China, it is important to study and learn about some successful experiences in agricultural production from developed countries such as Japan and consider the similarity of the natural endowments of the two countries. Second, Japan has abolished the Gentan policy, and the alternative option of its rice strategy is to promote the export of its agricultural products. One of the important target markets is China. Hence, it is important to compare the production cost and efficiency between China and Japan. Finally, the common issue for global agriculture is how to tackle global climate change and develop sustainable agriculture. It may require producing enough output for the market, raising revenue as high as possible for farmers, and stabilizing the market price of agricultural output. Therefore, this study aims to (1) examine the changes in the production costs of rice in China and Japan and (2) estimate and compare the production efficiency of rice between the two countries.

## 2. Comparisons of Rice Production Costs

This section provides a comparison of rice production costs between China and Japan, which typically consist of raw materials costs, labor costs, and land costs. It is important to note that labor costs include wages paid for family labor, and land costs include the rent paid for owned land. This study focuses on examining these inputs and chooses the category of Japonica rice as the research object. The data for China's rice production costs are sourced from the National Cost and Profit of Agricultural Products Materials Compilation and the National Bureau of Statistics, while the data for Japan's rice production costs are obtained from the database of the Ministry of Agriculture, Forestry and Fisheries of Japan.

Figure 1.6 shows the total cost of rice production per 10 acres in Chinese Yuan/ Japanese Yen. In China, the total cost of rice production per 10 acres has been found to have increased during our observation period, from 952 Chinese Yuan in 2006 to 2,190 Chinese Yuan in 2018. Conversely, the rice production cost per unit area has decreased in Japan, from 148,382 Japanese Yen in 2003 to 132,020 Japanese Yen in 2020.

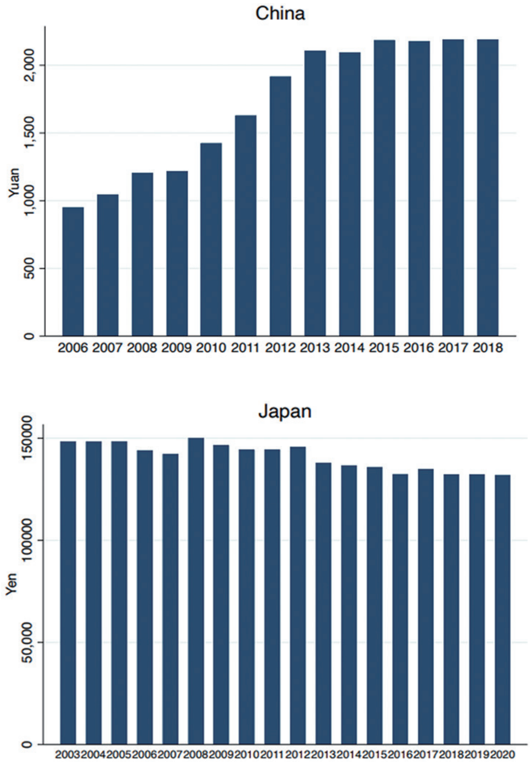



Figure 1.6 Comparisons of rice production costs (Japonica rice) between China and Japan.
Source: Calculated by the author.

Figure 1.7 shows the composition of costs and their changes in the two countries. In both China and Japan, raw material costs are mainly dominant. In China, raw materials, labor costs, and land costs have exhibited an increasing trend since 2006. Moreover, the growth rate of labor expenditure became higher and even exceeded that of raw materials during 2013–2016. Since 2017, raw material costs have still been higher than labor costs, but the gap between them has narrowed. In contrast to China, raw materials rather than labor costs are the major expense for rice production in Japan. All costs are leveling off, and especially labor costs and land costs show a similar variation with less fluctuation and a decreasing trend.

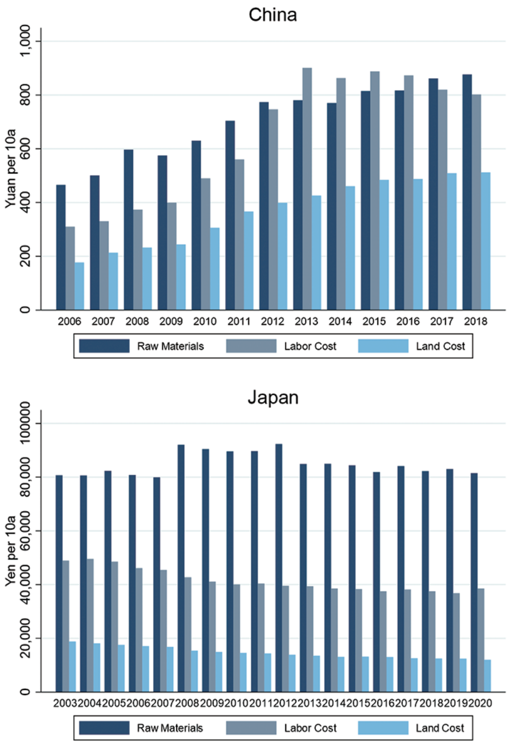



Figure 1.7 Composition changes in rice production costs between China and Japan.
Source: Calculated by the author.

Regarding labor input in rice production, family labor remains the mainstay of labor input in rice farming, both in China and Japan (see Figure 1.8). However, we can also see that family labor input has significantly decreased in both China and Japan, but employed labor input remains stable.

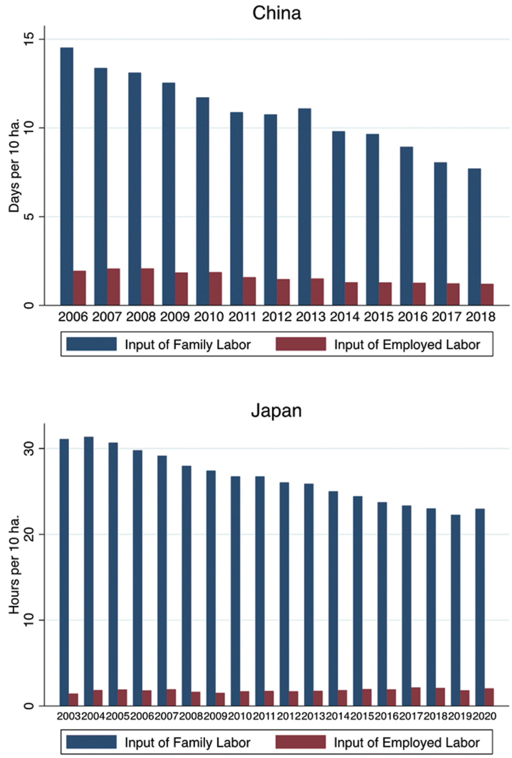



Figure 1.8 Comparison of labor input in rice production between China and Japan.
Source: Calculated by the author.

Correspondingly, the hourly wage is rapidly increasing in China but remaining flat in Japan (see Figure 1.9). As a result, we can infer the reasons accounting for reduced labor input in China's rice production are different from those in Japan's rice production. Possible explanations for reduced labor input in China's rice production are labor migration and rising labor wages. Conversely, the reasons for reduced labor input in Japan may be attributed to the aging agricultural population and the replacement of labor with capital.

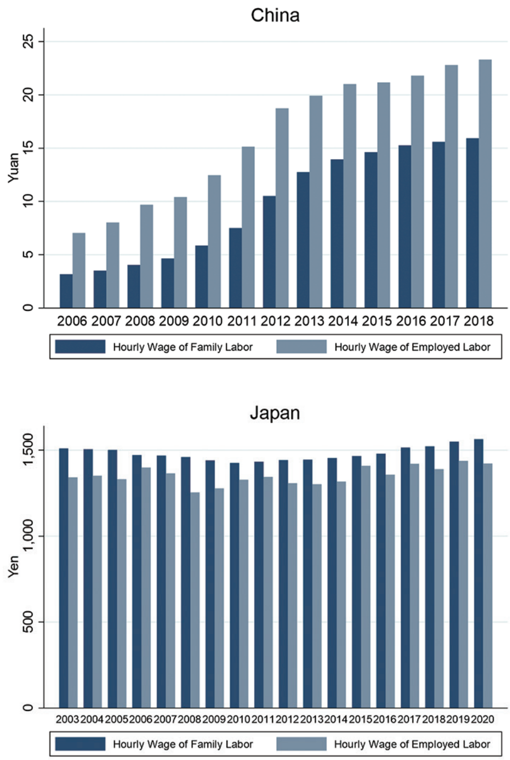



Figure 1.9 Comparison of hourly wage in rice production between China and Japan.
Source: Calculated by the author.

Concerning land rent in rice production (see Figure 1.10), we observe that both land rent of owned land and land rent of borrowed land are increasing in China, primarily due to China's rapid urbanization. However, land rent of owned land is decreasing, while the land rent of borrowed land remains flat in Japan. It is interesting to note that the land rent of owned land is higher than that of borrowed land for both countries.

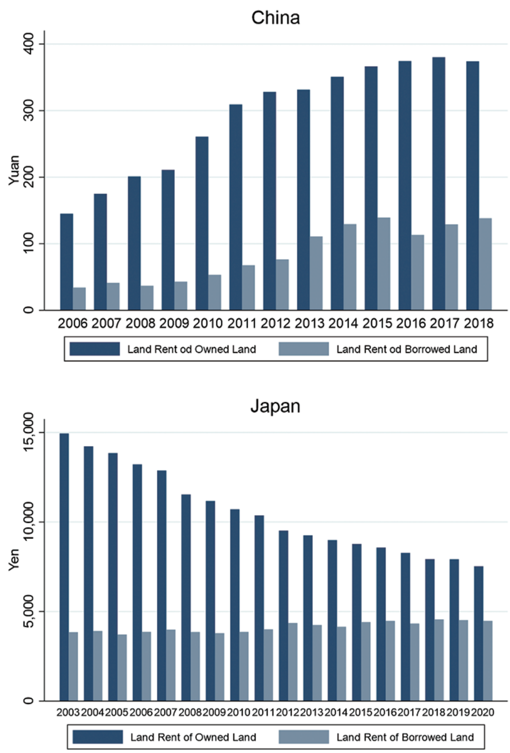



Figure 1.10 Comparison of land rent in rice production between China and Japan.
Source: Calculated by the author.

In brief, China's rice production costs have risen rapidly before leveling off, whereas Japan's production costs have decreased to four times as much as China's. In terms of cost composition, raw materials have been the main cost for both countries over the years, accounting for more than 60% in Japan and 43% in China (see Table 1.1). The share of labor cost is the largest in China (nearly 36%) while the share of raw materials is the largest in Japan. Labor wages and land rent are rising in China, while they remain level in Japan. In conclusion, China's rice production costs are primarily driven by labor expenses, while Japan's rice production costs are mainly influenced by capital and fertilizer inputs.

Table 1.1 Composition in the amount of money regarding rice production between China and Japan.

| Per 10 ha. | China | Japan |
|---|---|---|
| **% of Raw Materials** | 43.09 | 60.11 |
| **% of Labor Cost** | 35.86 | 29.21 |
| **% of Land Cost** | 21.04 | 10.68 |
| **Total Cost (current LCU)** | 1701 RMB | 140925 Yen (6921 RMB) |
| **Cost Revenue Ratio** | 0.79 | 1.29 |

Source: Calculated by the author.

Moreover, to measure the efficiency of rice production expenses in relation to its earnings in the two countries, I calculated the cost-revenue ratio of rice production in China and Japan, respectively. The cost-revenue ratio of China is calculated as 0.79, while that of Japan is 1.29. From this figure alone, it seems that rice production in Japan is unprofitable. Nevertheless, we should note that the cost includes what the farmers pay themselves. Namely, the shadow costs consist of wages paid for family labor, interest paid for owned funds, and rent paid for owned land. If we subtract the shadow costs, we can obtain the cost-revenue ratio without shadow costs.

The cost-revenue ratio without shadow costs is 0.65 for China and 0.84 for Japan, suggesting producing rice is still profitable even if the ideal cost is not obtained. And the shadow cost-revenue ratio is 0.14 for China and 0.45 for Japan. This study does not focus on revenue only because revenue involves more factors such as market stocks, government subsidies, etc. Interestingly, the following figures show the revenues per 10a, which is higher in China than in Japan (see Figure 1.11).

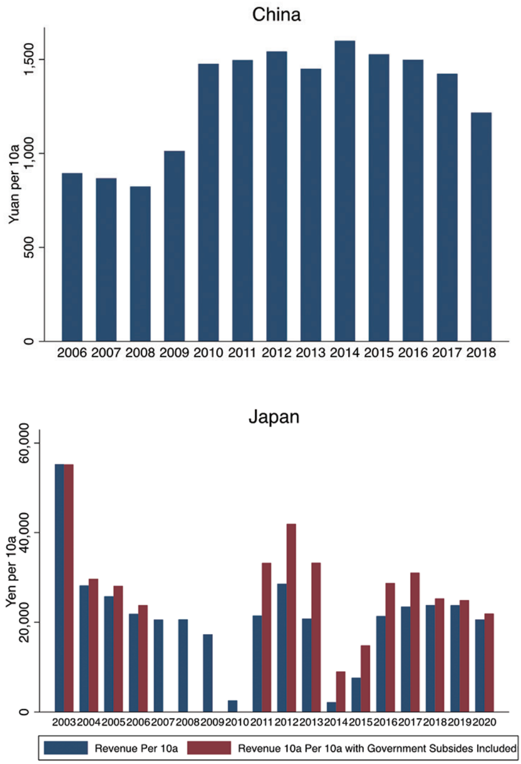



Figure 1.11 Comparison of revenue in China and Japan.
Source: Calculated by the author.

Table 1.2 reports the composition in the quantity of input uses in China and Japan. Labor input in China (on average, 100 hours) is much higher than in Japan (on average, 28 hours). Surprisingly, Japan consumes much more fertilizer input than China, with fertilizer amounts of 64.23 kg and 39.44 kg, respectively. The biggest difference between both countries is capital input. Especially, Japan consumes more than three times the capital input (2,084 RMB per 10ha) of China (316 RMB per 10ha). Rice production in China depends more on labor, while Japan depends more on capital.

Table 1.2 Composition in the quantity of input uses regarding rice production between China and Japan.

| Per 10 ha. | China | Japan |
|---|---|---|
| **Labor Input (Hours)** | 100.41 | 28.38 |
| **of which, Family Labor** | 88.10 | 26.54 |
| **of which, Employed Labor** | 12.77 | 1.83 |
| **Seeds (kg)** | 9.15 | 2.72 |
| **Fertilizer (kg)** | 39.44 | 64.23 |
| **Capital (current LCU)** | 316 RMB | 42299 Yen<br>(2084 RMB) |

Source: The data are from the National Cost and Profit of Agricultural Products Materials Compilation, the National Bureau of Statistics, and the database of the Ministry of Agriculture, Forestry and Fisheries of Japan.

## 3. Measurement of Production Efficiency

This study applied data envelopment analysis (DEA), a non-parametric method, to estimate the production efficiency of rice in China and Japan. DEA was initially proposed by Charnes et al. (1978) to calculate the operation efficiency of the decision-making unit (DMU) in public programs to improve the planning and control of these activities.

The efficiency of any DMU is obtained as a maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the similar ratios for each DMU be no more than unity in this method. In more precise form, it can be expressed as:

$$\max_{\mathrm{v,u}} \theta_i = \frac{u_1 y_{1i} + u_2 y_{2i} + \cdots + u_m y_{mi}}{v_1 x_{1i} + v_2 x_{2i} + \cdots + v_n x_{ni}} \qquad (1)$$

subject to

$$\frac{u_1 y_{1j} + u_2 y_{2j} + \cdots + u_m y_{mj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots + v_n x_{nj}} \leq 1 \;\; (j = 1, \ldots, t)$$
$$\mathrm{u}_p \geq 0 \;\; (p = 1, \ldots, m) \qquad (2)$$
$$\mathrm{v}_q \geq 0 \;\; (q = 1, \ldots, n),$$

where $y_{pi}$ and $x_{qi}$ are the known outputs and inputs of the $\mathrm{i}^{\mathrm{th}}$ DMU, p denotes the category of outputs and q denotes the category of inputs. $u_p$ and $v_q$ are the variable weights of each output and input which are called virtual multipliers and are to be determined by the solution of this problem. $\theta_i$ is the measured efficiency for the $\mathrm{i}^{\mathrm{th}}$ DMU.

In this study, I treat each agricultural province/region as a DMU and adopt the output-oriented DEA model with the variable returns to scale (VRS). The output variable is the rice output per 10 acres, while the input variables are the labor input per 10 acres in agricultural production activity, agricultural fixed assets costs per 10 acres, energy costs per 10 acres, fertilizer costs per 10 acres, and seeds costs per 10 acres. All data relating to the amount are deflated to the prices of 2015. Panel data was collected across provinces in China (2006–2018) and regions in Japan (2005–2020).

## 4. Empirical Evidence

Unsurprisingly, the estimated results from DEA show that the average efficiency score of rice production is 0.922 in China and much higher than that of 0.721 in Japan, suggesting China's rice production exhibits greater production efficiency than Japan's rice production. However, the summary of the estimated score in Figure 1.12 shows that there is an upward trend in production efficiency in Japan while it stays at a stable level in China.

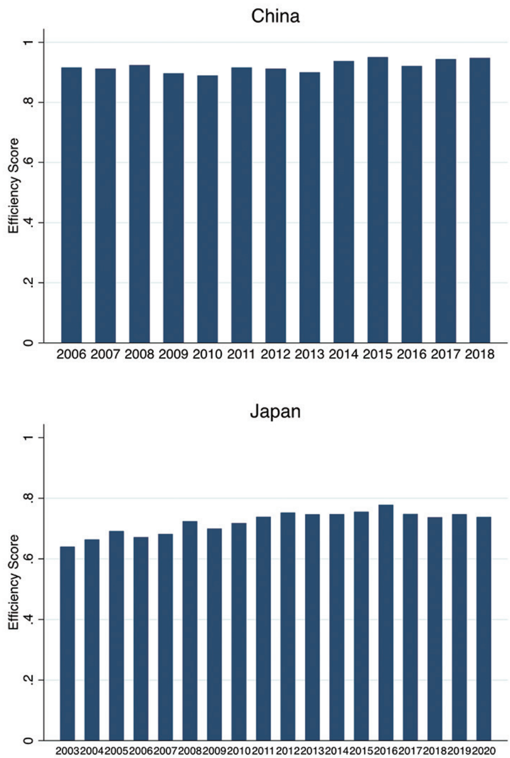



Figure 1.12 Estimated efficiency score of rice production in China and Japan.
Source: Calculated by the author.

Figure 1.13 shows the regional variation in efficiency scores in China and Japan. Initially, it was thought that regional variation is larger in China as it has a huge land area and climatic conditions are quite diversified, especially in the northern and southern regions. However, the estimated result shows that efficiency variation across regions is much larger in Japan. More specifically, rice production in the Hokkaido region is the most efficient since its farm size is much larger than other regions in Japan, followed by the Tohoku region.

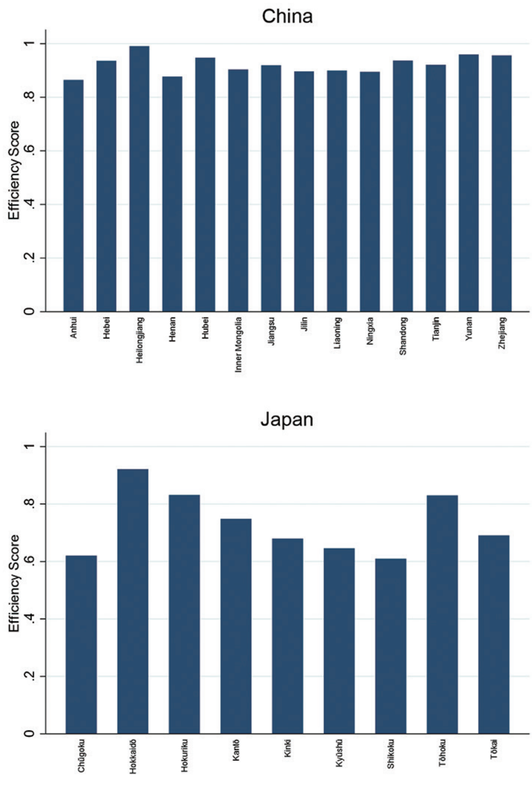



Figure 1.13 Variation in efficiency score by region.

Source: Calculated by the author.

In addition, the findings from Table 1.3 reveal the differences in the factors influencing rice production efficiency between China and Japan. The results indicate that the land rent of owned land has a positive and significant effect on rice production efficiency in China, while it has a negative and significant effect in Japan. This could be attributed to the fact that increasing the size of farms can enhance rice production efficiency in Japan, but it could have the opposite effect in China due to differences in labor and capital allocation per unit acreage between the two countries.

Interestingly, the shadow cost-revenue ratio has a significant and negative effect on rice production efficiency in Japan only. This suggests that farmers in Japan may not have sufficient motivation to improve their production efficiency, as they may already be earning enough money and see little need to work harder to increase efficiency in their rice production.

Table 1.3 Rice production efficiency and its determinant.

| VARIABLES | China | Japan |
|---|---|---|
| **Wage of family labor** | 0.036 | -0.001 |
| | (-0.033) | -0.01 |
| **Wage of employed labor** | -0.045 | 0.004 |
| | (-0.03) | -0.003 |
| **Land rent of owned land** | 0.0259** | -0.001*** |
| | (-0.012) | (0.000) |
| **Land rent of borrowed land** | 0.012 | -0.001* |
| | (-0.011) | (0.001) |
| **Shadow cost -revenue-ratio** | -3.703 | -18.860*** |
| | (-27.65) | (6.017) |
| **Constant** | 90.050*** | 93.390*** |
| | (2.704) | (9.057) |
| **Observations** | 120 | 157 |
| **Number of dmu** | 14 | 9 |
| **R-squared** | 0.144 | 0.485 |

Note: Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

## 5. Conclusion

This study compared the rice production between China and Japan by decomposing the production costs and estimating production efficiency in rice production. From the decomposition analysis of rice production costs, we find that the cost-revenue ratio (with shadow cost included) in Japanese rice production is much higher than that in Chinese rice production. However, if the shadow cost is excluded, the gap between the two countries becomes much less. Moreover, the shadow cost-revenue ratio is much larger in Japan than in China. It implies that while the costs of producing rice in China are lower, Japanese rice production is not completely unprofitable once its self-payments are subtracted.

There are several possible reasons accounting for the higher cost-revenue ratio in Japan's rice production than in China's rice production. One possibility is that it is due to most input prices being much lower in China than in Japan. Especially, labor wages are far lower in China's rice sector than that in Japan's rice sector, and China adopts an intensive labor input way of producing rice compared with Japan. Hence, even though China's rice sale prices are lower than Japan's rice sale prices, production costs are relatively lower in China than in Japan.

Another possibility is that China is producing rice more efficiently than Japan, which could also make its cost-revenue ratio lower than Japan's. To verify this point, we conducted a DEA method to estimate the rice production efficiency for the two countries. The results from the DEA reveal that the estimated efficiency score of rice production is greater in China (0.92) than that in Japan (0.72). Thus, regardless of variety or quality, China produces rice much more efficiently than Japan. The reasons behind this are that in China, regarding the policy and food self-sufficiency aims, the scarce input resources in rice production resulting from the structural transformation and the changes in the dietary structure make its rice production more efficient. Furthermore, the low shadow cost-revenue ratio stimulates its peasants to produce rice efficiently to acquire more profits. However, in Japan, the acreage reduction policy (or Gentan policy), the decreasing domestic demand for rice, the export disadvantage of rice, and the high shadow cost-revenue-ratio make the motivation for promoting rice efficiency less urgent. Hence, even though Japan's mechanization level is much higher than China's, its production efficiency is relatively lower.

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# Chapter 2
# Impact of High-Quality Rice Variety on Profit and Profit Efficiency: Evidence from Vietnam

Phuc Trong HO

**Abstract:** High-quality rice varieties (HQRV) are expected to contribute more profit than conventional rice varieties. However, the observed profit gap is not attractive. This study assesses the impact of HQRV adoption on farmer profit and profit efficiency (PE) using farm-level data from 356 rice farmers surveyed in Vietnam's Mekong River Delta. We combine a propensity score matching (PSM) method and a stochastic profit frontier framework to mitigate the effects of selection biases and technology gaps. We use the PSM method to find a comparable non-adopter group to control selection bias associated with observed variables. A sample selection stochastic frontier model is then used to correct selection bias stemming from unobserved factors. Finally, we apply a stochastic meta-frontier approach to compare PE between groups. The analysis shows that the profit and PE gaps between the two groups are significantly underestimated if selection biases and technology gaps are not considered. A comparison of profit and PE scores reveals that HQRV adopters, on average, exhibit higher variable profits than non-adopters (1,085 USD/ha vs. 982 USD/ha) but lower PE performance (0.61 vs. 0.72), suggesting that adopters will benefit more from HQRVs if inefficiencies are eliminated. The results also indicate that farm size, contract farming, rice plots, and geographical and seasonal factors influence HQRV adoption.

# 1. Background

Vietnam has been one of the world's leading rice producers (with nearly 44 million tons) and exporters (nearly 6.1 million tons) for the last decade (GSO 2018). The Mekong River Delta is the main rice-intensified area for export, accounting for approximately 90% of the total export volume (accounting for 5.4 million tons of milled rice) (GSO 2018) (Figure 2.1). The observed profitability of rice farming remains low. One of the main reasons is that rice farmers still use the traditional low-quality rice varieties. To improve its output quality and price, the Vietnamese government introduced and encouraged farmers to adopt high-quality rice varieties and hopefully increase output prices, competitiveness advantage, and farmers' income. High-quality rice varieties (HQRVs) are expected to increase profits for rice farmers by 30%; however, the profit gap between these varieties and conventional ones is not as high as expected. The goal of this study is to analyze and address how much difference in the profit and profit efficiency is between HQRV adoption and non-adoption.

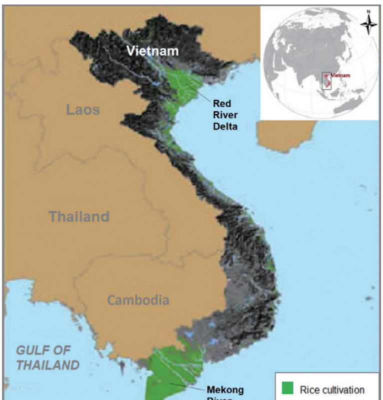


Figure 2.1 Distribution of rice area in Vietnam.
Source: (Shean 2012)

# 2. Research Approach

A direct comparison of profit and profit efficiency is not accurate due to (1) facing sample selection bias arising from both observable (e.g., age, education, and gender) and unobservable (e.g., risk preferences, motivation, and managerial ability) factors and (2) facing a technology gap between rice variety groups. Hence, to control sample selection bias and the technology gap between the two rice variety groups, this study uses a combined framework as applied in Villano et al. (2015). This is a combination of an impact evaluation technique (i.e., propensity score matching) and stochastic profit frontier framework to eliminate the potential effects of self-selection biases.

Step 1. A propensity score matching method (PSM) (Rosenbaum and Rubin 1983) is applied to correct selection bias stemming from observable variables.

Step 2. A sample selection corrected stochastic frontier model (Greene 2010) is employed to eliminate selection bias arising from unobservable factors.

Step 3. A stochastic meta-frontier approach (Huang et al. 2014) is applied to control the effects of the technology gap and make a direct comparison of profit efficiency between the two groups.

# 3. Empirical Models

### (1) Propensity Score Matching (PSM)

The PSM method is implemented to identify comparable adopter and non-adopter groups using a propensity score or probability model (Logit or Probit). Here, the Probit model is applied to estimate propensity scores, which are then used to match adopters and non-adopters for farms falling within a common probability range (or common support). We tested several matching criteria (e.g., one-to-one, nearest neighbor, radius, kernel, and local linear regression matching), and the nearest neighbor matching is used because it generates a better-matched sample. In our case, we used five matches per adopter, with a caliper of 0.005.

The Probit model for matching is expressed as:

$$DHQR_i = 1[\sum_{n=1}^{i} \alpha_n z_{ni} + e_i > 0] \quad (1)$$

where $i$ denotes farm, *DHQR* is a binary variable, 1 for adopters and 0 for non-adopters. $Z_n$ is a vector of explanatory variables for farmers' adoption decisions, including farm and farmers' characteristics. $\alpha$ is the vector of unknown parameters to be estimated, and $e$ is the disturbance term distributed as N (0,1)

## (2) Sample Selection Stochastic Frontier (SF) Model

After obtaining a matched sample, matched subsamples can be used to estimate a stochastic profit frontier model for each group and compare the results. However, the decisions on HQRV adoption can be affected by unobserved factors (e.g., managerial ability), which could lead to differences in efficiency. Thus, the sample selection stochastic frontier model proposed by Green (2010) is used to mitigate the potential effects of self-selection bias from unobserved factors.

The sample selection (Probit) model is described as follows:

$$d_i = 1[\alpha' Z_i + w_i > 0], w_i \sim (0,1)$$

where $d$ is a binary variable equal to 1 for adopters and 0 for non-adopters, $Z$ is a vector of observed explanatory variables, and $w$ is the unobservable error term.

Stochastic profit frontier model:

$$\pi_i = f\ (\beta;\ P_i;\ F_i)\ e^{(v_i - u_i)} \qquad (2)$$

($\pi_i$, $P_i$, $Z_i$) are observed only when $d_i = 1$ or $d_i = 0$, but not both

Composed error structure: $v_i - u_i$

Inefficiency term: $u_i \sim N^+(0,\ \sigma_u^2)$

Symmetric noise term: $v_i \sim N\ (0,\ \sigma_v^2)$

Error correlation between SF and selection model:

$$(w_i,\ v_i) \sim N_2\ [(0,0),\ (1,\ \rho\sigma_v,\ \sigma_v^2)]$$

where $\pi_i$ is variable profit (equal to revenue less variable cost), $P_i$ is a vector of input prices, $F_i$ is a vector of fixed inputs, and the composed error term comprises the statistical noise term $v_i$ and non-negative inefficiency term $u_i$. $\alpha$ and $\beta$ are unknown parameters to be estimated. $\rho$ shows the relationship between unobservable error in the sample selection model and statistical noise in the SF model.

However, PE between adopter and non-adopter groups cannot be directly compared because efficiency scores are estimated relative to each group's frontier, not relative to the meta-frontier and existing potential technology gaps between farmers using the two rice variety groups. Therefore, it is necessary to use a meta-frontier approach to generate a common frontier and estimate the technology gap ratio, which can construct a measure of overall PE.

### (3) Stochastic Meta-Frontier Model

In Step 1, the SF model for each group is estimated:

$$\ln \pi_{ji} = \ln f^j(\beta_j;\ P_{ji};\ Z_{ji}) + v_{ji} - u_{ji} \qquad (3)$$

Then, the profit efficiency scores are estimated, $PE^j$:

$$\widehat{PE_i^J} = \hat{E}\left(e^{-u_{jit}} \middle| (\widehat{v_{ji}} - \widehat{u_{ji}})\right)$$

In Step 2, the predicted values for adopters and non-adopters $\widehat{lnf^J}$ = ($\beta_j$; $P_{ji}$; $Z_{ji}$) are used as the dependent variables in the meta-frontier estimation:

$$\widehat{lnf^J}\,(\beta_j;\, P_{ji};\, Z_{ji}) = \ln f^m(\beta_j;\, P_{ji};\, Z_{ji}) + v_{ji}^m + u_{ji}^m \qquad (4)$$

Next, the technology gap is calculated, $\widehat{TGR_i^J} = \hat{E}\left(e^{-u_{ji}^m}\middle|(\widehat{v_{ji}^m} - \widehat{u_{ji}^m})\right)$

Then, it is possible to calculate meta-profit efficiency (Figure 2.2)

$$\widehat{MPE_i^J} = \widehat{TGR_i^J} \times \widehat{PE_i^J} \qquad (5)$$

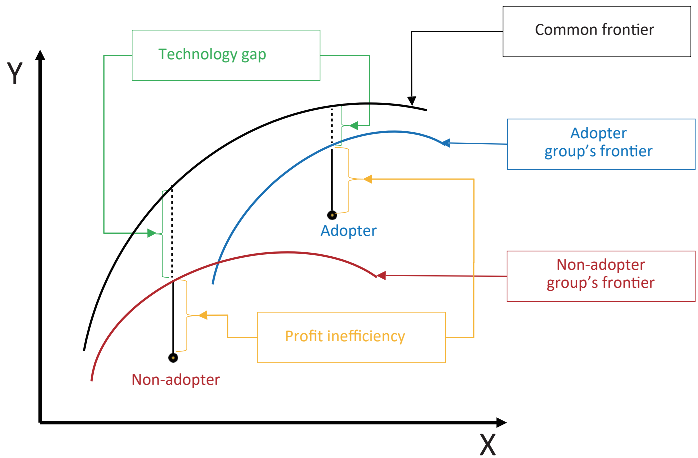


Figure 2.2 Meta-frontier approach.
Source: (Huang et al. 2014)

## 4. Data and Materials

This study was conducted in the Mekong River Delta. The sampling method is a three-step stratified random sampling technique. The sample size of 356 rice farmers was collected from 16 villages in three provinces: An Giang (AG), Can Tho (CT), and Bac Lieu (BL) (Figure

2.3), covering three cropping seasons of the production year 2016/2017. It generated 957 observations, with 414 adopters and 543 non-adopters. After matching, the remaining sample is 841 observations, with 319 adopters and 522 non-adopters.

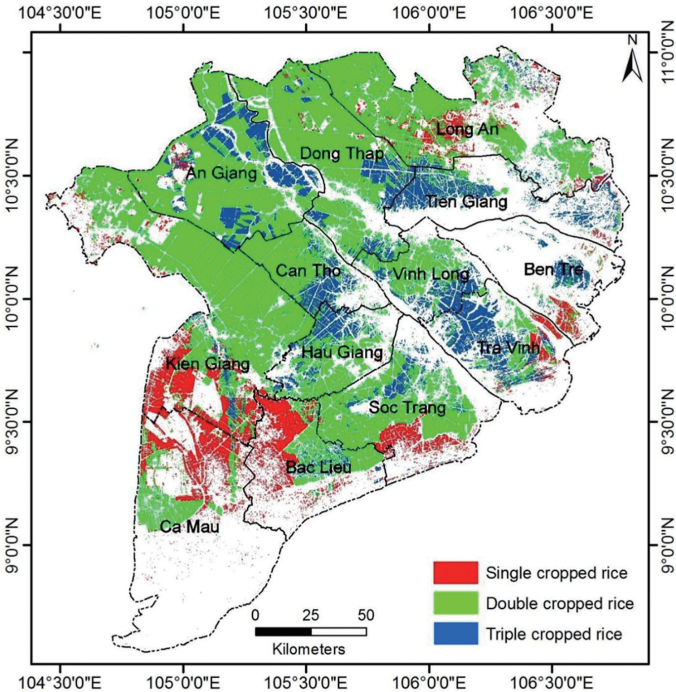


Figure 2.3 Rice Crop Map of the Mekong River Delta.
Source: (Nguyen et al. 2015)

As described earlier, the PSM method is used to identify a comparable control group to overcome the bias arising from differences in observed factors between groups. In this study, the observed variables included age (years), education (years of formal schooling), experience (years of rice farming), gender (1 for males, 0 otherwise), farm size (hectares), rice plots (numbers), and contract farming (1 for contract farming, 0 otherwise). Furthermore, two dummy variables of regions (Region 1-AG and Region 2-CT) and crop seasons (Season 2 and Season 3) are included to capture the effects of geographical settings and the effects of seasonal factors. These observed variables are regressed in the Probit model for the matching process and sample selection SF model.

## 5. Results

The result from Table 2.1 shows the influencing factors on decision-making on HQRV adoption or non-adoption based on the estimations of Probit selection models for HQRV using a full and matched dataset. It can be clearly seen that farm size and contract farming have positive effects on the farmers' decisions to become adopters, while the number of rice plots, regions, and seasons have negative effects on their decisions.

Table 2.1 Estimates of the Probit model for matching and sample selection model.

| Variable | Full sample | | Matched sample | |
|---|---|---|---|---|
| | Coef.† | S.E. | Coef.† | S.E. |
| Constant | 1.240*** | 0.419 | 0.969** | 0.437 |
| Age | 0.006 | 0.009 | 0.008 | 0.009 |
| Education | -0.011 | 0.015 | -0.023 | 0.016 |
| Experience | -0.002 | 0.008 | -0.004 | 0.009 |
| Gender | 0.188 | 0.251 | 0.230 | 0.267 |
| Farm size | 0.068* | 0.027 | 0.072** | 0.031 |
| Rice plots | -0.138*** | 0.036 | -0.156*** | 0.041 |
| Contract farming | 0.631*** | 0.176 | 0.616*** | 0.189 |
| Region 1 (AG) | -1.879*** | 0.148 | -1.558*** | 0.159 |
| Region 2 (CT) | -1.783*** | 0.148 | -1.497*** | 0.158 |
| Season 2 | -0.345*** | 0.108 | -0.428*** | 0.113 |
| Season 3 | -0.498*** | 0.116 | -0.529*** | 0.120 |
| *Model properties* | | | | |
| Log-likelihood (log*L*) | -485.88 | | -455.33 | |
| $X^2$ | 337.49*** | | 205.73*** | |

| | | |
|---|---|---|
| Pseudo $R^2$ | 0.258 | 0.184 |
| Observations | 957 | 841 |

Note: ***, **, * represent significant levels at 1%, 5%, 10%, respectively.

Source: Author

The result from Table 2.2 shows the comparisons in profit efficiency estimation between conventional SF models and sample selection SF models to select the best-fit model. Firstly, the pooled model is estimated using a log-likelihood ratio test to check whether only pooled model or separate estimation models are necessary. The result shows that it is necessary to estimate adopters and non-adopters separately. Also, the evidence on self-selection bias from unobservable factors and the log log-likelihood ratio test also show that it is necessary to additionally run a sample selection SF model.

Table 2.2 Estimates of conventional and sample selection SF models using matched sample data.

| Variable | Conventional SF model | | | | | | Sample selection SF model | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pooled | | Adopter | | Non-adopter | | Adopter | | Non-adopter | |
| | Coef.† | S.E. | Coef.† | S.E. | Coef.† | S.E. | Coef.† | S.E. | Coef.† | S.E. |
| Constant | 9.596*** | 0.359 | 9.741*** | 0.663 | 9.905*** | 0.430 | 10.222*** | 0.767 | 9.931*** | 0.496 |
| lnPseed | -0.084** | 0.034 | -0.126* | 0.066 | -0.017 | 0.043 | -0.120 | 0.072 | -0.020 | 0.054 |
| lnPfertilizer | -0.364*** | 0.071 | -0.398*** | 0.118 | -0.328*** | 0.083 | -0.257** | 0.106 | -0.338*** | 0.095 |
| lnPlabor | -0.162*** | 0.037 | -0.230*** | 0.081 | -0.170*** | 0.040 | -0.279*** | 0.092 | -0.170*** | 0.046 |
| lnLand | 1.003*** | 0.051 | 0.970*** | 0.091 | 1.081*** | 0.062 | 1.041*** | 0.099 | 1.088*** | 0.076 |
| lnCaptal | 0.022 | 0.049 | 0.048 | 0.086 | -0.049 | 0.062 | -0.034 | 0.096 | -0.056 | 0.075 |
| Season 2 | -0.267*** | 0.023 | -0.335*** | 0.040 | -0.204*** | 0.027 | -0.381*** | 0.046 | -0.195*** | 0.040 |
| Season 3 | -0.279*** | 0.025 | -0.359*** | 0.045 | -0.216*** | 0.026 | -0.430*** | 0.052 | -0.206*** | 0.040 |
| HQRV | -0.040* | 0.021 | – | | – | | – | | – | |
| *Model properties* | | | | | | | | | | |
| Lambda (λ) | 5.514*** | 0.021 | 6.905*** | 0.039 | 4.277*** | 0.024 | 4.654 | – | 4.264 | – |
| Sigma_u | 0.555*** | 0.017 | 0.677*** | 0.032 | 0.445*** | 0.018 | 0.665*** | 0.016 | 0.446*** | 0.010 |
| Sigma_v | 0.101*** | 0.009 | 0.098*** | 0.016 | 0.104*** | 0.010 | 0.143*** | 0.028 | 0.105*** | 0.010 |
| Rho(w,v) | – | | – | | – | | 0.975*** | 0.142 | 0.262 | 0.500 |
| Probot log*L* | – | | – | | – | | -252.60 | | -202.72 | |

| | | | | | |
|---|---|---|---|---|---|
| SF log*L* | -227.43 | -140.00 | -49.43 | -136.13 | -49.13 |
| Total log*L* | -227.43 | -140.00 | -49.43 | -388.74 | -251.86 |
| LR test | 76.01*** | | | 7.74*** | 0.59 |
| Observations | 841 | 319 | 522 | 319 | 522 |

Note: ***, **, * represent significant levels at 1%, 5%, 10%, respectively.

Source: Author

As expected, all estimates for input prices are negative and significant, except for the seed price coefficient in the non-adopter models. The estimate for the land variable is positive and significant, while the estimate for the capital variable is not. The coefficients for the two-season dummies are negative and significant in all models, implying that variable profit tends to be lower outside the main growing season. The coefficient for the dummy variable of HQRV in the pooled models is negative and significant, implying that HQRV adopters exhibit lower profits than non-adopters.

Then, the stochastic meta-frontier model is run to calculate the technology gap ratio (Table 2.3). As expected, all coefficients for input prices, fixed cost, and season dummy variables are significant at the 1% level and consistent across models. The parameter estimates of sigma_u and lambda differ significantly from zero at the 1% level, capturing statistical evidence for the technology gap between the two groups.

Table 2.3 Estimates of stochastic meta-frontier model.

| Variable | Full sample | | Matched sample | |
|---|---|---|---|---|
| | Coef.[†] | S.E. | Coef.[†] | S.E. |
| Constant | 10.079*** | 0.047 | 10.007*** | 0.042 |
| lnPseed | -0.067*** | 0.005 | -0.069*** | 0.005 |
| lnPfertilizer | -0.338*** | 0.009 | -0.332*** | 0.007 |
| lnPlabor | -0.209*** | 0.005 | -0.180*** | 0.005 |

| | | | | |
|---|---|---|---|---|
| lnLand | 1.046*** | 0.007 | 1.068*** | 0.006 |
| lnCapital | -0.035*** | 0.006 | -0.043*** | 0.006 |
| Season 2 | -0.268*** | 0.005 | -0.261*** | 0.005 |
| Season 3 | -0.285*** | 0.005 | -0.273*** | 0.005 |
| *Model properties* | | | | |
| Lambda (λ) | 7.316*** | 0.004 | 11.906*** | 0.003 |
| Sigma_u | 0.097*** | 0.003 | 0.096*** | 0.003 |
| Sigma_v | 0.013*** | 0.002 | 0.008*** | 0.001 |
| Log-likelihood | 1,433.31 | | 1,307.76 | |
| Observations | 957 | | 841 | |

Note: ***, **, * represent significant levels at 1%, 5%, 10%, respectively.

Source: Author

In summary, Table 2.4 compares the profit efficiency between adopters and non-adopters estimated in all SF models. The result shows that HQRV adopters perform less profit-efficiently than non-adopters, and that profit efficiency gaps between the two groups are significantly underestimated if selection biases and technology gaps are not considered. Specifically, without controlling for any self-selection bias and technology gap (Model 1), the average profit efficiency scores for adopters and non-adopters are 0.67 and 0.70, respectively, with a profit efficiency gap of 4.6%. When selection bias from observable and unobservable factors was controlled (Model 4), the profit efficiency gap increased to around 9.5%, with mean profit efficiency scores of 0.68 for adopters and 0.75 for non-adopters. However, that direct comparison between the two groups is not accurate because it faces the problem of a technology gap. After correcting for the technology gap (MPE in Model 5), the mean profit efficiency for adopters and non-adopters are 0.61 and 0.72, with a profit efficiency gap of 15.4%.

Table 2.4 PE scores for adopters and non-adopters from SF models.

| Model | Adopter | | Non-adopter | | Difference in mean | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean (%) | *t*-statistic† |
| 1. Full sample Pooled PE | 0.67 | 0.21 | 0.70 | 0.15 | -0.03 (-4.55%) | -2.76*** |
| 2. Matched sample Pooled PE | 0.69 | 0.20 | 0.72 | 0.15 | -0.03 (-4.06%) | -2.42** |
| 3. Conventional PE | 0.67 | 0.19 | 0.75 | 0.15 | -0.08 (-10.64%) | -6.75*** |
| 4. Sample selection PE | 0.68 | 0.19 | 0.75 | 0.15 | -0.07 (-9.50%) | -6.12*** |
| 5. TGR | 0.89 | 0.06 | 0.96 | 0.03 | -0.07 (-6.87%) | -20.19*** |
| MPE | 0.61 | 0.17 | 0.72 | 0.14 | -0.11 (-15.36%) | -9.90*** |
| Observations | 319 | | 522 | | | |

Note: ***, **, * represent significant levels at 1%, 5%, 10%, respectively.

Source: Author

The difference in profit efficiency scores between the two groups is also shown in Figure 2.4, which presents the distribution of profit efficiency scores between HQRV adopters and non-adopters. The distribution for the adopter group is more dispersed to the lower value range, implying an overall lower profit efficiency performance than the non-adopter group. This suggests that there is statistical evidence supporting the negative impact of HQRVs on farmers' profit efficiencies.

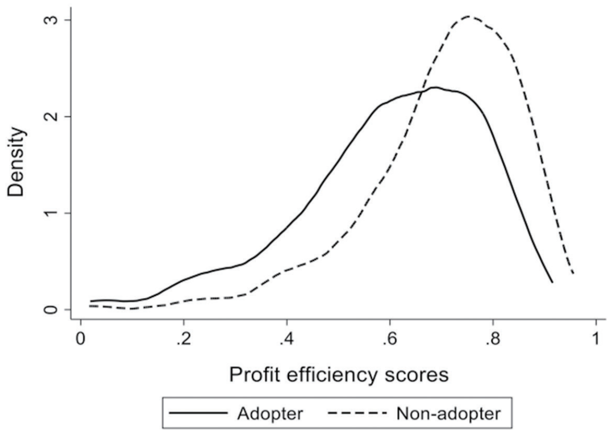


Figure 2.4 Distribution of profit efficiency scores for adopters and non-adopters.
Source: Author

The results from Table 2.5 show the effects of HQRV adoption on farmers' variable profit. The result shows that the difference in actual (observed) variable profit between adopters and non-adopters is around 10.5%. It is obvious that this profit gap is not as attractive as expected (around 30%). This can be a possible reason why the adoption rate of HQRV is not high. However, the underlying reason is that HQRV adopters perform less efficiently, which makes their profit efficiency lower than non-adopters. After correcting for self-selection biases arising from observed and unobserved heterogeneity and the technology gap, the profit gap increases to around 28%. Particularly, the maximum variable profit for adopters can be 1,741 USD/ha and higher by 28% compared to non-adopters (1,358 USD/ha). Currently, compared to the frontier, adopters can lose 655 USD/ha while non-adopters can lose 376 USD/ha.

Table 2.5 Effects of HQRV adoption on farmers' variable profit.

| Variable | Adopter | | Non-adopter | | Difference | |
|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | (%)† |
| Observed variable profit (USD/ha) | 1,085 | 463 | 982 | 363 | 103 | (10.49%)*** |
| Frontier variable profit (USD/ha) | 1,741 | 474 | 1,358 | 404 | 382 | (28.12%)*** |
| Variable profit loss (USD/ha) | 655 | 272 | 376 | 192 | 279 | (74.20%)*** |
| Observations | 319 | | 522 | | | |

Note: ***, **, * represent significant levels at 1%, 5%, 10%, respectively.

Source: Author

## 6. Conclusion

This study analyzes the impacts of HQRVs on rice farmers' profit and profit efficiency performance and investigates the determinants of HQRV adoption decisions.

The results show that farm size, rice plots, contract farming, regions, and seasons significantly influence HQRV adoption decisions. The observed variable profit of HQRVs (per ha) is only 10.5% higher than that of conventional varieties, not as high as expected. This is explained by the fact that HQRV adopters perform 15.4% less efficiently (0.61) than non-adopters (0.72). If inefficiency were eliminated, HQRV adopters could achieve around 28% (382 USD/ha) higher variable profit than non-adopters.

The results suggest that to better exploit the potential of HQRVs, policies should be targeted to improve rice farmers' profit inefficiency and promote the adoption of HQRVs. The findings recommend that policies should consider increasing farm size and contract farming to promote the adoption of HQRVs. In addition, HQRVs should be developed to be better adapted to adverse production conditions.

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# Chapter 3
# Drought Effect and Adaptation of Farmers in Northeast Thailand

Orawan SRISOMPUN

**Abstract:** The drought situation in Thailand tends to increase in frequency. In 2019, Thailand experienced its worst drought in four decades. Most of the drought-affected plantations are in the Northeast. So, drought stress has extensively affected the farmer households with high levels of vulnerability to poverty in Northeast Thailand. This study analyzes the effect and adaptation of drought on farmer households in the study area. The results revealed that 80% of the farmers affected by drought in 2019 were small farmers. On average, the decline in paddy yields caused by drought ranged from 1,757 to 4,661 kilograms per household (equating to approximately 25,840–50,171 Thai baht per household). In addition, drought caused 30.12% of farmers in recognized drought areas to have insufficient rice available for consumption. The agricultural income of farmer's households in declared drought areas diminished from 27.82% to 20.49% of total income. Farmers in irrigated areas adapted most effectively to drought by suspending rice growing, searching for additional water sources, adjusting the growing period, reducing the amount of land used for rice growing, adjusting the rice ecotypes cultivated, cultivating different plants instead of rice, and temporarily changing to rearing livestock and other occupations. However, more than 50% of farmers lacked crop insurance because insurance premiums may increase the cost of rice growing. Although the Thai government has continued measures to mitigate the effects of drought, they failed in the long term. It is necessary to have a long-term

plan and extensive investment in drought management, as well as to adjust stakeholders' strategies throughout the supply chain.

## 1. Introduction

The frequency of drought situations in Thailand is tending to increase. In 2019, Thailand experienced its worst drought in four decades. The drought-affected rice cultivation area is about 3.90 million rai (1 rai=0.16 hectare), or about 6.60% of the country's rice-cultivated area. The amount of damage is estimated to be approximately 8,900 million Thai baht. Most of the drought-affected plantations were in the Northeast regions. In 2015, 2018, and 2019, approximately 62.58%, 94.36%, and 76.29% of the total drought-affected rice plantations were in the Eastern region. The total damage from the drought was 3,649 million Thai baht, or accounted for 40.62% of the total damage value of the country. The Northeast regions have had a serious drought for a long time and face problems with poverty and low rice yields (Figure 3.1).

Figure 3.1 Farmers coping with drought. Source: Author

A serious drought in Thailand in 2019 caused a shortage of water supply for agriculture. Especially, lack of water and weed problems in rice fields are emerging issues. Consequently, the quantity and quality of rice are adversely affected. In the Northeast region, the main purpose of rice cultivation is mainly for household consumption. If there is rice left over from consumption and it is assured that the following year's rice yield will be sufficient for consumption, then the farmer will sell the remaining rice to the market. Therefore, drought affects not only household income but also food security. To cope with drought and its impacts, farmers applied a variety of coping strategies. They included additional water sources, adjusting the growing period, reducing rice area, changing to other plants, keeping livestock and other occupations. The ability for adaptation is different between resource-based, economic-based, and social characteristics. The conceptual framework of this study is shown in Figure 3.2.

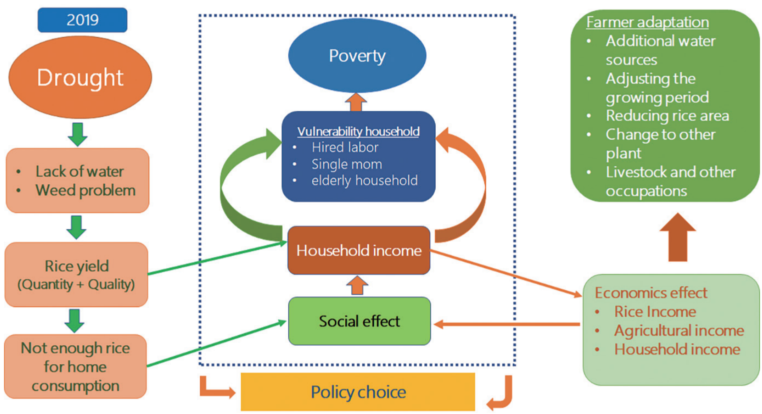


Figure 3.2 Conceptual framework. Source: Author

This study aims to (1) understand the economic and social impacts of the drought situation on farmer households in the Northeast, (2) analyze the pattern of drought adaptation among farmer households in the Northeast, and (3) analyze the factors affecting the farmers' adaptation to drought problems in the Northeast.

## 2. Data, Sampling, and Study Area

The sampling method used in this research is the three-step stratified sampling technique. The first step is to determine the target province in the survey by integrating data from three sources: the Department of Agricultural Extension, the Department of Land Development, and the Department of Disaster Prevention and Mitigation (DDPM) (Table 3.1).

Table 3.1 Target province in the survey

| No. | Province | Department of Agricultural Extension | | | Department of Land Development | DDPM | Score |
|---|---|---|---|---|---|---|---|
| | Year | 2019 | 2018 | 2017 | 2004–2014 | 2019 | (Maximum = 5) |
| 1 | Khonkaen* | ☑ | ☑ | ☑ | ☑ | ☑ | 5* |
| 2 | Chaiyaphom* | ☑ | - | - | ☑ | ☑ | 3* |
| 3 | Burirum* | ☑ | ☑ | ☑ | ☑ | ☑ | 5* |
| 4 | Nakonratchasima* | ☑ | - | ☑ | ☑ | ☑ | 4* |
| 5 | Mahasarakham* | ☑ | ☑ | ☑ | ☑ | ☑ | 5* |
| 6 | Nongkai | ☑ | - | - | - | ☑ | 2 |
| 7 | Buengkan | ☑ | - | - | - | ☑ | 2 |
| 8 | Nakornphanom* | ☑ | - | ☑ | ☑ | - | 3* |
| 9 | Sisaket* | - | ☑ | ☑ | ☑ | ☑ | 4* |
| 10 | Surin* | - | ☑ | ☑ | ☑ | - | 3* |

Source: (Srisompun 2021)

The second step is to select the target district from the Department of Agricultural Extension database.

The final step is to select the target district (Department of Agricultural Extension database and suggestions from local government staff). The samples were divided into two groups: 1) the farmers affected by drought and 2) the unaffected by drought group, the sampling method for each group is as follows:

1. Sub-districts representing drought-affected areas must be sub-

districts that have been affected by drought for at least two years during the past five years (2015–2019); choose one study area in each province. A total of eight sub-districts were involved.

2. Sub-districts representing areas not affected by drought must be sub-districts with no drought-affected areas during the past five years (2015–2019); select one study area in each province. A total of eight sub-districts were involved (Figure 3.3).
3. Samples are randomly drawn from the list of farmers receiving drought compensation. (Department of Agricultural Extension in 2019)

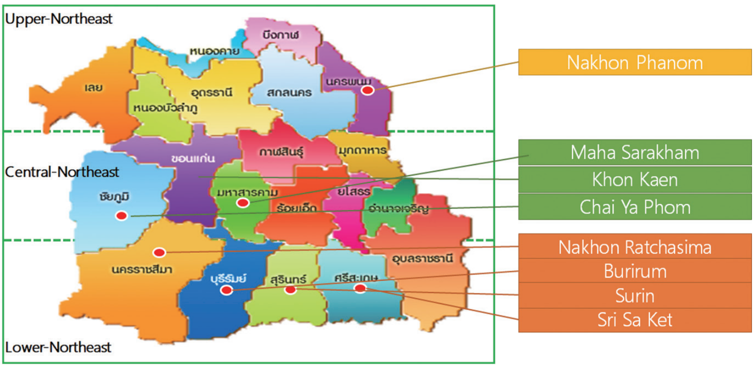


Figure 3.3 Research areas. Source: Adapted from (Boonmas 2021)

This study uses both secondary and primary data. Primary data was collected from 600 questionnaires of farmers in irrigated and rainfed areas of the Northeast region including eight provinces of Nakhon Phanom, Maha Sarakham, Khon Kaen, Chai Ya Phom, Nakhon Ratchasima, Burirum, Surin, and Sri Sa Ket.

Factors affecting decision-making on adaptation among farmers in drought situations were analyzed using the logistic regression model.

# 3. Economic and Social Effects of Drought on Rice Farm Households

## (1) Drought Effect on Farmers in Northeast Thailand

According to surveyed data, 80% of the farmers affected by drought in 2019 were small farmers. Thailand has been suffering from continuous drought since 2015, with severe impacts on rice production. During 2015–2020, most of the surveyed farmers experienced serious impacts, especially farmers in rainfed areas (Figure 3.4).

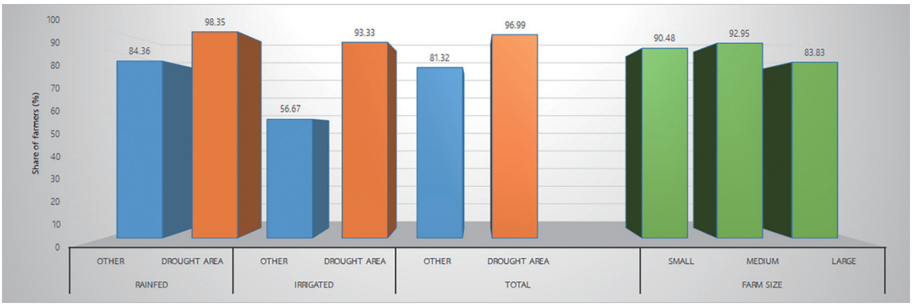


Figure 3.4 Proportion of sample farmers who have been affected by drought in the past six years (2015-2020), by production environment and farm size. Source: (Srisompun 2021)

Paddy quality and yield loss caused by drought varied by farm size. During the serious drought in 2019, farmers faced a water shortage for rice cultivation. Consequently, the lack of water adversely affected rice yield. The average rice yield per Rai and per household in drought-declared 2019 areas was lower than in 2020 in all production environments (i.e., rainfed and irrigated) (Figure 3.5). For small farms, rice productivity in 2019 was also lower than in 2020.

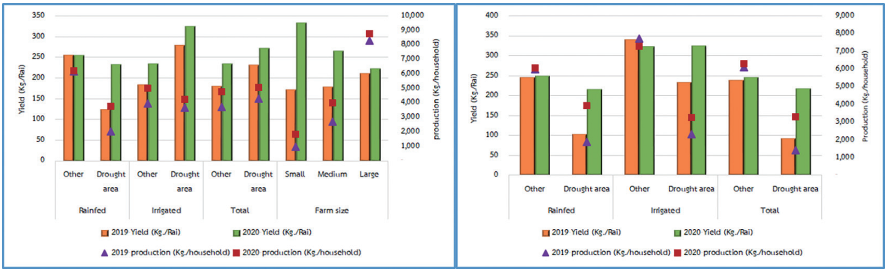


Figure 3.5 Average rice yield of sample farmers in 2019-2020 classified by production environment, type of water source, and farm size. Source: (Srisompun 2021)

The amount of yield and the damage value of rice yield from drought are directly proportional to the size of the planting area. Especially, yield and rice values of small farms are observed to be lower than those of large farms, and the rice yield of large farms is the highest in terms of both quantity and value. On average, the decline in paddy yields caused by drought ranged from 1,757 to 4,661 kilograms per household (equating to approximately 25,840–50,171 baht per household). (Figure 3.6).

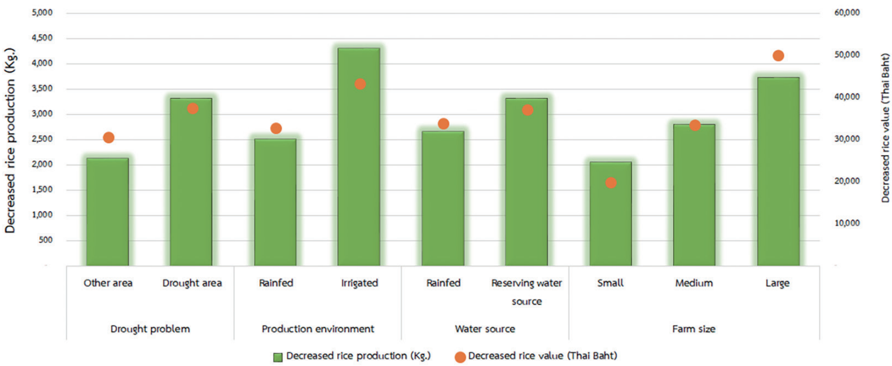


Figure 3.6 The impact of drought in 2019 on the quantity and value of rice yields. Source: (Srisompun 2021)

As mentioned above, rice farmers in Northeast Thailand grow rice not only for commercial use but also for household consumption. When there is excess rice left over from consumption and it is assured that the following year's rice yield will be sufficient for consumption, they will decide to sell the remaining rice to the market. Therefore, serious droughts in Northeast Thailand adversely affect not only households' incomes but also their food security. According to the surveyed result, drought caused 30.12% of farmers in recognized drought areas to have insufficient rice for household consumption. When comparing the proportion of farmers whose rice yield was insufficient for consumption, it was found that the drought-prone areas had a higher proportion of farmers who were affected than in other areas. Farmers in the rainfed areas had a higher percentage of rice damage than those in irrigated areas. Regarding farm size, there was the highest proportion of farmers whose rice production was insufficient for household consumption, although rice production of small farmers was less affected than that of large-scale farmers (Figure 3.7).

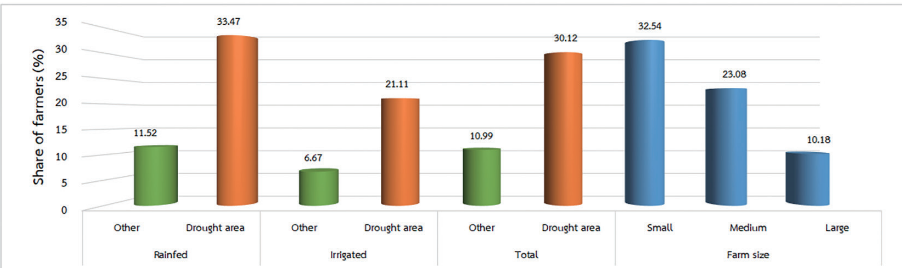


Figure 3.7 Proportion of sample farmers whose drought problems resulted in insufficient rice production for household consumption in 2019. Source: (Srisompun 2021)

To solve the problem of insufficient rice production for household consumption, most farmers decided to buy milled rice from the market, while others decided to buy rice from other farmers or borrow from neighbors or other farmers in the village (Figure 3.8). Especially in some villages, there are rice bank projects that provide rice for farmers who do not have enough rice for household consumption. However, some farmers became worried about the duration of these projects and thought that they would continuously face insufficient rice for household consumption when these projects ended.

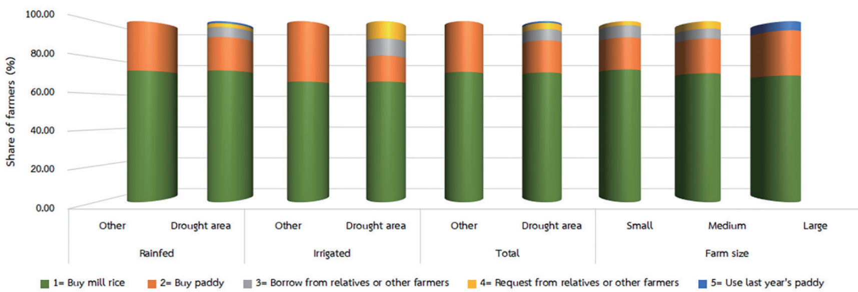


Figure 3.8 Methods for solving the problem of insufficient rice production for household consumption of the sample farmers in 2019. Source: (Srisompun 2021)

The drought affects not only agriculture but also the natural food supply. The result from Figure 3.9 shows that drought-prone areas had the greatest proportion of farmers affected by the decline in natural food supply. There were 8.13% of farmers who experienced an average decrease in the value of food at about 394 Thai baht per household per year. Farmers in irrigated areas had the largest decline in food value. Meanwhile, small-scale farmers were seriously affected by drought and had lower yield values than medium- and large-scale farmers. Most of the small farms are tended by farmers who practice subsistence farming and do not focus on commercial production.

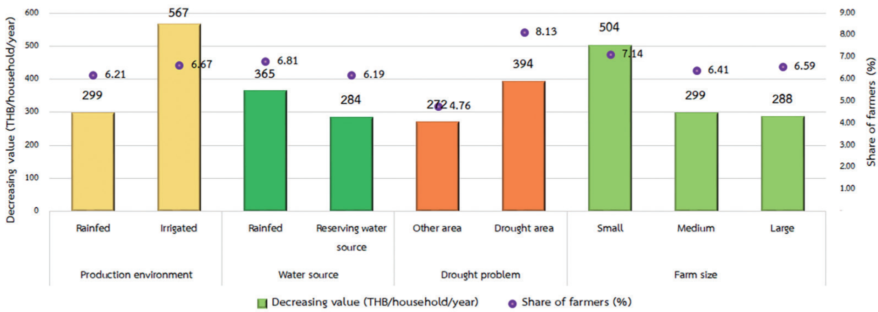


Figure 3.9 The proportion of farmers and the value of food for household consumption decreased by the drought problem in 2019. Source: (Srisompun 2021)

Household income significantly varies by farm size. Large-scale farmers had the highest average household income of 237,645 Thai baht/year (44.25% of total income is agricultural income) (Table 3.2). In 2019, the impact of the drought resulted in severe damage to rice yields and a sharp drop in rice farming incomes. Especially in drought-prone areas, net income from rice cultivation in 2019 decreased by 7,157 Thai baht per household and lower than income from rice in 2020 by about 14,392 Thai baht per household. As a result, the proportion of income from the agricultural sector in 2019 of farmers in drought-declared areas (year experiencing drought) decreased from 27.82% to only 20.49% of total income. In that case, income from non-agricultural sectors has become an important source of income for farmers. The cultivation of other crops such as rubber, sugarcane, cassava, and maize are the main sources of income for most farmers in the study area, especially in areas where farmers do not suffer from drought or unstable weather. Other income sources are about 23,000 Thai baht per household on average, accounting for 10.11–12.90% of total income. However, the income of farmers was affected not only due to the decrease in rice production but also due to the decline in the production of other crops, it was found that, for example, in 2019, farmers earned an average of only 5,969 Thai baht per household or 3.87% of their total income. Table 3.2 reflects a clear picture of the impact of drought on household income sources in the agricultural sector.

Table 3.2 Income and sources of income of sample farmer households for the year 2019-2020 classified by declared drought areas.

| **Source of household income** | **Income (Share (%))** | | | |
|---|---|---|---|---|
| | **Other areas** | | **Declared drought areas** | |
| | **2019** | **2020** | **2019** | **2020** |
| Agricultural net income | 45.51 | 41.02 | 20.49 | 27.82 |
| - Rice income | 19.88 | 15.69 | -4.64 | 4.99 |
| - Other crops | 10.11 | 12.90 | 3.87 | 8.88 |
| - Livestock/fishery | 3.88 | 1.81 | 4.28 | 0.63 |
| - Other farm incomes | 6.30 | 5.43 | 9.18 | 7.98 |
| - Non-farm income | 5.34 | 5.19 | 7.80 | 5.35 |
| Non-agricultural net income | 54.49 | 58.98 | 79.51 | 72.18 |
| Income from non-agricultural labor (daily) | 8.37 | 7.76 | 11.45 | 9.62 |
| Salary | 17.27 | 19.92 | 27.31 | 26.59 |
| Trading/Business/Services/Handicrafts | 11.94 | 11.97 | 11.82 | 8.90 |
| Remittance | 11.44 | 13.24 | 17.43 | 15.83 |
| Government support | 3.36 | 4.23 | 5.40 | 5.56 |
| Other income | 2.12 | 1.86 | 6.10 | 5.67 |

Source: Author

Farmers with large plantations had the highest average household income of 237,645 baht per year, with income from agriculture at 44.25% of total income. Farmers with large farms have a lower reliance on non-farm income than small and medium-sized farms, where the proportion of non-farm income is as high as 72.03% and 71.50% of total income. In addition, when calculating the change in household income by comparing the year that farmers experienced severe drought (2019) and the current year (2020), it was found that the source of income from the agricultural sector in 2019 was lower than in 2020, especially income from rice and income from other crops. The decline in income becomes more serious among small and medium-sized farms than large farms. Especially, in drought periods, rice income from small and medium farms decreased by 5,157 Thai baht per year and 6,388 Thai baht per year, respectively. Moreover, small farms accounted for a decrease in remittance income (Figure 3.10).

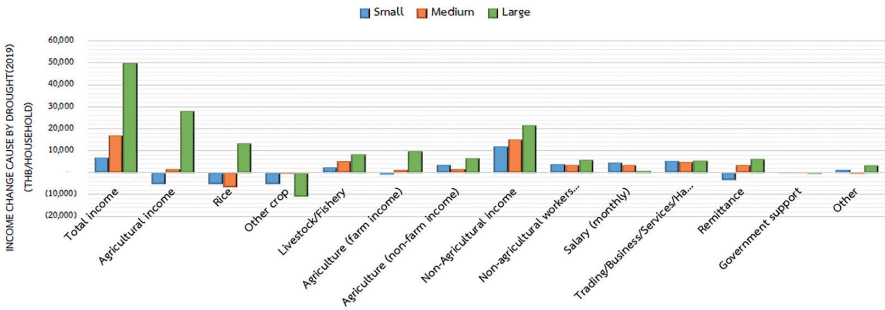


Figure 3.10 Changes in household income in the year of drought (2019), by farm size. Source: Author

Note: Change in income = 2019 household income (drought year) – 2020 household income (non-drought problem)

Large and medium farms had the greatest proportion of farmers whose rice income was reduced by drought (40.12% and 40.06% of those in the group, respectively). Moreover, the decrease in rice yields of large farms in 2019 was less than that of other sized farms, but the price of rice that farmers received in 2019 was higher than in 2020. Therefore, farmers with restricted arable land could earn more from rice in 2019 than in 2020, despite the drought. This is because the average yield was not much different. Despite being offset by higher rice prices, the drought did not affect the average income of large farmers (Figure 3.11).

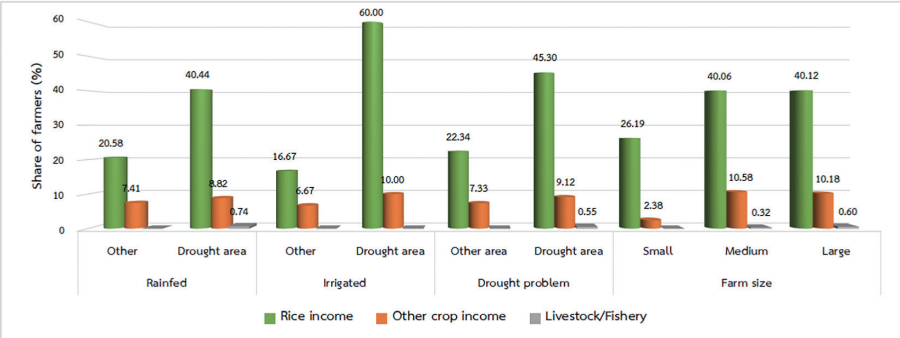


Figure 3.11 Proportion of sample farmers whose household income is affected by drought. Source: Author

## (2) The Factors Affecting Farmers' Adaptation to Drought

Farmers' ability to adapt and cope with the effects of drought varies by the resource base, the economic base, and the social characteristics of the household. The survey data revealed that the proportion of farmers in irrigated areas affected by drought had the greatest proportion of farmers who adapted to drought (Figure 3.12).

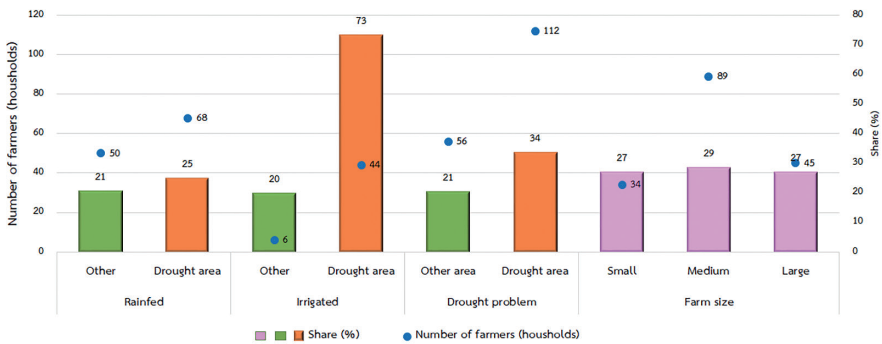


Figure 3.12 Proportion of sample farmers adapted to drought problems. Source: Author

Farmers in the study areas also adapted to drought in various ways, including suspending rice growing, finding additional water sources (for example, digging ponds, wells, or groundwater), adjusting the time of planting or slowing the rice sowing. Some others have reduced the number of rice cultivation areas, adjusted the use of rice varieties, adjusted the types of crops that are grown instead of rice or turned to keeping livestock instead of growing rice, especially in the rainfed area. Some farmers turned to other occupations outside of the agricultural sector instead during water shortages (for example, hiring for construction, trading, housework, security, sewing, other handicrafts, selling food, driving a car, or working as hired labor in the agricultural sector.) Although a greater proportion of small farmers are affected by drought, the adaptation ratio of farmers was not different according to farm size (Figure 3.13).

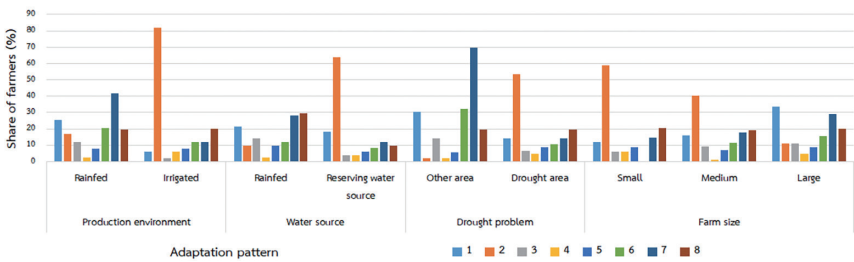


Figure 3.13 Adaptation pattern to drought problems of farmers in study area. Source: Author

Note: Adaptation patterns: 1. Search for additional water sources; 2. Stop growing rice; 3. Adjust the growing period; 4. Reduce the rice area; 5. Adjust the rice cultivars; 6. Cultivate different plants instead of rice; 7. Change to livestock; 8. Change to other occupations

The estimated results (Table 3.3) using the logistic regression model revealed that the factors affecting farmers' decision-making to adapt to drought were statistically significant. They included production environment (rainwater/irrigation), number of years experiencing drought, commercial rice cultivation, main income from non-agricultural sectors, planning to expand the production area in the farm (cultivation/raising animals), planning for the offspring to inherit agriculture careers and the number of smartphones in a household.

Table 3.3 Factors affecting to decision-making on drought adaptation of farmers in the study area.

| **Variable** | **Mean** | **Std. Err.** | **Coefficient estimates** | | **Marginal effect model** | |
|---|---|---|---|---|---|---|
| | | | Coef. | Std. Err. | Coef. | Std. Err. |
| **Human capital** | | | | | | |
| Sex | 0.613 | 0.021 | 0.037 | 0.191 | 0.009 | 0.047 |
| Age | 0.470 | 0.021 | -0.322* | 0.191 | -0.079* | 0.047 |
| Natural capital | | | | | | |
| Dummy of drought declared area | 0.578 | 0.021 | 0.268 | 0.197 | 0.066 | 0.048 |
| Production environment | 0.182 | 0.016 | 1.342*** | 0.297 | 0.328*** | 0.072 |
| The number of droughts (2015–2020) | 2.250 | 0.045 | 0.172* | 0.089 | 0.042* | 0.022 |
| **Economic capital** | | | | | | |
| Growing rice for commercial | 0.564 | 0.021 | 0.520*** | 0.201 | 0.127*** | 0.049 |
| Main income from non-agricultural sector | 0.223 | 0.018 | 0.646 | 0.237 | 0.158 | 0.058 |
| Access to agricultural credit | 0.595 | 0.021 | 0.313 | 0.195 | 0.077 | 0.048 |
| **Social capital** | | | | | | |
| Farming career is stable | 0.899 | 0.013 | -0.058 | 0.326 | -0.014 | 0.080 |
| Planning to expand the rice field | 0.541 | 0.021 | 0.372* | 0.198 | 0.091* | 0.048 |
| Planning for the children to inherit the agricultural career | 0.719 | 0.019 | -0.186 | 0.225 | -0.045 | 0.055 |
| A member of a farmer's group | 0.879 | 0.308 | -0.021 | 0.014 | -0.005 | 0.003 |
| Number of smartphones | 0.250 | 0.034 | 0.261** | 0.129 | 0.064** | 0.032 |
| Constant | | | -1.040*** | 0.402 | | |
| Log likelihood = -353.930 | | | LR $\lambda^2$ = 79.46*** | | Pseudo $R^2$ = 0.1044 | |

Source: Author

## 4. Conclusion and Policy Implications

The drought situation in Thailand tends to increase in frequency. In 2019, Thailand experienced its worst drought in four decades. 80% of the farmers affected by drought in 2019 were small farmers. Rice quality and yield loss caused by drought varied by farm size. On average, the decline in paddy yields caused by drought ranged from 1,757 to 4,661 kg per household (approximately 25,840–50,171 Thai baht per household). Drought caused 30.12% of farmers in recognized drought areas to have insufficient rice available for consumption; accordingly, 8.13% of farmers experienced reduced food sources, worth 394 Thai baht per household a year. The agricultural income of rice farm households in declared drought areas diminished from 27.82% to 20.49% of total income. The Northeast region of Thailand is a significant area for quality rice cultivation. Rice is not only the main household income for small-scale farms, but also an important staple food for this region's residents.

To cope with the impacts of drought, farmers in the study areas performed various adaptation measures including stopping rice growing, finding additional water sources (for example, digging ponds, wells, or groundwater), adjusting the time of planting or slowing the rice sowing, reducing the number of rice cultivation areas, adjusting the use of rice varieties, adjusting the types of crops that are grown instead of rice, or turned to keeping livestock instead of growing rice, especially in the rainfed area. Some farmers decided to turn to other occupations outside of the agricultural sector instead during water shortages. To mitigate the effects of drought, the requirements of some projects were consistent with the demands of farmers. A long-term plan and extensive investment in drought management are necessary. The drought allocation budget process should begin with community-based research to be consistent with the needs and conditions of drought problems in each area.

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# Chapter 4
# Rice Production for Sustainable Agriculture: Case Studies in Vietnam and Japan

Thanh Tam HO

**Abstract:** As climate change poses significant challenges to global food security and safety, strategic policies to mitigate food safety risks while minimizing environmental impacts in the era of climate change are becoming more important. Sustainable agriculture is a potential solution for sequestering carbon as climate change mitigation, improving environmental health and economic performance, as well as satisfying society's need for food security. This research reports on two case studies. The first case will present climate change responses in the Mekong Delta, Vietnam. To cope with more frequent and serious salinity intrusion and drought, national policies promote mitigation strategies with the aims of reducing GHGs emissions and managing resource uses as well as promoting adaptation strategies as emergent action for farmers to effectively reduce climate change vulnerability and enhance resilience. Especially, this study will focus on how these climate change responses could improve the economic performance of rice farmers. The second case will introduce the development of sustainable agriculture, especially sustainable rice in Shiga Prefecture, where the unique policy of direct payment was the earliest and most advanced in Japan and has since been popularly adopted at the national level. The study concludes with policy implications for both cases.

## 1. Introduction

In the era of climate change, our food security and safety are being seriously threatened, while at the same time, it is becoming increasingly challenging to devise strategies to mitigate food safety risks while minimizing the environmental impacts. Sustainable agriculture can be part of the solution.

In Vietnam, due to serious droughts and extreme weather events during 2016–2017, rice production was remarkably reduced. Meanwhile, in Japan, heavy rains and windy storms caused by five typhoons and rainy season fronts brought about 126.4 billion Japanese yen in agricultural damage in 2017 (MAFF 2018). Consequently, rice production was also affected in both countries (Figure 4.1).

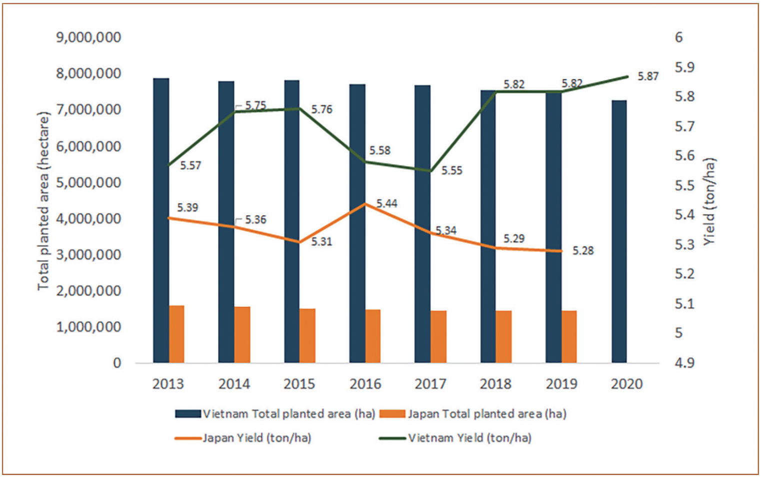


Figure 4.1 Rice production in Japan and Vietnam during 2013–2019.
Source: Author

In Vietnam, rice is the most important crop, occupying more than 90% of total grain food. Vietnam is the world's third major rice exporter. In 2020, the country exported 6.2 million tons (3.1 billion USD), accounting for 13.8% of total production. Recently, Japan's rice exports have grown further. 7,640 tons of Japanese rice were exported in 2015. In 2020, Japan exported 19,700 tons of rice (47.79 million USD), accounting for 0.2% of total production (Figure 4.2).

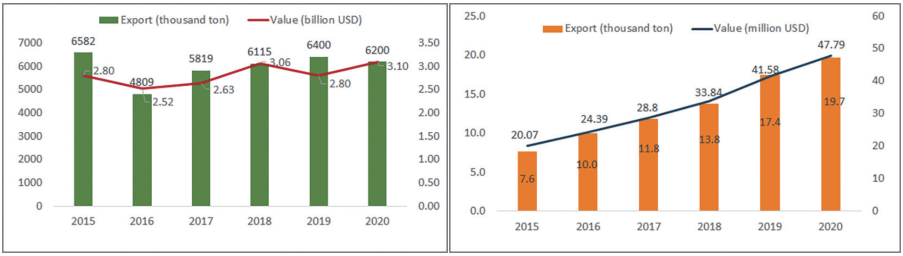


Figure 4.2 Rice exports in Vietnam and Japan. Source: Author

There are several problems in rice production in both Vietnam and Japan. In Vietnam, serious climate change and extreme weather events (i.e., drought, salinity intrusion), the low efficiency of rice farming (i.e., overuse of inputs such as fertilizers and chemical uses), and low quality of rice are the three main concerns. Whilst, in Japan, a decreasing demand for rice in the domestic market, an aging population, and a decreasing labor force for agricultural sectors are the main constraints. This study aims to give an overview by measuring the effects of climate change responses on rice production in Vietnam and a review of the sustainable agriculture and promotion policy of rice in Japan.

## 2. A Case Study in Vietnam

### (1) Background

The Mekong Delta in Vietnam is one of the biggest rice production regions (GSO 2018), contributing 52% of the total rice production of the country, ensuring livelihoods for 60% of its regional residents. Also, it is one of the most vulnerable regions to climate change and sea-level rise in the world (Yusuf and Francisco 2010). Rice production potential in Vietnam is forecast to decline by up to 50% by the year 2100. To cope with climate change and its adverse impacts, adaptation and mitigation are emergent responses to enhance the resilience of the agricultural sector, protect the livelihood of poor communities, and ensure food security and the environment. Therefore, it is necessary to investigate the effects of climate change responses on rice farming in the Mekong Delta of Vietnam.

### (2) Data and Method

#### 1) Data Collection

The cross-section data of 352 rice farmers in the study were collected from the field survey in three provinces in the Mekong Delta: Long An, Ben Tre, and Tra Vinh in February 2018. These three provinces were purposively selected as the case studies because they are representative of each group of low, medium, and high levels of vulnerability to climate change and have intensive rice farming (2-3 cropping seasons per year). In each province, two districts were randomly selected, and then two communities were chosen from each district.

#### 2) Research Approach and Method

Decisions in response to climate change depend on a farmers' ability and motivation. In addition, their ability and motivation also contribute to different farm performances regarding their choices (i.e., self-selection). These could lead to selection bias. Therefore, the multinomial endogenous treatment effect model (Multinomial ETEM) (Deb and Trivedi 2006a; 2006b) is used to estimate the effects of climate change responses on rice farming and the propensity score analysis for categorical treatment (Inverse Probability Weighting, IPW) (Guo and Fraser 2015) is also used to check the robustness of the estimated results.

### 3) The Effects of Climate Change Responses

According to the surveyed data, 71% of farmers implemented climate change responses and 29% did not implement any response. Climate change responses are different across geographical locations (i.e., provinces with different levels of vulnerability to climate change). Those climate change responses are divided into four main groups: (1) crop management (i.e., changing rice varieties, changing fertilizer and chemical use, or applying integrated pest management (IPM)), (2) water management, (3) income diversification, and (4) soil conservation (i.e., reduce the farming area of rice, soil preparation) (Figure 4.3).

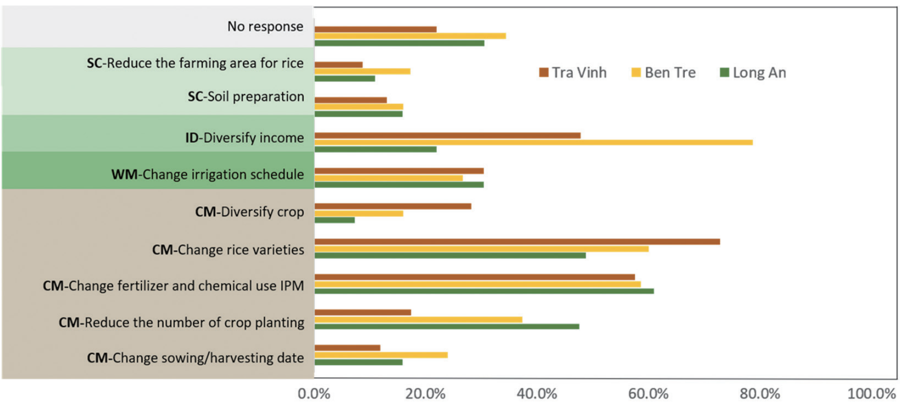


Figure 4.3 Climate change responses by local Vietnamese farmers. Source: Author
Note: SC – Soil conservation package; ID – Income diversification package; WM – Water management package; CM – Crop management package

The key determinant of multiple choices of climate change responses (i.e., one package, two packages, and three or more packages) is sources of information on climate change response. Education and farm size are also found to influence the multiple choices among rice farmers. Furthermore, geographical locations (i.e., provincial level or vulnerability level and access to water sources) significantly drive the choice of multiple climate change responses among rice farmers (Table 4.1).

Table 4.1 Determinants of multiple choices of climate change responses.

| Covariate | Category 1 | Category 2 | Category 3 | Category 4 |
|---|---|---|---|---|
| Education | 0.00 (0.06) | -0.22* (0.12) | 0.03 (0.06) | 0.04 (0.06) |
| Age | 0.01 (0.02) | -0.04 (0.03) | -0.00 (0.02) | -0.02 (0.02) |
| Information on CC responses | 0.83** (0.37) | 1.22** (0.72) | 0.66* (0.38) | 1.21*** (0.38) |
| Asset | -0.00 (0.00) | -0.01 (0.01) | -0.01 (0.01) | -0.00 (0.00) |
| Farm size | 0.09 (0.15) | 0.11 (0.27) | 0.09 (0.17) | 0.28** (0.16) |
| Region (Low vulnerability) | -0.27 (0.42) | 0.71 (0.89) | -0.89* (0.7) | -1.07** (0.49) |
| Region (Medium vulnerability) | -2.02*** (0.50) | -0.51 (0.95) | -0.39 (0.44) | -0.34 (0.45) |
| Access to water (Near) | 1.46** (0.72) | 1.06 (1.21) | 1.19* (0.70) | 0.35 (0.68) |
| Access to water (Medium) | 1.54** (071) | -0.23 (1.36) | 1.12* (0.70) | 0.87 (0.67) |
| Constant | -2,09 (1.27) | -0.58 (2.22) | -1.45 (1.26) | -0.72 (1.15) |
| Likelihood-ratio $chi^2$ (32) | 187.27 | | | |
| Probability > $chi^2$ | 0.00 | | | |
| Pseudo $R^2$ | 0.08 | | | |
| Observations | 90 | 12 | 76 | 71 |

Note: ***, **, and * represent significant levels at 1%, 5%, and 10% respectively. Category 1 - A package related to crop management; Category 2 - A package related to water management, income diversification, or soil conservation; Category 3 - Two packages; Category 4 - Three or more packages. Source: Author

To measure the benefits of climate change responses on the outcome of rice farming, both the multinomial ETEM and propensity score matching (i.e., IPW) are applied. The multinomial ETEM shows a more reliable result compared to the IWP estimates. One up to multiple packages of climate change coping practices can significantly improve rice yield, profitability, and income, and reduce chemical fertilizer use. A more comprehensive package would not always result in greater profitability than a less comprehensive package (Table 4.2).

Table 4.2 Effects of categorical climate change responses on outcomes of rice farming.

| **Outcome** | **Category 1** | **Category 2** | **Category 3** | **Category 4** |
|---|---|---|---|---|
| **Ln Yield** | | | | |
| IPW | 0.22*** (0.04) | 0.20*** (0.06) | 0.22*** (0.05) | 0.22*** (0.05) |
| Multinomial ETEM | **0.13*** (0.03)** | **0.11*** (0.05)** | **0.13*** (0.03)** | **0.15*** (0.03)** |
| **Ln Profitability** | | | | |
| IPW | 0.46*** (0.11) | 0.46** (0.15) | 0.50*** (0.12) | 0.38*** (0.12) |
| Multinomial ETEM | **0.14*** (0.04)** | **0.11* (0.06)** | **0.14*** (0.04)** | **0.14** (0.04)** |
| **Ln Income** | | | | |
| IPW | 0.72*** (0.16) | 1.50*** (0.15) | 0.80*** (0.18) | 0.99*** (0.17) |
| Multinomial ETEM | **0.19*** (0.05)** | **0.25*** (0.08)** | **0.23*** (0.05)** | **0.26*** (0.05)** |
| **Ln Fertilizer use** | | | | |
| IPW | -0.18*** (0.07) | 0.12 (0.15) | -0.22*** (0.07) | 0.00 (0.01) |
| Multinomial ETEM | **-0.07*** (0.01)** | 0.00 (0.02) | **-0.08*** (0.01)** | -0.01 (0.01) |

Note: ***, **, and * represent significant levels at 1%, 5%, and 10% respectively. Category 1 - A package related to crop management; Category 2 - A package related to water management, income diversification, or soil conservation; Category 3 - Two packages; Category 4 - Three or more packages. Source: Author

## 3. A Case Study in Japan

### (1) Background

Japan is one of the world's top five greenhouse gas (GHG) emitters, with nearly 1,200 million tons of $CO_2$ equivalent in 2019. Especially, GHG emissions from agriculture are the third largest contributor to global warming in Japan (47.44 million tons of $CO_2$), behind the energy and industrial sector. In 2019, the largest source of $CH_4$ emissions was rice cultivation, accounting for 46.2%. Japan is the third largest fertilizer user with nearly 232 kg per ha in 2017 and the second largest pesticide user, with around 11.85 kg per ha in 2014. The overuse of chemical fertilizers and pesticides for a long time has resulted in polluting the air, water, and soil.

### (2) A Review of Sustainable Agriculture and Promotion Policy

The Japanese government has recognized its responsibility to address agri-environmental issues in its domestic agricultural policy. The importance of biodiversity in Japanese rural areas, including paddy fields, has recently attracted more attention. Figure 4.4 shows the historical data of agricultural policies which promote sustainable agriculture involving environmentally friendly agriculture and organic agriculture.

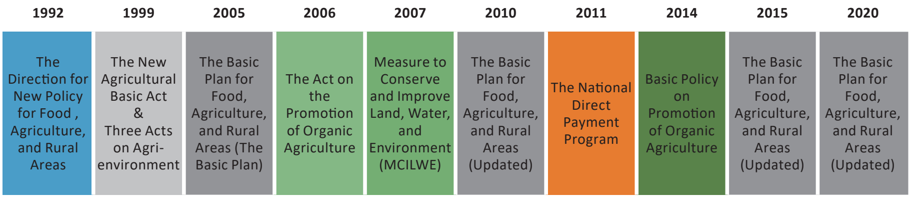


Figure 4.4 Government policy regarding sustainable agriculture in Japan.

Source: Author

The term "environmentally friendly agriculture" was mentioned for the first time in The Direction for New Policy for Food, Agriculture, and Rural Areas by the Ministry of Agriculture, Forestry and Fisheries (MAFF) in June 1992. This policy document was the starting point for the renewal of the Agriculture Basic Act.

Measures for sustainable agriculture during this phase were the dissemination of environmentally friendly farming practices to farmers, and the promotion of farmers' awareness of the environment. Since 1999, the Food, Agriculture, and Rural Areas Basic Act and the Three Acts on Agri-environment have been enacted and seriously focused on promotion and development.

In 2005, MAFF released a five-year plan, namely the Basic Plan for Food, Agriculture and Rural Areas (or the New Basic Plan). The Good Agricultural Practices Harmonious with Environment Plan was also introduced in the same year. After this, the Act on the Promotion of Organic Agriculture was enacted in 2006.

The Measures to Conserve and Improve Land, Water, and Environment plan which started in 2007, is known as a subsidy program. Under this subsidy program, action groups receive financial aid for collaborative action to maintain and improve farmland and water resources and for farming activities reducing chemical inputs.

In the Basic Policy for Promotion of Organic Agriculture enacted in 2014, the main goal is to double the percentage of agricultural land devoted to organic farming to 1.0% by FY2018.

### (3) Shiga Prefecture and Promotion Policies for Sustainable Agriculture

Lake Biwa, which occupies one-sixth of the entire area of Shiga Prefecture, is the largest lake in Japan. Lake Biwa was seriously polluted due to population growth and industrial developments in the 1960s. Also, the extensive use of pesticides and chemical fertilizers in the agricultural sector was another cause of the water pollution in the lake. Especially, eutrophication spread in the 1970s. In 1977, Lake Biwa experienced a large-scale freshwater red tide for the first time and such outbreaks continued up to the 1990s. Recently, however, the number of days during which red tides occur and affected areas have decreased. Blue-green algae first appeared in Lake Biwa in 1983 and has continued to appear almost every year since then.

Perceiving the importance of Lake Biwa as a water source and for its biodiversity, the Shiga government has enacted several laws, regulations, and policies to protect biodiversity and the environment, especially in water preservation, agriculture, and forestry conservation. The details are described as follows:

- 1979: Ordinance for Eutrophication Prevention in Lake Biwa
- 1980: Clean and Recycling Agriculture
- 1984: Landscape Preservation Ordinance
- 1985: Special Law for Preserving Lake Water
- 1987: Lake Water Quality Conservation Plan
- 1990: Master Plan for Environmental Management of Yodo River System
- 1992: Reed Colony Conservation Ordinance
- 2001: Shiga's Vision for Agriculture and Forestry, especially Environmentally Friendly Agriculture (EFA)
- 2002: Lake Biwa Sport Activities Control Ordinance
- 2003: Shiga Prefecture Ordinance Promoting Environmentally Friendly Agriculture
- 2004: Shiga Agri-environmental Direct Payment Scheme
- 2007: MCILWE (developed by MAFF) and Development of the Plan for Conservation of the Lake Water Quality in Lake Biwa, Fifth Period
- 2011: The National Policy on Direct Payment Program (MAFF) and The Lake Biwa Comprehensive Conservation Plan (Mother Lake 21 Plan) were revised
- 2012: Development of the Plan for Conservation of the Lake

Water Quality in Lake Biwa, Sixth Period

- 2015: Development of the Plan for Conservation of the Lake Water Quality in Lake Biwa, Seventh Period
- 2017: Development of the Plan for the Lake Biwa Conservation and Regeneration Measures
- 2021: Shiga Prefecture Basic Plan for Agriculture and Fisheries

Based on the definition of sustainable agriculture from the government, Shiga Prefecture set up cultivation standards for environmentally friendly agriculture, which include:

(i) The amount of chemically synthesized pesticides used is less than half of the normal amount, and the total number of ingredients is seven or less.

(ii) The amount of chemical fertilizer (nitrogen component) is less than half of the normal amount, 4kg/10a or less.

(iii) Adopted environmentally friendly cultivation techniques for Lake Biwa.

(iv) A record is kept of how it was cultivated.

The “Fish Cradle Rice Paddies Project” and Shiga’s Vision for Agriculture and Forestry, especially Environmentally Friendly Agriculture (EFA) have been implemented in Shiga since 2001. Although rice-fish farming, a traditional practice for more than 170 years in Japan, has been declining, it has recently received renewed interest for its potential as a sustainable agricultural practice. Farmers enrolling in this project must comply with several conditions including the use of pesticides that result in the lowest level of fish toxicity and specific water management to maintain fish habitats. Furthermore, the Shiga government established the Ordinance for Promotion of Environmentally Friendly Agriculture in March 2003 to proactively promote “environmentally friendly agriculture” which aims to reduce the pollution load to Lake Biwa, conserve its biodiversity, and provide consumers with safe and reliable agricultural products. As early as 2004, Shiga Prefecture started an agri-environmental policy, namely the Environmentally Friendly Agriculture Direct Payment Scheme which is the most advanced policy with the aim of Lake Biwa conservation. This unique policy by Shiga Prefecture was adopted at the national level by Measures to Conserve and Improve Land, Water, and Environment (2007–2011) and has developed into the National Direct Payment Scheme since 2011.

In Japan, Shiga has the largest amount of EFA cultivated area, about 33%. Especially, the total of EFA rice in Shiga is nearly 13,000 ha, occupying about 44% of the total cultivated area of rice (nearly 30,000 ha), and nearly 90% of total EFA farming in Shiga (total of EFA: 14,057 ha) (Figure 4.5).

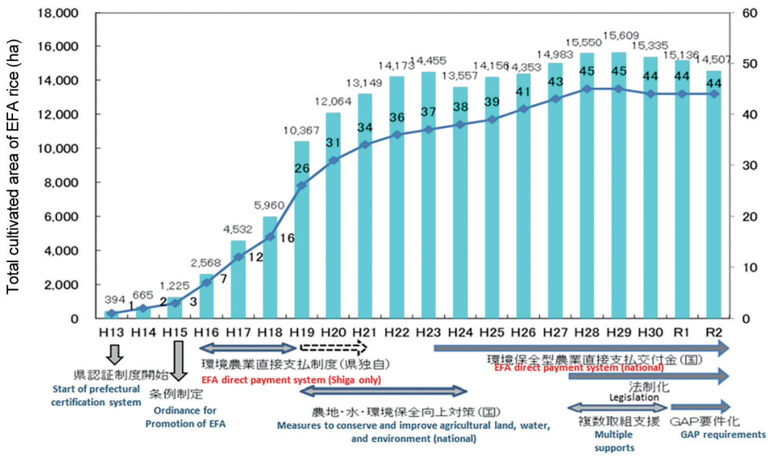


Figure 4.5 Change in the cultivated area of EFA and key policies in Shiga.
Source: (Shiga Prefectural Government Report 2022)

## (4) Environmentally Friendly Agriculture (EFA) and Direct Payment Subsidy Policy in Shiga Prefecture

According to the report from MAFF (2019), EFA significantly reduces approximately 143,393 tons of $CO_2$ equivalent per year. Combining multiple practices simultaneously with organic agriculture cropping systems is increasingly common to achieve economic and environmental viability such as suppressing weeds, pests, and disease pressure; meeting crop nutrient demands; and optimizing overall crop productivity. Table 4.3 shows the main EFA farming methods in Shiga Prefecture and the direct payment subsidy for each farming method.

Table 4.3 Direct payment subsidy for EFA farming methods

| **Activities** | **Direct payment subsidy (JPY/ha)** | **Cultivated area (ha)** | **Reduction amount of GHG emissions per unit (ton $CO_2$/ha/year)** |
|---|---|---|---|
| IPM practice, manual weeding on ridges and long-term integrated pest management | 40,000 | 5,996 | 3.87 |
| Use of slow-release fertilizer and long-term mid-drying | 40,000 | 5,005 | 2.19 |
| Applying compost | 44,000 | 697 | 2.26 |
| Organic farming | 30,000–120,000 | 346 | 0.93 |
| Ecosystem-friendly weed management | 40,000 | 243 | - |
| Planting cover crops | 60,000 | 181 | 1.77 |
| Fish cradle paddy rice | 30,000 | 148 | - |
| No pesticide or chemical fertilizer use | 60,000 | 122 | - |
| Living mulch | 32,000–54,000 | 67 | 1.02 |
| Others | | 170 | - |
| **Total** | | **12,987** | |

Source: (MAFF 2020) and (Shiga Prefectural Government Report 2022)

According to surveyed data, here is a brief comparison of the profitability between EFA rice and conventional rice. EFA rice has a higher profitability at 15,400 Japanese yen/ha (≈102.4 USD/ha) which includes the direct payment subsidy amount, but it becomes unprofitable when the labor cost (i.e., both hired and family labor) is included (Table 4.4).

Table 4.4 An example of cost and benefit of EFA rice, Shiga Japan.

| **Item** | **Environmental-friendly rice** | **Conventional rice** |
|---|---|---|
| Average yield (ton/ha) | 5,000.95 | 5,000.98 |
| Selling price (JPY/60kg) | 10,700 | 10,400 |
| Sale (JPY/ha) | 891,670 | 866,670 |
| Direct payment subsidy (JPY/ha) | **40,000** | 0 |
| **Total income (JPY/ha)** | **931,670** | **866,670** |
| Labor (man-hours) | 124 | 21 |
| Seeds and seedlings cost (JPY/ha) | 164,434 | 164,434 |
| Fertilizer cost (JPY/ha) | 112,000 | 62,400 |
| Agricultural chemical cost (JPY/ha) | 28,800 | 28,800 |
| Herbicide cost (JPY/ha) | 25,000 | 25,000 |
| Cost for using drying facility (JPY/ha) | 145,660 | 145,660 |
| **Total cost (JPY/ha)** | **475,800** | **426,200** |
| **Profitability (JPY/ha)** | **455,870** | **440,470** |

Source: (Shiga Prefectural Government Report 2022)

According to the Shiga Prefecture Report and the present study's survey (2022), Shiga rice farmers have a high awareness of sustainable agriculture. Their motivations for implementing sustainable agriculture are to protect Lake Biwa, add to the value of rice on the market, and produce safe products. However, there are several challenges to developing sustainable agriculture, especially for sustainable rice production: (1) It is time- and labor-consuming, (2) profitability is low if the labor cost is included, and (3) there is an aging agricultural population and shortage of labor force in the agricultural sector.

## 4. Conclusion

Climate change and coping strategies are emerging concerns in agriculture, especially in developing countries. In Vietnam, climate change responses are beneficial for rice farmers in avoiding losses of yield, improving profitability and income, and reducing fertilizer use. There is a need to improve rice quality (i.e., rice variety, safety) and its stability. Sustainable agricultural practices with certification are still limited in Vietnam. Also, there is a need to design an appropriate policies to promote sustainable agriculture, especially rice.

In Japan, current agricultural policies effectively promote sustainable agriculture and add to the value of Japanese rice. Nevertheless, new challenges may arise from the situation of depopulation and aging in rural communities, a decline in the total area of cultivated rice, a shortage of labor, and a decline in rice consumption due to changes in dietary habits. Therefore, policies for promoting sustainable agriculture should pay attention to the public concern over the economic impacts on the quality of the global commons. In order to make agriculture sustainable smart agriculture should be considered to assist in solving the problem of the shrinking labor force and improving efficiency. In addition, adopted policies should include conversion to other strategic crops such as wheat, soybeans, rice for processing, and also keeping livestock. Moreover, innovations and technologies developed in Japan such as digital tools and pest management should be considered for countries facing the same challenges, especially developing countries like Vietnam.

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# Chapter 5
# The Effect of Risk Preference and Farmer Perception on Climate Change to Farmer Participation on Farm Insurances

Mohammad RONDHI, Suci Virgianti DIANI,
Rizky YANUARTI

**Abstract:** Agricultural farming is one of the most vulnerable sectors in Indonesia since weather, pests, diseases, and other factors may directly affect crop yield. Since 2015, the national policy for climate change adaptation has provided agricultural insurance for rice farmers. This study aims to explore how farmers perceive the impacts of climate change on rice farming and investigate factors influencing farmer's participation in the national insurance scheme. Logistic regression and propensity score matching (PSM) were used to analyze the factors influencing participation in farm insurance and the impact of farm insurance on farmer income. The results revealed that risk preference, age, and education have positive effects on farmers' willingness to participate in farm insurance, while land ownership has a negative effect on it. Furthermore, farmers' incomes were significantly different between national insurance participants and non-participants. Finally, it is concluded that the national insurance program is important for rice farmers in medium and high-risk areas.

## 1. Introduction

Agricultural farming is a risky business since weather, pests, diseases, and other factors may directly affect crop yields (Cline 2007; Nordhaus 1991). Rice is one of the staple foods in Indonesia which relies on the climate conditions. Changes in rainfall intensity and frequency can cause extreme weather such as floods and droughts which also affect irrigation water availability and adequacy. Accordingly, adverse weather causes production loss (Surmaini et al. 2011).

The impact of adverse climate change (CC) on farming is determined by the vulnerability of farmers which has three interrelated functions: exposure to hazard, sensitivity to damage, and ability to cope (IPCC 2014). One of the ways to reduce the impact of CC is by promoting adaptive strategies (Jamshidi et al. 2019). Some studies justify that farm adaptation to CC in farm practices can reduce farm losses (Khanal et al. 2018). Adaptation can be classified as autonomous adaptation, and planned adaptation (Stage 2010). While in autonomous adaptation farmers practice adaptation strategies based on their knowledge independently, in planned adaptation, the government plays an important role in planning and implementing an adaptation policy.

One of the adaptation policies run by the government is farm insurance. Since 2015, the Indonesian government has actively supported the implementation of national agricultural insurance, locally called Asuransi Usaha Tani Padi (AUTP), especially for paddy farming. The insurance provides subsidies for rice farmers with 80% premium payment while the rest is paid independently by the farmers themselves. However, from 2015 to 2018 the number of farmers participating in farming insurance is still low, only 3–4% (Table 5.1). Although the percentage seems to be increasing, it is still low compared to other sectors and other countries. This research aimed to find out the reason why farmers' participation is low and to find an alternative solution.

Table 5.1 Paddy rice area in Indonesia based on participating in agricultural insurance.

| Year | Paddy Area (Ha) | Registered Area (Ha) | Percentage (%) |
|---|---|---|---|
| 2015 | 14,116,638 | 233,500 | 1.65 |
| 2016 | 15,156,166 | 307,217 | 2.02 |
| 2017 | 15,712,015 | 997,961 | 6.58 |
| 2018 | 15,994,512 | 806,199.64 | 5.04 |
| **Total** | **60,979,331** | **2,344,877.64** | **3.82** |

Source: Ministry of Agriculture, Indonesia, 2018.

## 2. Rice Farming, National Policy, and Farmer's Perception

In Indonesia, rice productivity varies from area to area and year to year. On average, rice productivity in Indonesia was around 5 tons per ha in 2015, decreasing in 2016–2017, and slightly increasing in 2018. Therefore, there are some hypotheses that rice productivity may depend on areas, environmental factors such as climate change, and input uses as macro conditions. Rice productivity in Java is higher than outside of Java. Especially, rice productivity in Java and Sulawesi is higher than in other areas due to better agricultural infrastructures for irrigation. Meanwhile, Sumatra and Kalimantan have low rice productivity due to many areas being used for plantation crops (i.e., palm oil trees, and forestry).

In addition, most farmers in Indonesia manage their own land (70%), while others are renting (18%), and sharecropping (10%) (Table 5.2). Sharecropping is high in some areas such as Sumatra and Java while it is low in some other areas such as Maluku and Papua. The question "How do they manage their farming?" was raised. The answer is that it mainly depends on ownership. It means that farmers who have their own land can access and manage their farms easily, but for farmers who are leasing or sharecropping, it still depends on their location.

Table 5.2 Land management and sharecropping.

| Region | Own | Lease | Sharecropping | Ratio |
|---|---|---|---|---|
| Sumatra | 14,452 (23.39%) | 5,826 (36.90%) | 3,101 (33.16%) | 2 |
| Java | 24,708 (39.99%) | 4,976 (31.52%) | 3,319 (35.49%) | 3 |
| Kalimantan | 6,646 (10.76%) | 1,243 (7.87%) | 829 (8.87%) | 4 |
| Sulawesi | 7,535 (12.20%) | 1,414 (8.96%) | 676 (7.23%) | 4 |
| Bali & Nusa Tenggara | 7,064 (11.43%) | 2,222 (14.07%) | 1,270 (13.58%) | 3 |
| Maluku | 747 (1.21%) | 72 (0.46%) | 57 (0.61%) | 6 |
| Papua | 632 (1.02%) | 35 (0.22%) | 99 (10.6%) | 5 |
| Indonesia | 61,784 (70.75%) | 45,788 (18.08%) | 9,351 (10.71%) | 3 |

Source: Statistics Indonesia (BPS), 2014.

In Indonesia, the non-irrigated area is around 55%, higher than the irrigated area of 45%. The percentage of irrigated land in Java is higher than outside of Java (Table 5.3).

Table 5.3 Share of cultivated land in Indonesia.

| Region | Non-irrigated land | Irrigated land | Ratio |
|---|---|---|---|
| Sumatra | 13,674 (28.61%) | 9,791 (24.77%) | 13 |
| Java | 16,466 (34.45%) | 16,720 (42.30%) | 9 |
| Kalimantan | 3,212 (6.72%) | 8,776 (14.08%) | 5 |
| Sulawesi | 8,757 (18.32%) | 905 (2.29%) | 96 |
| Bali & Nusa Tenggara | 4,988 (10.44%) | 5,608 (14.19%) | 8 |
| Maluku | 226 (0.47%) | 651 (1.65%) | 3 |
| Papua | 477 (1%) | 291 (0.74%) | 16 |
| **Indonesia** | **47,800 (54.73%)** | **39,530 (45.27%)** | **12** |

Source: Statistics Indonesia (BPS), 2018.

### (1) The Strategic Goals and Targets of RAN-API

Indonesia is one of the agricultural countries most vulnerable to climate change and its impacts. To mitigate the negative impacts of climate change, the Government of Indonesia has formulated a national action strategy plan, namely the Nation Action Plan for Climate Change Adaptation (RAN-API). The existence of seven main programs supports these strategies, including: 1) Adapting the food production system to climate change, 2) Expanding the area of food production, 3) Improving and developing climate-proof agricultural infrastructure, 4) Food diversification, 5) Developing innovative and adaptive technologies, 6) Developing information and communication systems (for climate and technology), 7) Establishing supporting programs. Some areas received government subsidies.

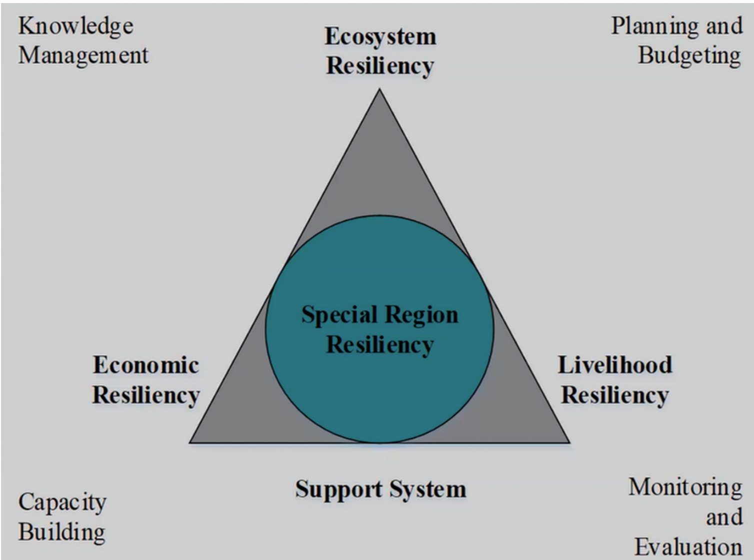


Figure 5.1 The strategic goals and targets of RAN-API. Source: (BAPPENAS)

More specifically, since 2015, the Indonesian government has implemented a national agricultural insurance scheme locally called

Asuransi Usaha Tani Padi (AUTP), especially for paddy farming. The insurance scheme as a financial instrument provides subsidies that will help farmers who experience crop failure owing to climate change to enhance their capacity and continue their farming activities. The farmers only need to pay 20% of the insurance premium of Rp 200,000 or US$13 per ha. It is quite a small amount of money when compared to rice productivity and profit. The rest, 80% of the insurance premium, will be subsidized by the government. When crop failures caused by climate change occur, the insurance payment is about one-third of total productivity and nearly US$700. It is much higher than the insurance cost.

Regarding climate change perceptions, farmer's perception was identified to be influenced by demographic, institutional, environmental, and psychological/social factors. Environmental factors seem to be macro-conditions, while demographic and psychological factors can be maintained and depend on environmental and institutional factors. Therefore, the perceived impact of climate change can increase autonomous adaptation and affect adaptation outcomes (Rondhi et al. 2019). When the way to adapt to climate change is correct, the benefits for rice production will come. However, incorrect ways of adapting to climate change (or maladaptation) can lead to a decline in rice production.

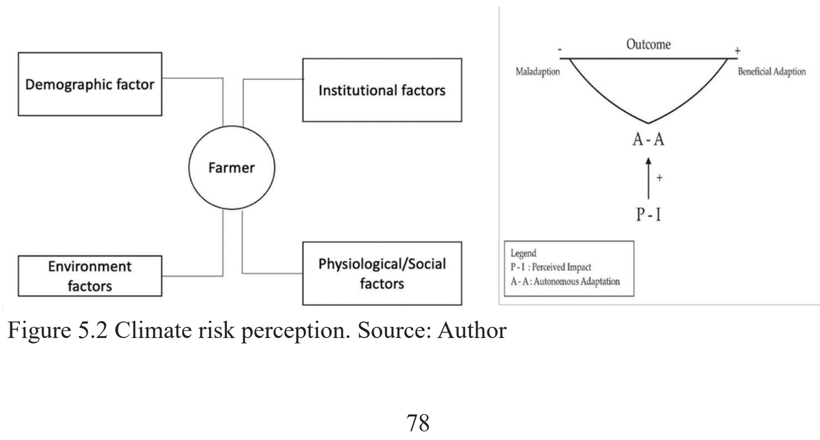


Figure 5.2 Climate risk perception. Source: Author

### (2) Research Site and Method

The study was conducted in Jember District, East Java, Indonesia, through interviews with 87 rice farmers. The study uses the logistic model to identify farmers' perceptions and influencing factors. The regression model is expressed as follows:

$$\ln\left(\frac{P_1}{1-P_1}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 D_1 + \beta_7 D_2$$

Where $Y_i$ presents AUTP participation (1 = participation, 0 otherwise), $X_1$ – risk preference, $X_2$ – age of rice farmers (years), $X_3$ – total area (ha), $X_4$ – education (years), $X_5$ – family members (persons), $D_1$ – farmer perception (Dummy variable with 1 = 51-100%, 0 = 0-50%), and $D_2$ – land ownership (Dummy variable with 0 = own, 1 = not own). Furthermore, propensity score matching (PSM) was applied to explain the impact of farmer's participation in farm insurance on farm income.

## 3. Results and Discussion

### (1) Perceived Impact of Climate Change on Rice Farming in Indonesia

Climate change and its impacts in the study are related to drought, flood, and pest attacks. Figure 5.3 shows that farmers in some areas (i.e., West Kalimantan) perceived a high impact of climate change where drought is dominant compared to others. Meanwhile, farmers in some other areas (i.e., Java) perceived the low impact of climate change, where flooding is more predominant than droughts and pest attacks. Farmers in west Borneo Island (West Kalimantan) and Riau Island perceive a higher impact of drought than others. East Kalimantan and South Sumatra provinces face a higher flood risk than others. On the other hand, rainfall and pest attacks occurred in all provinces at low levels.

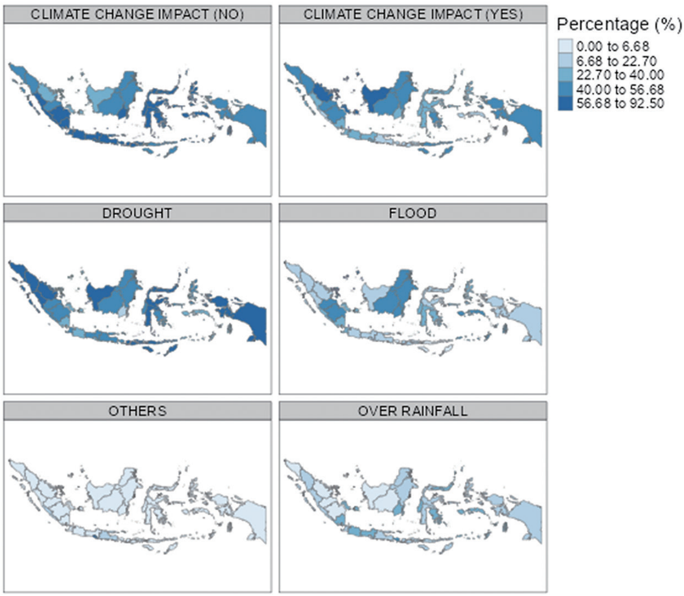


Figure 5.3 The percentage of farmers perceived the impacts of climate change in Indonesia. Source: Author

As mentioned above, for risk preference, this study divides risk preference into risk-averse farmers (who avoid risks and have a low-risk tolerance) and risk-takers (farmers who are more willing to take risks). The average age of surveyed rice farmers is 50 years old. Most of the rice farmers surveyed have attended mainly elementary school (37%) and senior high school (29%). The average number of family members is around four people. Regarding the perception of CC, more than 70% of farmers perceived the impacts of CC. The majority of farmers (73%) cultivate rice in their own land (Table 5.4).

Table 5.4 Descriptive statistic.

| Variable | Average (frequency) |
|---|---|
| Risk preference ($X_1$) | |
| Risk averse | 71 |
| Risk taker | 16 |
| Age (year) | 50 |
| Area (ha) | 0.1–0.5 |
| Education ($X_4$) | |
| Not primary | 6 |
| Elementary | 37 |
| Junior high school | 11 |
| Senior high school | 29 |
| University/academy | 4 |
| Family member ($X_5$) | 4 |
| Perceptions ($D_1$) | |
| Yield decreasing 1–50% | 16 |
| Yield decreasing 51–100% | 71 |
| Land ownership ($D_2$) | |
| Own | 73 |
| Rent/share | 14 |

Source: Field Survey, 2020.

### (2) Factors Affecting Farmer's Participation in AUTP Insurance

The results from Table 5.5 show that risk preference has a positive significance on participation in a farming insurance scheme. This means that risk-taking farmers have low participation, while risk-averse farmers tend to participate in insurance. In some areas with high impacts of climate change, farmers also tend to participate in insurance. In addition, there is a positive relationship between farmers' ages and their participation in AUTP insurance. This means that an increase in the age of rice farmers can increase the probability of participating in the national insurance of the Indonesian government. It shows the same trend as for the education variable. It means that education can also facilitate participation in national insurance schemes. Importantly, the variable of land ownership has a negative impact on insurance participation. This means farmers renting land or sharecropping are less likely to participate in farming insurance, while farmers owning land are more likely to participate in a farming insurance scheme.

Table 5.5 Result of logistic model.

| Variable | B | S,E, | Wald | Df | Sig, | Exp(B) |
|---|---|---|---|---|---|---|
| Risk preference ($X_1$) | 0.640 | 0.208 | 9.468 | 1 | 0.002** | 1.897 |
| Age ($X_2$) | 0.079 | 0.027 | 8.679 | 1 | 0.003** | 1.082 |
| Area ($X_3$) | -0.233 | 0.645 | 0.131 | 1 | 0.717 | 0.792 |
| Education ($X_4$) | 0.181 | 0.079 | 5.260 | 1 | 0.022** | 1.198 |
| Family member ($X_5$) | 0.120 | 0.224 | 0.286 | 1 | 0.592 | 1.127 |
| Perceptions ($D_1$) | -1.205 | 0.928 | 1.684 | 1 | 0.194 | 0.300 |
| Land ownership ($D_2$) | -2.010 | 0.779 | 6.664 | 1 | 0.010** | 0.134 |
| Constant | -4.955 | 1.801 | 7.566 | 1 | 0.006 | 0.007 |

Source: Field Survey, 2020.

**(3) Discussion**

Risk-averse farmers tend to participate in farm insurance, especially farmers whose plots are in areas affected by climate change risks such as pest attacks and flooding. The government has a specific program for each area in Indonesia due to the specific characteristics of the environment in each respective area. Generally speaking, this finding supports previous research (Vassalos and Li 2016; Rondhi et al. 2019). Farmers who have experienced farm failure tend to be risk averse and tend to participate in farm insurance.

Land-owning farmers tend to participate in farm insurance, as they have full access to the management of their land, while land-sharing farmers or land-renting farmers do not have much access to land. Hence, they are less likely to participate in farm insurance. Land-sharing or land-renting farmers perceive that an insurance claim will be paid after they harvest the crop, and at that time, the farmer does not have the right to manage the plot. Therefore, those farmers prefer not to participate in farm insurance.

There is a difference in income between AUTP and non-AUTP farmers by Rp 895,052. The result shows that AUTP farmers receive more income (Rp 6,956,096) than non-AUTP farmers (Rp 6,061,044). Those farmers manage their farms as recommended by good practices (GAP). Moreover, AUTP farmers receive insurance claims for farm failures. The ease of making claims due to farm failure raises farmers' eagerness to participate in farm insurance.

## 4. Conclusion

This study attempted to find out the factors influencing rice farmers' decisions on insurance participation in Jember District, East Java of Indonesia. The national insurance program can partially enhance farmers' adaptation capacity to climate change to ensure their livelihood. However, actual participation in insurance schemes is still low among rice farmers.

The findings indicate that farmer determinants to participating in AUTP insurance are risk preference, age, education, and land ownership, while farmers' perceptions and the number of family members do not affect their participation. Risk-averse farmers and land-owning farmers tend to participate in farm insurance. Importantly, the AUTP program should be addressed to rice farmers in medium and high-risk areas.

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# Chapter 6
# From Science to Policy: Sustainable Rice Production in the Mekong Delta, Vietnam

Melanie CONNOR

**Abstract:** Over the last decades, Vietnam has benefited from a rapid intensification of rice production that has led to environmental degradation and adverse health effects. As a result, complex sustainable rice farming packages such as the national program "One Must Do, Five Reductions" (1M5R) have been introduced, but adoption still appears to be low. The technology package includes the reduction of fertilizers, pesticides, post-harvest losses, water use, and seed rates. An additional requirement is the use of certified seeds. This chapter will cover the diffusion and adoption process and will specifically focus on adoption constraints, and how they can affect policy outcomes and adaptations. The chapter will highlight the outcomes from various policy-supported initiatives and unpack plausible pathways that generated the widespread adoption of 1M5R in different provinces.

## 1. Introduction

There are a lot of different ways that we engage knowledge of science with policy. There is a great deal of literature in different modes explaining how policymakers use that scientific knowledge to create various interdisciplinary themes, not only in economics. In this chapter I would like to discuss the "Knowledge supply mode." (Figure 6.1)

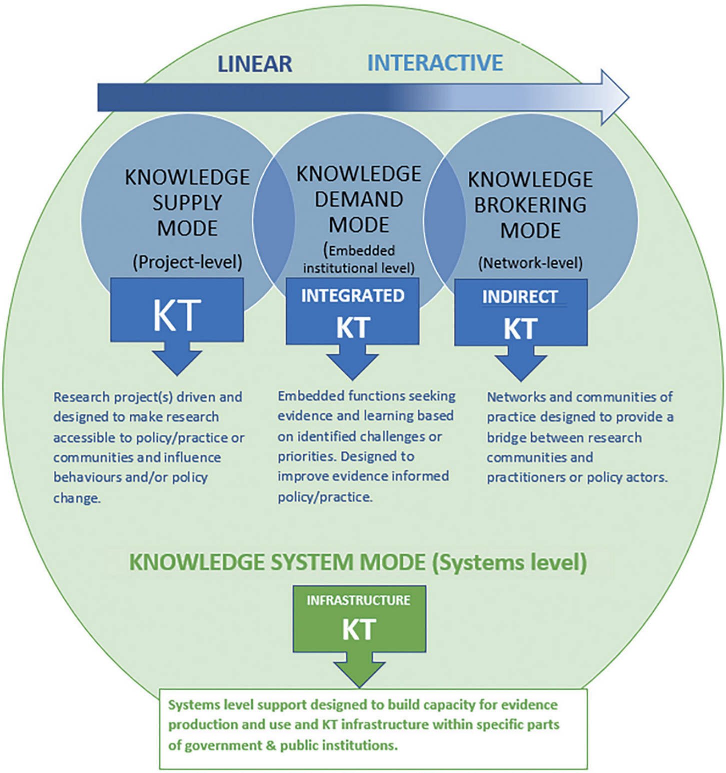


Figure 6.1 Engaging evidence with policy. Source: Author

At the International Rice Research Institute, we provide a lot of information to policymakers and expect them to use that knowledge to make new policies. For instance, how will this knowledge influence farmers to implement that policy and change their behavior? As a psychologist, I am interested in studying farmers' behavior, behavioral change, and how behavior affects their decision-making.

What we need to have to make effective policy is useable evidence. Here I would like to show you some case studies in the past seven years with the Closing Rice Yield Gaps in Asia with Reduced Environmental Footprint Project (CORIGAP) (Figure 6.2). CORIGAP aims to improve food security and gender equity, and to alleviate poverty by optimizing yield and sustainable rice production in China, Myanmar, Thailand, Indonesia, Sri Lanka, and Vietnam. Especially, the CORIGAP program aims to explore how to: (a) Reduce yield gaps with the aim to strengthen future food security and (b) Increase environmentally sustainable rice production in intensive lowland systems.

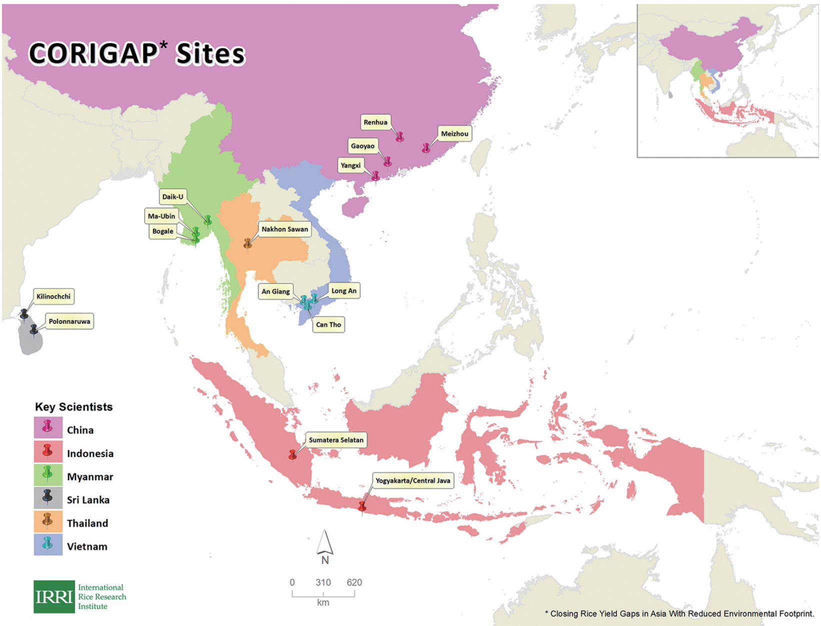


Figure 6.2 CORIGAP Sites. Source: https://ricetoday.irri.org/wp-content/uploads/2017/02/CORIGAP-map.jpg

## 2. The Approach of Adaptive Research

The study uses an adaptive research approach. Farmer participatory research needs assessment, field plots, adaptive research, and cross-site visits. Especially, for the bottom-up approach to provide recommendations to policymakers and all farmers, we use disciplinary knowledge produced by scientists from the International Research Rice Institute (IRRI).

Aligned with national best management initiatives for lowland irrigated rice, we assisted with rice farm development in Vietnam (1 Must Do, 5 Reductions), Myanmar, Thailand, Indonesia (Best Management Practices (BMP)); China (3 controls technologies + Alternate Wetting and Drying (AWD) for irrigation water saving). This study is focused on the Mekong Delta of Vietnam (Figure 6.3).

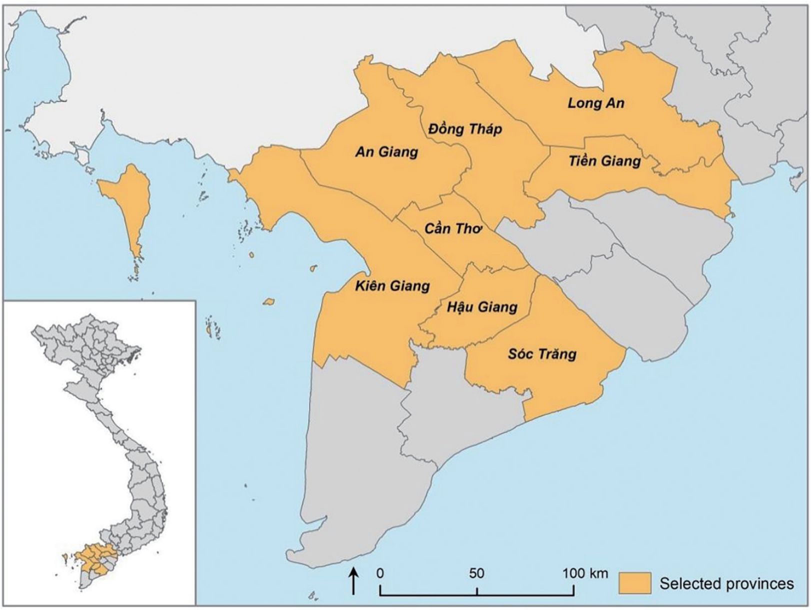


Figure 6.3 Map of research area, Mekong Delta of Vietnam. Source: Author

## 3. Challenges and Research for Development

### (1) Current Challenges

There are some challenges in rice production in the Mekong Delta, Vietnam, including: input overuse and environmental degradation, climate change and increased natural disasters, rising sea levels and soil salinization, particularly in the Mekong River Delta, and increasing crop residue and rice straw.

### (2) Research for Development and Activities

The program introduces new sustainable, climate-smart technologies and practices, and hopes that farmers can adopt these technologies (Figure 6.4). In detail, these technologies and practices include using a drum seeder, alternate wetting and drying (AWD), a flatbed dryer, laser land leveling, ecologically based rodent management, HYVs, IRRI, a super bag, a mechanical transplanter, a solar bubble dryer, IRRI Rice Knowledge Bank, a lightweight thresher, and a combine harvester.

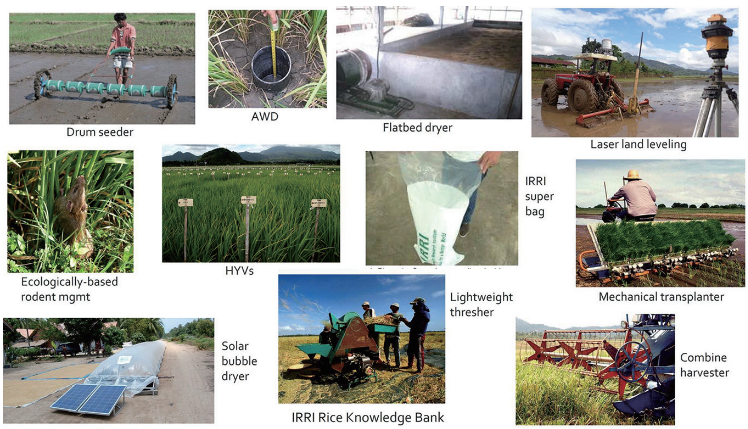


Figure 6.4 The development of integrated programs that use new technologies and practices to increase sustainability. Source: Author

The Vietnam Government has introduced a national policy, namely "One Must Do – Five Reductions," which aims to promote the use of best management practices in lowland rice cultivation. This includes the use of certified seeds as well as the reduction of seed rates, fertilizer use, pesticide use, irrigation water use, and post-harvest losses (Figure 6.5). However, it can be clearly seen that there are different values. For instance, seed rates are sometimes set at a maximum of 100 kg per ha but can increase to 120 kg per ha. This is because farmers could apply these different seed rates for different rice crop seasons. The adoption can be seen as a function of Yes vs. No, or Adoption vs. No adoption. Therefore, our study focuses on how we can specifically define the adoption at a specific level for each category. The reduction of fertilizer use, defined as adoption 1M5R, is set at the level of 100–110 kg per ha. The adoption of pesticide reduction is defined as: i) the use of a maximum 1–3 insecticide application(s) and no insecticide before 40 days of seeding (DAS), ii) the use of maximum 3 fungicide applications and none within 20 days before harvesting, iii) the use of maximum 2 fungicide application and none after flowering. Regarding the reduction of water use, the adoption is defined as a minimum of two dry-downs in the Dong Xuan (Winter-Spring) crop season, a minimum of one dry-down in the He Thu (Summer-Autumn) crop season, or the use of safe AWD with water tubes.


Figure 6.5 One must do – five reductions and adoption of innovation (1M5R).

Source: Author

Figure 6.6 shows the framework for the adoption of innovation (1M5R) and its process.

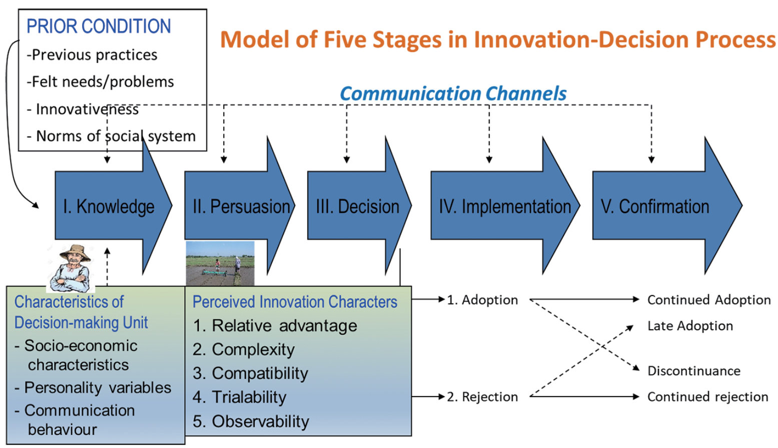


Figure 6.6 Adoption of an innovation (1M5R). Source: Author

# 4. Case Studies in Vietnam

## (1) Case 1: Qualitative Analysis of the Diffusion and Adoption Constraints in Vietnam

### 1) Data Source

Data was collected from 155 farmers and extension officers from MARD in 17 focus group discussions and analyzed by thematic content to know how those different stakeholders perceive the adoption of the 1M5R. Almost all farmers followed all requirements, especially fertilizer and pesticide reduction, and post-harvest loss reduction. However, farmers meet difficulties in applying AWD and reducing the seed rates.

There are some influencing factors mentioned in the group discussions:

- ➢ Social networks including other farmers, friends, millers, and traders can influence their willingness to adopt in practice.
- ➢ Information access such as weather forecasts, pest forecasts, access to markets, cropping calendar and extension services can influence farmers' adoption.
- ➢ Farming systems such as soil type, access to irrigation, and transportation methods might have a big influence on farmers' adoption or non-adoption.
- ➢ Access to equipment such as drum seeders, laser levelers, and combine harvesters might negatively affect the post-harvest losses.

### 2) Summary of Results

A multi-stage process consisting of several workshops for multiple stakeholders and several farmers' focus groups is important for the effective implementation of the 1M5R in order to bring beneficial results. The qualitative analysis shows that external factors seem to be the main barriers. In the case of water reduction and reduction of seed rate, external factors such as the geographical location of the farm, land preparation, and access to machinery must be addressed further by the government and public-private partners. Knowledge provision, demonstration fields, and access to extension services are important to increase the adoption of sustainable rice farming practices.

### (2) Case 2: Vietnam – Adoption of 1M5R

#### 1) Data Source

Adoption and barriers to adoption of the five reduction requirements and the use of certified seeds specified under 1M5R were investigated by means of a survey questionnaire created using CommCare (Dimagi), a widely used data collection platform, predominantly for monitoring health information in developing countries (Agarwal et al. 2016). There was a total of 465 participants — 94% male with a mean age of 50.9 (Standard deviation = 12.4). In addition, there was a training session for enumerators to use the survey application before conducting the survey.

According to surveyed data (Figure 6.7), 91% of farmers have been using certified seeds with 37% using high-yielding varieties. Farmers have also reduced their seed rate (86%). However, considering a seed rate of ≤100kg/ha, only 4.7% (n = 22) of the farmers applied that. There are a number of farmers who reported that they have reduced their pesticide use (74.4%), including fungicides (88%), herbicides (94%), insecticides (90%), rodenticides (62%), and molluscicides (93%). 74% of participants reported that they reduced their fertilizer use, but only 45% of the participants reported reducing their water use and 35% of the farmers reported to be applying AWD in their fields.

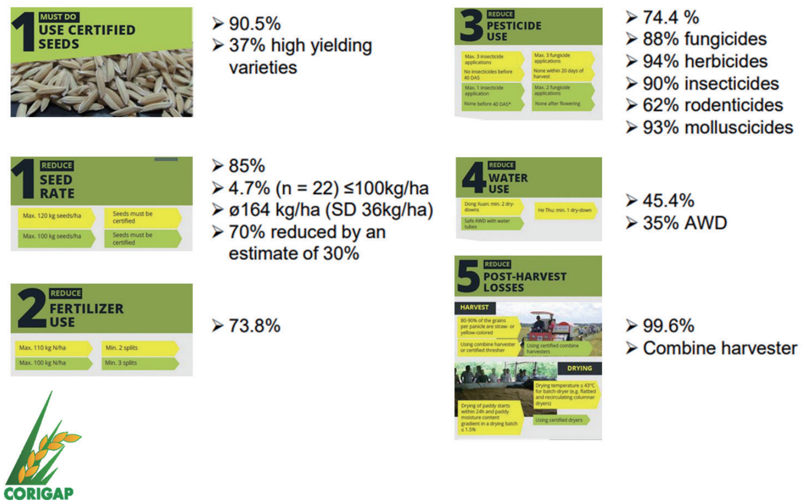

Figure 6.7 Summary of surveyed data on 1R5M adoption in the study sites.
Source: Author

All farmers who adopted practices were still using them in 2019 and reported to be willing to continue using them.

## 2) Benefits and Barriers

Rice farmers perceived a variety of benefits when adopting the single requirements specified under 1M5R. Most of the farmers perceived for each requirement that "it is easy to apply 1M5R," "Labor costs are lower," "It is less expensive," and "It fits my crop pattern" (Figure 6.8).

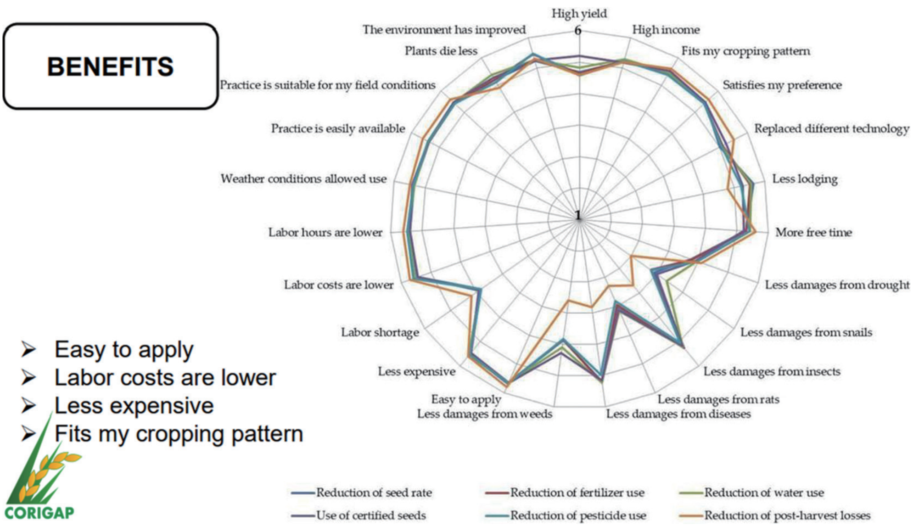


Figure 6.8 Benefits of 1M5R adoption. Source: Author

Farmers also perceived some barriers to adopting the 1M5R. The main barriers to using certified seeds were "Technology is not suitable for my field conditions," "It's too expensive," and "It doesn't satisfy my preferences." Farmers reported several barriers to reducing seed rates and fertilizer use including "Weather conditions do not permit it," "It doesn't fit my cropping pattern," and "It produces a low yield." Barriers to reducing water use were "It doesn't fit my cropping pattern," "It's too difficult to apply," and "Weather conditions do not permit it" (Figure 6.9).

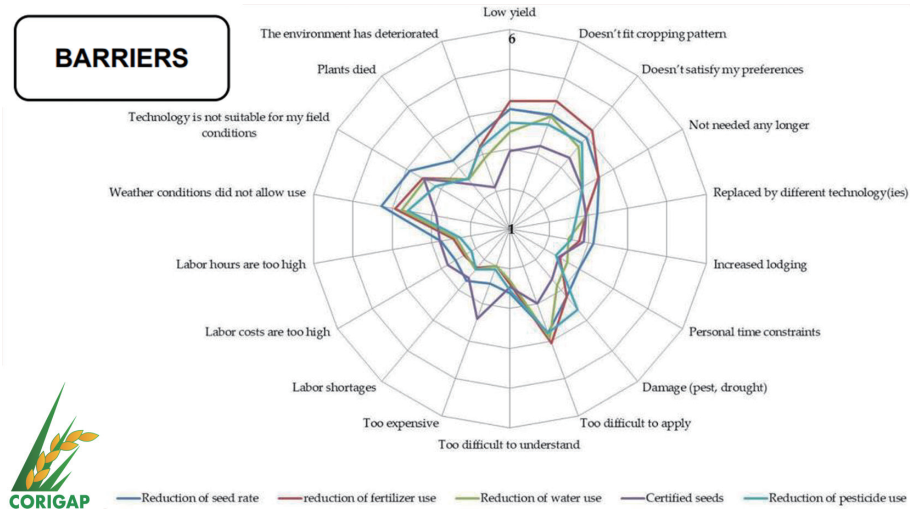


Figure 6.9 Barriers of adoption 1M5R. Source: Author

**3) How often were Certain Combinations Adopted?**

When analyzing the requirements using AWD and a seed rate of ≤100kg/ha, the use of certified seeds occurs more often in combination with the reduction of fertilizer and pesticides, and the use of a combine harvester, whereas the use of AWD (water use reduction) and the reduction of seed rate remain separate and, therefore, used less frequently in combination with the other requirements (Figure 6.10).

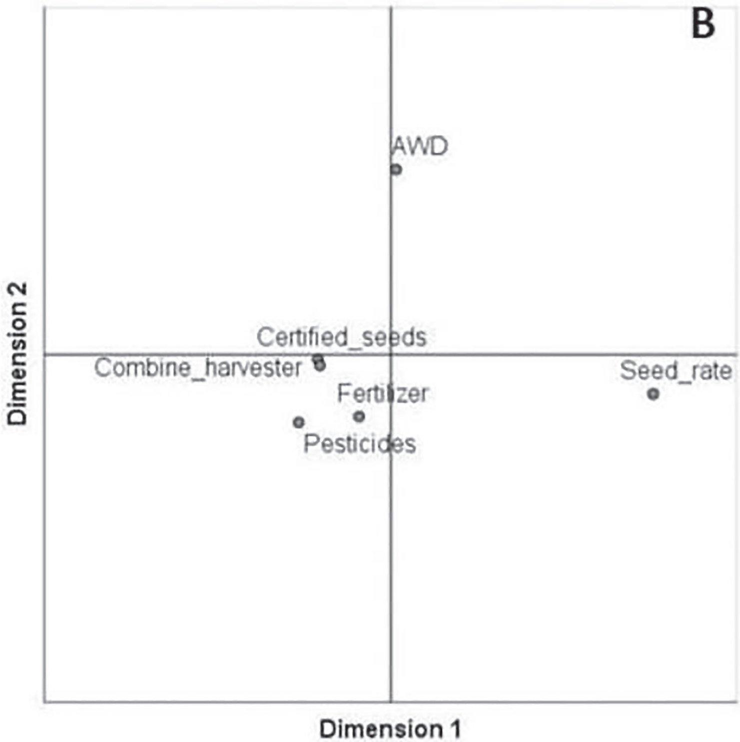


Figure 6.10 Combination adopted. Source: Author

**4) Factors Influencing the Adoption of 1M5R**

A linear regression model was used to investigate the factors influencing how many elements of 1M5R were adopted by rice farmers. For the adoption analysis of generally phrased requirements, farmers' satisfaction, the ease of 1M5R, non-rice income, and education were significant predictors. Meanwhile, for the adoption of the requirements using AWD and a seed rate of 100kg per ha, farmers' years of farming become an additional predictor apart from three predictors of the ease of 1M5R, non-rice income, and education (Table 6.1).

Table 6.1 Influencing factors on 1M5R adoption

| | (A) Adoption generally phrased requirements, r2 = 24.9% | | | (B) Adoption for requirements using ADW and a seed rate of 100kg/ha. R2 = 23.5% | | |
|---|---|---|---|---|---|---|
| | Beta | t | p | Beta | t | p |
| Total area | 0.008 | 0.521 | .603 | 0.010 | 0.852 | .395 |
| Years of farming | 0.008 | 1.787 | .075 | 0.007 | 1.913 | .056 |
| Expectations | 0.016 | 0.188 | .851 | 0.086 | 1.242 | .215 |
| Saticsfaction | 0.206 | 2.280 | .023 | 0.065 | 0.879 | .380 |
| Ease of 1M5R | 0.530 | 6.462 | .000 | 0.418 | 6.163 | .000 |
| Average yield | 0.089 | 1.610 | .108 | 0.038 | 0.828 | .408 |
| Non-rice income | 0.470 | 4.194 | .000 | 0.006 | 3.680 | .000 |
| Province | 0.093 | 0.789 | .431 | -0.024 | -0.243 | .808 |
| Education | 0.218 | 3.173 | .002 | 0.130 | 2.298 | .022 |
| Member of cooperative | 0.184 | 1.481 | .139 | 0.005 | 0.048 | .961 |
| Subjective knowledge | -0.126 | -1.008 | .314 | 0.018 | 0.170 | .865 |

*Note*. N = 464. Variable province was coded 1 = An Giang, 2 = Can Tho. Variable non-rice income was coded 0 = no, 1 = yes.

Source: Author

The results from seven logistic regression models for seven rice farming practices were summarized in Figure 6.11. The use of certified seed was significantly affected by farmers' education and the ease of 1M5R, while the reduction of seed rates was significantly influenced by their satisfaction and the ease of 1M5R. In addition, the ease of 1M5R strongly affected their willingness to reduce fertilizer use, pesticide use, water use, and AWD. Moreover, the higher the percentage of their non-rice income, the more their willingness to reduce fertilizer use, pesticide use, water use and AWD. Meanwhile, satisfaction and average yield are influencing factors in the reduction of fertilizer use, while expectations and satisfaction are other key factors in the adoption of AWD.

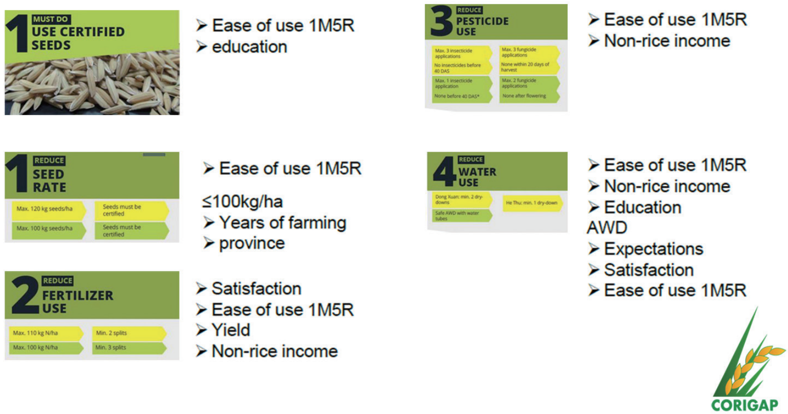


Figure 6.11 Summary results of the regression model. Source: Author

### (3) Case 3: Vietnam – Psychological Factors Influencing the Acceptance of Sustainable Farming Practices

#### 1) Household Survey 1

a) Study Site and Data Collection

The survey was conducted in three provinces of the Mekong Delta — An Giang (n = 38, 17 cooperative farmers), Can Tho (n = 35, 10 cooperative farmers), and Tien Giang (n = 38, 18 cooperative farmers) in 2018. The majority of participants were male (91%). The mean age was 51.5 years.

b) Sustainable Farming Practices

A total of eight sustainable farming practices with respect to rice straw were introduced to farmers for assessing their acceptance. They include on-field practices and off-field practices (Figure 6.12). Regarding on-field practices, there are two main managements: 1) the incorporation of rice straw into the field which can improve soil fertility and nutrient balance. However, the speed of degradation can vary, and an increase in organic matter in irrigated soil can increase GHG emissions; and 2) rice straw burning which is a quick, simple, and affordable method of reducing biomass quantities in the field, but this causes GHG emissions and release of pollutants. Meanwhile, the off-field practices involve composting rice straw, rice collection methods, anaerobic digestion – biogas production, mushroom production, and cattle feed.

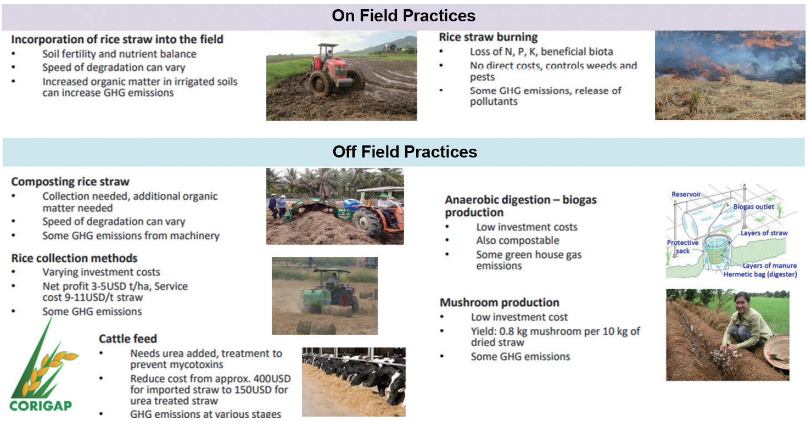


Figure 6.12 On field and off field practices. Source: Author

c) Method – Fact Sheets

All fact sheets regarding rice straw management had the same format and started with a short introduction to the management practice. After this short explanation, a colored picture of the management practice followed. The second half of the fact sheet showed the specific features of the straw management practices in bullet-point format which include benefits, risks, costs, and GHG emissions (Figure 6.13).

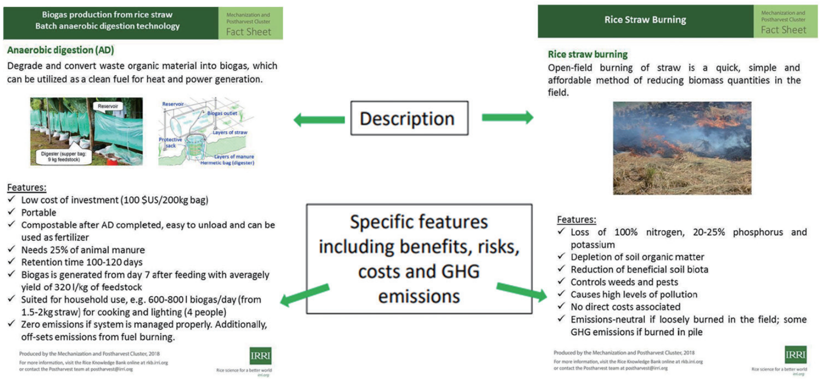


Figure 6.13 Fact sheets. Source: Author

## d) Theoretical Framework

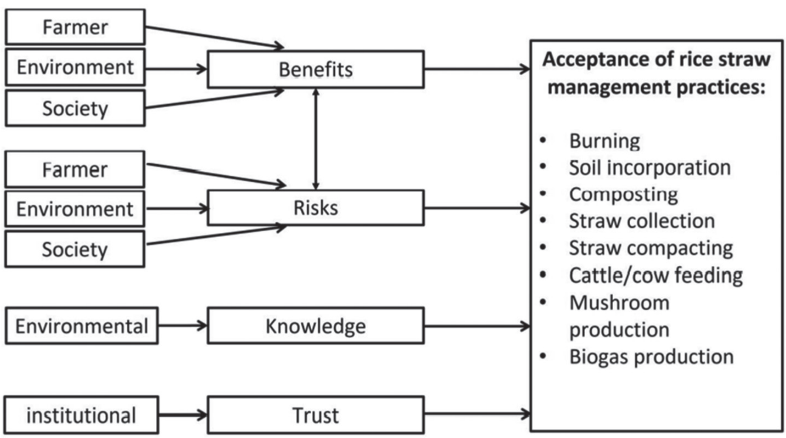


Figure 6.14 Theoretical framework. Source: Author

## e) Results

Results show that farmers often burn their rice straw even though they perceive high risks, few benefits, and expressed low levels of acceptance for rice straw burning. However, acceptance of rice straw management practices differs between practices, and their behavioral intentions are high. All other management practices are perceived to have high benefits and relatively low risks — practice depends on, and whether farmers know about the management option.

The perceived benefits were a strong predictor for farmers' acceptance of all other rice straw management practices. The results of the study also show that risk perceptions were weak but a significant predictor for the acceptance of rice straw incorporation into the soil, straw burning, biogas production, and cattle feed.

Furthermore, knowledge about climate change was also a predictor for the acceptance of straw incorporation into the soil, composting, cattle feed, baling, compacting, and mushroom production.

The results show that support from institutions is a significant predictor for baling and compacting rice straw. Farmers need support from different actors; especially from the government and research institutions to have access to straw collection machinery since participants are all small-holder farmers and have limited access to machinery.

Farm size has a negative impact on the incorporation and composting, while only rice yield had a positive significance for biogas production. Therefore, it is necessary to carefully take into account different factors for different practices and policies.

**2) Household Survey 2**

a) Data collection

Data were collected from 180 farmers twice (in 2015 and 2019) using a tablet-based questionnaire. They were classified into a project and a control group. The sampling is by purposive geographic selection, and project farmers were selected randomly from the farmers' list, and control farmers were purposively matched. Especially, the selection of farmers was based on the local extension staff's network of farmers who proactively participated in commune-level farming activities such as training facilitated by the extension staff.

b) Results

- There were no sociodemographic and farm-specific differences between the farmer groups in both survey years.
- Adoption rate was high for combine harvesters, drum seeders, AWD, and improved varieties → there were no significant differences between farmer groups.
- Farmer profitability increased by 5.7% and rice yield by 4.7%.
- Socioeconomic and agronomic differences between farmer groups in both survey areas: (1) project farmers applied lower quantities of inputs, (2) project farmers' yield and rice income were also lower.

**(4) Case 4: Consumer Acceptance and Willingness to Pay for Sustainably Produced Rice**

The Sustainable Rice Platform (SRP) standards—the world's first sustainable production standard for rice—has recently been introduced in Vietnam, but the market demand and potential for price premiums for SRP-certified rice are not known (My et al. 2018, 2021). This study aims to examine the relationship between climate change knowledge and consumer willingness to pay for SRP-certified rice in Vietnamese supermarkets. Data for the study was collected from 410 consumers through a questionnaire survey. Most participants were female (86.3 %), and the average age was 41.7 years.

1) Theoretical Framework

The conceptual framework for this study is presented in Figure 6.15. This study attempts to investigate the influence of knowledge (i.e., about climate change and of sustainably produced rice), attitudes towards sustainable production, and socio-demographic and economic variables on consumers' willingness to pay for sustainably produced rice. Especially, consumer's evaluations of three different attributes of the SPR standard will be investigated, namely consumers' perception of ecological production, ethical production, and low-emission production.

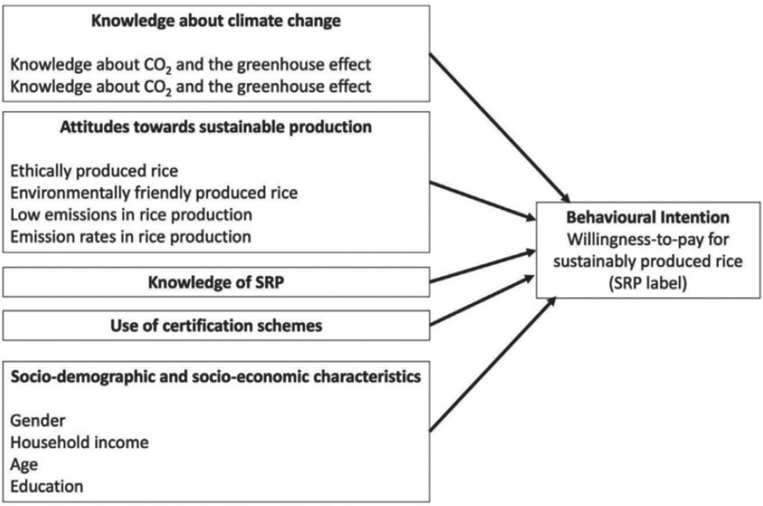


Figure 6.15 Conceptual framework of the study; determinants of consumer's willingness to pay for SRP labelled rice (adapted from My et al. 2018; 2021)

2) Results

The results of this study show that consumers are willing to pay a 29% price premium for sustainably produced rice. Knowledge about climate change and its impacts positively influenced willingness to pay.

Especially, focusing on the country's contexts is extremely important for policy implications and finding some similarities for applying in the Vietnamese context. Moreover, household income positively influenced willingness to pay. If consumer demand for sustainably produced rice can be increased, production will need to follow. The findings of this study are important for policymakers to increase the inclusiveness of SRP rice by creating an enabling environment for investment in the supply and demand for SRP rice.

## 5. Conclusion

In summary, the 1M5R program is suitable for farmers' conditions in the Mekong Delta. This program has been strongly and consistently supported by MARD, particularly by the Department of Crop Production and Plant Protection. The program is now a provincial regulation and policy and has also been modified for application in Lao PDR and Thailand.

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# Concluding Remarks and Discussion

Thanh Tam HO

Climate change poses significant challenges to global food security and safety. Strategy policies to mitigate food safety risks while minimizing environmental impacts in the era of climate change are becoming more important. Sustainable agricultural practices are potential solutions for sequestering carbon as climate change mitigation, improving environmental health and economic performance, as well as satisfying society's need for food safety. Identifying not only the farmers' decision-making but also the consumers' preferences for safe food can provide academic insights into understanding the potential strategies for a safe products market. Nevertheless, the diversity and heterogeneity of agricultural systems characterized by geographical regions or across countries might imply diversified policy implications for climate change adaptation and developing sustainable agriculture.

This booklet is a record of the AJI International Workshop which was held online under the restraints of the COVID-19 pandemic, with the aim of promoting international communication and academic collaboration among young researchers in Asian Universities and Institutions. Furthermore, it is my hope that this opportunity will drive sustained and long-term connections through collaborative research projects in the near future. Our discussion mainly concentrated on three issues.

## 1. Climate Change and Challenges to Agriculture

Climate change has become a major threat to global agricultural production and food security. Recently, extreme weather events such as drought, severe floods, and storms have increased in frequency and intensity, seriously damaging agricultural production. Increases in floods and droughts are anticipated due to variations in rainfall patterns, and dry seasons are expected to become longer in the future. Developing regions of the globe are more sensitive to climate variability and change as these regions implement old technologies, whereas developed regions can mediate climate-driven extremes through the implementation of modern technologies. Consequently, climate change would pose a direct and severe challenge to rice production, especially in Asian countries — the main rice production region of the world. Indirectly, the price of rice and the rural livelihoods of rice farmers would also be affected. Therefore, it is urgent to develop agricultural systems that are more sustainable and resilient to climate change.

Dr. Orawan Srisompun addressed the drought situation and its negative impacts on rice production in Thailand. Climate change adaptation (i.e., stopping rice growing, finding additional water sources [i.e., digging ponds, wells, or groundwater], adjusting the time of planting or slowing the rice sowing, reducing the number of rice cultivation areas, adjusting the use of rice varieties, adjusting the types of crops that are grown instead of rice, or changing to livestock instead of growing rice) were ascertained as practices to cope with insufficient rice for consumption and agricultural income for farm households. Importantly, she mentioned that a long-term strategy plan for climate change, especially drought management, is necessary to ensure rural livelihood, especially income and self-sufficiency.

Dr. Mohammad Rondhi et al. reported on Indonesian farmers' decision-making on farming insurance as an adaptation measure to climate change. Participation in farming insurance might be attractive for risk-averse and land-owning farmers. A high level of risk aversion would be of concern for the policymakers as it potentially hinders farmers' adoption of new technologies. They discussed the specific program from the government for each specific area in Indonesia. They concluded that the government should pay more attention to farmers with rented or sharecropping land and high-risk aversion as the targets for improving farmers' participation in the government's agricultural insurance scheme.

Climate change adaptation is essential for sustaining agricultural productivity, reducing vulnerability, and enhancing the resilience of agricultural systems. Building adaptation and mitigation in agricultural systems requires simultaneous attention to increasing production by adopting varieties of technologies, adopting sustainable land management practices, building on and using local knowledge and social culture, and formulating enabling policy and institutional setups. Improving resilience and farmers' adaptive capacity to cope with climate risks has become increasingly important not only in Asian countries but also in other vulnerable regions and communities.

Recently, awareness of agriculture in harmony with the environment and its biodiversity has continually risen. Though several adaptation options are available in agriculture, not all of them can be applied to all locations, as they are mostly location-specific. Therefore, cooperation and collaboration among institutions at international and national levels are extremely important for coping with the challenges of climate change, food security, and food safety at the cross-country level.

## 2. Towards Sustainable Rice Agriculture

Today's unsustainable farming practices put global food security at risk. This would adversely impact the world's most vulnerable populations, including rice farmers. The global population is expected to exceed nine billion by 2050, and even more people will rely on rice for nutrition. As one of the most important food staples, we must transform the rice sector to feed the world sustainably. Although rice is a staple food for many in Asia, smallholder farmers still face many challenges, including decreasing yield productivity from the effects of climate change and the pressure to meet the rising demand for food as the world's population continues to grow.

It is important to have an intimate understanding of farmers' immediate needs. With farmers' means of support as a priority, positioning climate-smart agriculture solutions as directly beneficial to farmers' livelihoods is necessary to get greater engagement. Therefore, the integration of adaptation and mitigation strategies is a primary challenge to promote sustainability and productivity.

With the global demand for rice continuing to rise and limited potential to expand yields in traditional producers such as China, the countries of mainland Southeast Asia are poised to take center stage as the world's rice bowl if they can increase their resilience to social and environmental pressures. However, climate change and labor shortages threaten rice production in a region that feeds an ever-larger share of the world's rice consumers. Major rice producers such as Thailand and Vietnam produce rice for their own populations, as well as exporting to other regions, while other traditional producers in the region, such as China, India, and Indonesia, are increasingly turning to imported rice to keep their populations fed.

Dr. Phuc Trong Ho proposed the adoption of high-yielding and high-quality rice varieties in the Mekong Delta as a solution for increasing rice production to meet the increasing consumption demand of population growth. In developing countries like Vietnam, policies should focus on increasing farm scale and farming contracts as well as reducing land fragmentation to speed up the adoption of high-quality rice varieties. Furthermore, high-quality rice varieties should be developed with consideration for adapting to adverse production conditions and climate change impacts.

Moreover, Dr. Melanie Connor stressed that it is essential to develop rice and protect its sustainability for global food security and environmental conservation with the consideration of policymakers and scientists not only in Asia, but also in Africa. Improving sustainable rice production in Africa through capacity development and innovation is another challenge. Sub-Saharan Africa is the world's most food-insecure region. In order to secure a stable supply of food for the region and achieve the eradication of hunger, food production technology that can adapt to the increasingly unstable growing environment and effectively utilize limited resources such as water and nutrients is required. To this end, it is important to develop new technologies and knowledge that will lead to increased production of rice, a key crop in the region, and improved food self-sufficiency and nutrition for the people, with the aim of building a sustainable food production system centered on rice cultivation.

Furthermore, strengthening social norms for motivating farmers' intentions and their behaviors toward sustainable agriculture is extremely important. Especially, establishing trust among farmers is another issue which should be focused on, and this can be done by working closely with farmers' associations and investing in demonstration farms to "show by doing."

## 3. Economic Challenges and Policy Aspects

The major concern about the economic sustainability of rice farming is that subsidies are necessary if the price of rice is to be kept low. The social, political, and economic importance of rice in all of the major rice-producing countries is such that their governments seek to ensure that sufficient rice is available at a price all can afford.

Dr. Qi Dong addressed the importance of resource input use and rice production efficiency with a comparison between China and Japan. Especially, the scarce input resources in rice production resulting from structural transformations and changes in dietary structure constitute the main differences in rice production between the two countries. The shadow costs can lead to a significant gap between the two countries and affect rice farmers' enthusiasm. In addition, the costs for sustainable rice farming seem to be remarkably high compared to conventional rice farming. High labor costs and a shrinking labor force are emerging issues, more so in a developed country like Japan than in developing countries.

This author also addresses the economic aspects of climate change adaptation in reducing productivity loss as well as improving farmers' profitability. Nevertheless, promotion policies are facing several challenges not only in developed countries like Japan but also in developing countries like Vietnam. More specifically, the Japanese direct payment policy can be a solution for ensuring farmers' income and their motivation toward sustainable agriculture. Nevertheless, the question of how the government with their direct payment policies can really achieve the sustainable production of rice in the long term should be tackled.

Meanwhile, promotional policies for sustainable rice farming or organic farming could add value to production. For specific regions like Thailand and Vietnam, developing local rice varieties (i.e., drought-tolerant, salt-tolerant, pest-tolerant) should be focused on. Large-scale farming policies are necessarily different across regions. Thailand's farmers, especially those in the Northeast regions, would not benefit from economies of scale, while Vietnam's farmers, especially those in the Mekong River Delta regions, would benefit from increasing farm scales. Agricultural innovation and technology should be paid more attention not only at the national level but also at the local level. Simultaneously, policy recommendations for sustainable rice farming should be involved at transnational levels.

Importantly, our discussion not only shared academic knowledge linked to the various situations of Asian rice but also aimed at the establishment and activation of researcher networks, even under the constraints of the COVID-19 pandemic. An international and multidisciplinary research approach towards sustainable rice agriculture is definitely important for our future collaboration. It is necessary to mention here that the inequities within countries and across countries in Asia and how these are potentially exacerbated by existing socio-political systems should be given more attention in future research.

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Asia-Japan Research Institute, Ritsumeikan University