A SNAPSHOT OF VIETNAM'S RICE PRODUCTION SYSTEMS IN IRRIGATED AREAS:

THE MEKONG RIVER DELTA EXPERIENCE

Jesusa C. Beltran, Rhemilyn Z. Relado, Mary Rose L. San Valentin, Estrella V. Tulay, Flordeliza H. Bordey, Piedad F. Moya, and Truong Thi Ngoc Chi

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The Philippine Rice Research Institute (PhilRice) is a chartered government corporate entity under the Department of Agriculture. It was created through Executive Order 1061 on November 5, 1985 (as amended) to help develop high-yielding, cost-reducing, and environment-friendly technologies so farmers can produce enough rice for all Filipinos.

It accomplishes this mission through research, development, and extension work in its central and seven branch stations, coordinating with a network that includes 57 agencies and 70 seed centers strategically located nationwide.

PhilRice has the following certifications: ISO 9001 (Quality Management), ISO 14001:2004 (Environmental Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

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The International Rice Research Institute (IRRI) is the world's premier research organization dedicated to reducing poverty and hunger through rice science; improving the health and welfare of rice farmers and consumers; and protecting the rice-growing environment for future generations. IRRI is an independent, nonprofit, research and educational institute, founded in 1960 by the Ford and Rockefeller foundations with support from the Philippine government. The institute, headquartered in Los Baños, Philippines, has offices in 17 rice-growing countries in Asia and Africa, and more than 1,000 staff members.

Working with in-country partners, IRRI develops advanced rice varieties that yield more grain and better withstand pests and disease as well as flooding, drought, and other harmful effects of climate change. More than half of the rice area in Asia is planted to IRRI-bred varieties or their progenies. The institute develops new and improved methods and technologies that enable farmers to manage their farms profitably and sustainably, and recommends rice varieties and agricultural practices suitable to particular farm conditions as well as consumer preferences. IRRI assists national agricultural research and extension systems in formulating and implementing country rice sector strategies.

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CONTENTS

TABLES

FIGURES

ABBREVIATIONS

ha - hectare
kg - kilogram
km - kilometer
L - liter
md - manday
VND - Vietnamese Dong
t - ton
US$ - United States dollar
yr - year

PREFACE

In 1995, the International Rice Research Institute coordinated an international effort that looked into the causes of declining productivity trends in intensive irrigated rice systems in the Philippines, China, Indonesia, Thailand, Vietnam and India. A major feature of this study is the development of a database on input use, level of rice output, prices and detailed cost of rice production. In this study, the costs of producing rice in Central Luzon, Philippines were compared with those in Central Plain, Thailand; Mekong Delta, Vietnam; West Java, Indonesia; Tamil Nadu, India; and Zhejiang, China. More than a decade has passed since then, and new government policies, as well as trade regimes, may have caused changes in relative prices. A cost structure of paddy production that is comparable across countries is in short supply. Thus, it is imperative to update the findings of the study.

Rice is intricately related to food security and international trade policies in major rice producing countries. As a result, the Philippine Rice Research Institute of the Department of Agriculture and the International Rice Research Institute, with the participation of the Philippine Council for Agriculture and Fisheries also of the Department of Agriculture jointly planned, designed and implemented a project entitled "Benchmarking the Philippine Rice Economy Relative to Major Rice–Producing Countries in Asia". The Philippine government, through the Department of Agriculture, provided the full financial support for this undertaking.

The country monograph is one of the major outputs of this project. This monograph is intended for a general audience who would like to learn about the current status of rice production in Asian countries. It attempts to provide the most detailed information on rice farming in intensively cultivated irrigated rice areas of the major rice-producing countries in Asia. These countries include Indonesia, Philippines, Thailand, Vietnam, India and China. All of these countries are among the top 10 rice producers in the world. Data from each country were collected through interviews using electronic questionnaires, which included questions on paddy output, input use, cost of rice production for crop year 2013-14, as well as basic farm and household characteristics.

Each monograph contains a detailed description of each country's crop management practices, input use, labor using and labor-saving practices and various support and services provided by their government to enhance rice production. Given the impending implementation of the free trade agreement which is expected to increase the flow of rice trade among Asian rice bowls, these studies also evaluated the costs and profitability of producing paddy rice.

Results from this study can provide insights on how a country can further improve its competitiveness in rice production and marketing. We gain a perspective on the policies being implemented by our neighbors to make their respective rice industry competitive. By understanding the costs of producing and marketing rice amidst different government policy frameworks in major rice-producing countries, agricultural policymakers can make appropriate decisions on how to best position the country's interest in terms of rice food security. Policymakers and planners can use this information in crafting sustainable development programs for the rice industry.

Project Leaders

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We would also like to thank the highly dedicated staff of IRRI, PhilRice, and DA BAR who helped us in administrative matters and coordination work to implement this project.

We are also thankful to our country collaborators who helped facilitate our field work in each study site.

Lastly, we would like to thank all the rice farmers in the various sites who willingly provided all the information that we needed to complete these studies.

ABSTRACT

This paper gives a profile of the rice production system in Can Tho province, which is within the Mekong River Delta in Vietnam. It discusses the current rice production system in irrigated areas with increased cropping intensity and higher adoption of minimum tillage. Specifically, the paper describes production and marketing practices, cost and profitability, government policies, and changes in the farming landscape. Whenever possible, findings of this paper were compared with results of a previous project on reversing the trends of declining productivity in 1994-1999. To attain the objectives, primary and secondary data were used. A structured electronic questionnaire was developed for the farm surveys. A quota sampling of 100 respondents was employed and they were interviewed for the three seasons during crop year 2013-14. Results suggest that labor productivity in the study area has improved because of higher yield and lower labor use. Nitrogen productivity has also improved over the years due to increases in yield. Moreover, good practices such as increased cropping intensity, synchronous planting, mechanization of harvesting and threshing, direct seeding, and use of few varieties were observed. Improvement in productivity and profitability can be achieved through adoption of lower seeding rates, use of high-quality seeds, and less dependence on pesticides.

Keywords: rice, yield, cost, profitability, rice production

INTRODUCTION

Rice is an important agricultural crop in Vietnam in terms of food security, the rural economy, and national revenue. Before 1986, rice production in Vietnam has low productivity, which resulted in the country importing rice to meet local demand. However, when the government implemented *doi moi* (a new model policy) in 1986, production increased substantially (Hoanh et al., 2002). The country liberalized the rice and agricultural input markets and set forth policies to promote the cultivation of high-yielding varieties. Since then, Vietnam has experienced a steady growth in rice production and exports. Parallel to this growth is the declining trend in rice per capita consumption as a result of changes in the population's diet (Thang and Huong, 2012). This contributes to the reduction of total domestic consumption and sustaining surpluses for exports.

Majority of Vietnam's rice production came from irrigated areas, where rice is often grown in monoculture with double or even triple crops a year, depending on water availability (Young et al., 2002). Given many concerns about the long-run sustainability of intensive rice cropping, the International Rice Research Institute (IRRI) launched a six-country collaborative project with the national agricultural research systems (NARS) in 1994-99. This project, titled "Reversing Trends of Declining Productivity (RTDP)," included biophysical and socioeconomic assessments of intensive cropping systems in the rice bowls of these six countries (including the Mekong River Delta of Vietnam). The project aimed to enhance national capacities for increased rice production and to ensure efficient use of inputs in intensively cultivated irrigated areas in tropical and subtropical Asia. Results suggest that the profitability of rice production systems does not only depend on yield and input quantities but also on government policies that determine prices of inputs and outputs. Further, the project concludes that generating new technologies and enhancing management strategies also raise rice productivity (Moya et al., 2004).

In this study, the RTDP sites in Vietnam were revisited after program implementation in 1994-99 to understand how rice farming systems in those areas have changed since the introduction of site-specific nutrient management (SSNM). In addition, little is known about the sustainability of current rice production systems in Vietnam, particularly those with triple cropping and minimum tillage (Dobermann et al., 1996; Tan et al., 2004).

This paper aims to (1) describe the current rice production system and marketing practices of famers in irrigated areas of Vietnam vis-à-vis previous practices; (2) examine the costs and profitability of rice production; (3) identify problems and constraints of rice farmers; (4) identify government programs that support the local rice industry; (5) determine farmers' perceived changes in rice farming practices; and (6) document the best practices and areas for improvement.

Vietnam's rice industry

Rice production in Vietnam has experienced large and sustained growth over the years. It is the fifth largest rice producer in the world, producing almost 44 million t of paddy from 7.9 million ha (FAO, 2014a). Average rice yield in 2013 was 5.6 t ha^{-1} (GSO, 2014a). With such performance, the country has become a major rice exporter since 1989. Currently the second largest rice exporter in the world (tied with Thailand), Vietnam exported as much as 6.6 million t in 2013 (FAO, 2014b). The country's remarkable growth in rice production is attributed to the conversion from single to double or triple rice cropping; improved drainage and irrigation systems; increased adoption of modern, short-season varieties; and higher fertilizer application (Young et al., 2002; Tan et al., 2004).

About 80% of Vietnam's current total rice area is classified as irrigated, clustering around two deltas: the Red River Delta (RRD) in northern Vietnam and the Mekong River Delta (MRD) in southern Vietnam. The RRD accounts for 16% of total rice area and contributes about 20% of national rice production. On the other hand, the MRD constitutes around 45% of total rice area and produces about 50% of total output. Ninety percent of the export volume of the country in 2012 came from MRD (Young et al., 2002). As the largest rice granary in Vietnam, the MRD was previously selected as the RTDP site and thus became the focus of this study.

In MRD, rice is produced during three cropping seasons: winter-spring (WS) (*dong xuan*), summer-autumn (SA) (*he thu*), and autumn-winter (AW) (*thu dong*). WS has the largest rice production, with harvesting that falls from February to April; followed by SA with harvesting period from July to September. AW has the lowest production and harvesting is done from September to November (Young et al., 2002). In 2013, MRD produced almost 25 million t from 4.3 million ha at an average yield of 5.76 t ha^{-1} (GSO, 2014a). Biophysical conditions such as flat topography with many fertile alluvial soils and abundant freshwater sources make MRD well-suited to rice cultivation (Tan et al., 2004).

Table 1 shows paddy production, area harvested, and yield of rice-producing provinces in MRD. Although Can Tho only ranked sixth among the rice-producing provinces, it can be considered a representative site because most of the recent trends in rice production are observed to be the same for the whole MRD. The RTDP project had previously selected Can Tho to represent rice farming in MRD. Can Tho has increased its production and improved its productivity in the past years due to increased cropping intensity. Despite pressure on rice land nationally, the rice-growing areas in Can Tho have remained stable over the last two decades. In 2013, Can Tho produced 1.37 million t from 0.27 million ha, averaging 5.79 t ha^{-1} (GSO, 2014a). Most of the rice produced in Can Tho came from Thoi Lai and Omon districts.

Table 1. Paddy production, area harvested, and yield in provinces of the Mekong River Delta, 2013.

Province	Production ('000 t)	Area harvested ('000 ha)	Yield (t ha^{-1})
An Giang	4010	641	6.25
Đồng Tháp	3327	542	6.14
Sóc Trăng	2220	371	5.98
Vĩnh Long	1064	182	5.85
Kiên Giang	4482	770	5.82
Cần Thơ	1370	237	5.79
Tiền Giang	1349	236	5.72
Hậu Giang	1191	212	5.62
Bạc Liêu	1014	182	5.58
Trà Vinh	1275	236	5.41
Long An	2816	528	5.34
Bến Tre	332	72	4.59
Cà Mau	544	130	4.19

Source: GSO, 2014

METHODOLOGY

The study used both primary and secondary data. Primary data were collected through a survey of rice farmers in Can Tho, MRD, in Vietnam. This site was a previously selected area under the RTDP project, representing tropical climate and rice-rice cropping systems in the country.

The data set covered three rounds of survey: the first round in SA 2013, the second in AW 2013, and the third, WS 2014. The survey concentrated on four municipalities covering eight villages in Thoi Lai District and another village in one municipality in Omon District. These villages, former sample villages of the IRRI RTDP Project, represent the intensively cultivated irrigated rice areas in the province. The sample farmers were selected using the following criteria: (1) farmers who participated in the RTDP project, (2) those living in the same villages; (3) those with at least 10 years' farming experience; (4) those with irrigated rice farms; and (5) those that have a standing crop in 2013. A quota sample of 100 respondents was set in each season and they were interviewed using a structured electronic questionnaire. However, there were respectively eight and six farmers who were replaced at the time of the interview in AW and WS because of unavailability and reluctance to participate. A total of 114 unique respondents were interviewed across the three seasons. Figure 1 shows the geographical location of the study's survey areas in Can Tho, MRD. The project sites of RTDP were also located in these areas.

Data on farm and household characteristics, yield, input use, crop management practices, and prices of inputs and output were gathered. Farmers' problems in rice production, their perceptions of government support, and changes in their rice production practices were also asked. To provide an in-depth analysis of government policies, key informant interviews were done.

Secondary data (e.g., time-series data on production, yield, and area harvested) obtained from the Food and Agriculture Organization (FAO), AgroViet, Vietnam General Statistics Office (GSO), and IRRI's Rice Knowledge Bank were also used to describe trends in the rice industry and complement the primary data generated.

Data analyses

A farm budget structure was constructed for the production of paddy rice in the irrigated ecosystem in the area using actual and imputed prices. The cost structure was disaggregated by season. Relevant

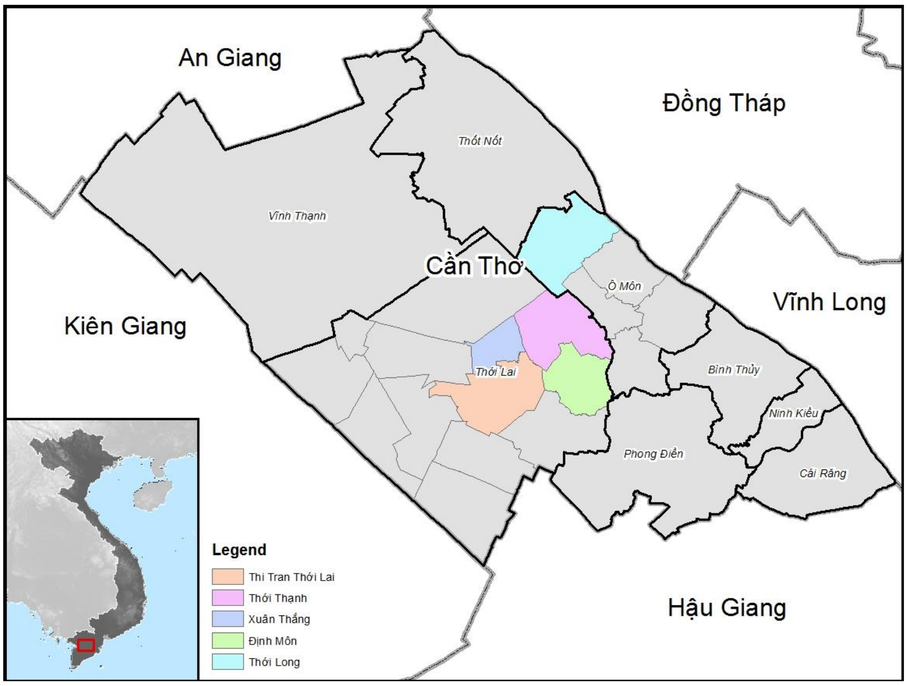

Fig.1. Location of study sites, Can Tho, Vietnam, 2013 (Source: www.google.maps.com).

costs included seed, fertilizer, pesticide, irrigation, machine rental, fuel and oil, transportation, labor (land preparation, crop establishment, crop care and maintenance, harvesting and threshing, and postharvest), rental value of land, and interest cost of capital. All costs were expressed on a per-hectare basis. Gross revenue was calculated by multiplying rice yield (after threshing) with the price of wet paddy. Net returns above production cost per hectare were computed using this equation:

$$\pi = (y \times p) - \left(\sum_j x_j\right) \qquad \left(j \in \{seed, fertilizer, pesticide, labor, irrigation, land, others\}\right) \quad (1)$$

where π is net returns, y is rice yield, p is price of paddy, and x's are the cost items. Using the farm budget structure, the costs of rice production and profitability of rice farming were compared across seasons.

The partial factor productivities of nitrogen (N) and labor inputs were also analyzed. Following Moya et al. (2004), N productivity was calculated by getting the ratio of kilogram grain output to kilogram N applied. Similarly, labor productivity was measured by dividing total grain output with total man-days (1 man-day = 8 hours of work) employed in rice production for one cropping season.

Descriptive statistics such as means and frequency distribution were also employed. T tests were used to discern if differences in average yield, input use, and costs across seasons are statistically significant. For this study, the 2013 exchange rate used for converting Vietnam dong into US dollar is US$1=VND 20,933 (IMF, 2015).

Data limitation

In using this dataset, several limitations should be considered. First, the information is based on farmer interviews and accuracy of information is thus affected by farmers' ability to estimate input use or recall total expenditure in rice farming for each cropping season. Second, data collection proved to be challenging because of the language barrier between study proponents (who are foreigners) and local farmers. Third, interviews were done with the aid of translators/interpreters; the accuracy of information is also dependent on how good the translators are. Lastly, information was only gathered from intensively cultivated irrigated rice areas; therefore, the results of the descriptive and farm budget analyses may not have captured conditions in other farm ecosystems that also have large amount of rice production. Despite these drawbacks, the dataset remains the most useful and updated source of information for revisiting rice production in Can Tho, MRD.

Data gathering through personal interview guided by a structured questionnaire and aided by translator.

RESULTS & DISCUSSION

This section discusses farm and household characteristics, crop management practices, and costs and returns in rice farming. Also, constraints to rice farming, government support/programs, and farmers' perceptions of their crop management practices are presented. Taking these aspects into consideration, the strengths and weaknesses of Can Tho's rice farming practices were also described.

Farm and household characteristics

In 2013, a typical farmer was around 50 years old, a male, a landowner, and has 8 years of education (Table 2). In general, household size in Can Tho was five. Only 38% were members of farm organizations and 63% had attended rice training courses in the last 5 years. About 78% of the total annual household income of the respondents came from rice. Of the 114 respondents from 2013 to 2014, 53% borrowed money to be used as capital for rice production. Since the farmers relied more on custom service provision, only less than 3% owned four-wheel tractors.

Table 2. Demographic profile of farmers, Can Tho, Vietnam , 2013.

Characteristic	Value (n=114)
Age (yr)	48
Education (yr)	8
Household size (no. of persons)	5
Sex (% male)	99
Tenure (% owner)	88
Organization (% member)	38
Training (% trained)	63
Capital (% borrower)	53
Rice Income (%)	78

With regard to farm characteristics, landholding[1] clustered around 1.3, 1.4, and 1.2 ha for SA, AW, and WS, respectively. The average size of land cultivated by farmers was 1.4 ha for the three seasons, divided

[1] Landholding refers to the land that a farmer was given the right to use by the government. It is usually the same or smaller than the land cultivated because some farmers also rent from other farmers. By rent, we mean paying for the right to use the land.

into two parcels on average. In this case, each parcel is less than a hectare. Respondents reported that their farms are located within 2.4 km from the nearest markets, with concrete (41%) and asphalt (34%) roads prevailing. Nevertheless, the common mode of transport is through a river using a boat. More than half (50-72%) of the farmers primarily used state-owned and communal irrigation canals as source of irrigation for all cropping seasons (Fig. 2). In AW, it is notable that farmers (72%) heavily relied on state-owned and communal irrigation canals. On the other hand, a large number of farmers (28-50%) also accessed river/streams as main sources of irrigation water. With abundant water supply from the Mekong River, irrigation was not a problem.

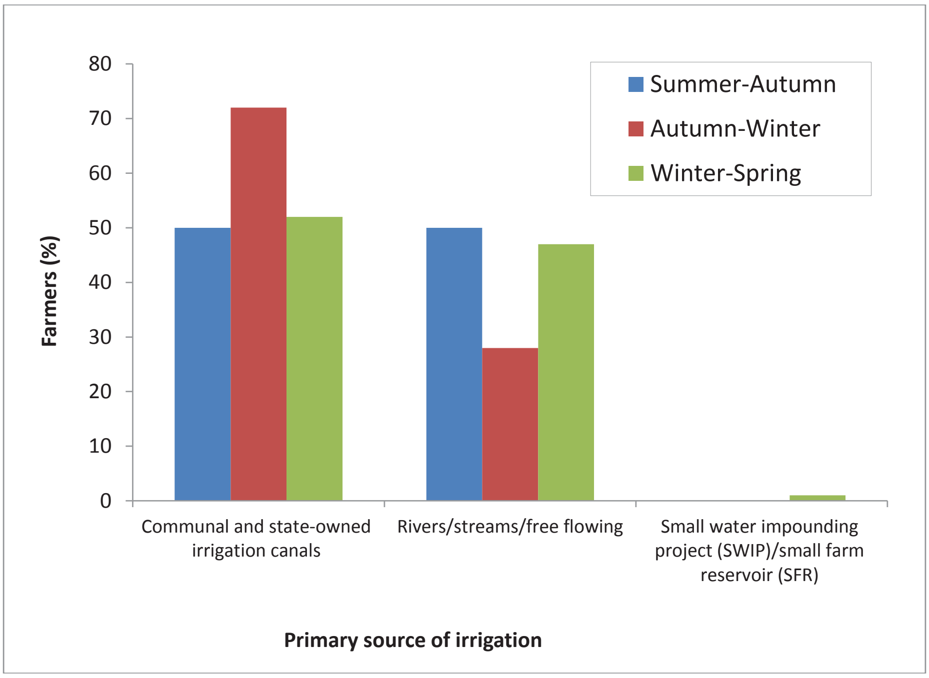

Fig.2. Distribution of irrigation source, by season, Can Tho, Vietnam, 2013.

Transport of paddy rice in river using boat.

Yield, paddy price, and gross revenue

Farm-level yields varied considerably across seasons (Fig. 3). On average, the estimated yield was 6.8 t ha^{-1} in SA; 6.1 t ha^{-1} in AW; and 9.4 t ha^{-1} in WS (Table 3). Moisture content of rice averaged 20% in SA and WS and 22% in AW. Using 14% moisture content, the estimated dry paddy yield equivalent during SA was 6.3 t ha^{-1}, 5.6 t ha^{-1} in AW, and 8.8 t ha^{-1} in WS. The WS crop had a superior yield advantage, 39% over the SA crop and 54% over the AW crop. The high yield of the WS crop is attributed to more favorable growing conditions, higher solar radiation, and more fertile soil relative to those noted in the other cropping seasons (Tan et al., 2004). A fallow period, brought about by flooding in October, contributed to the replenishment of soil nutrients in the area, consequently improving the soil condition in WS.

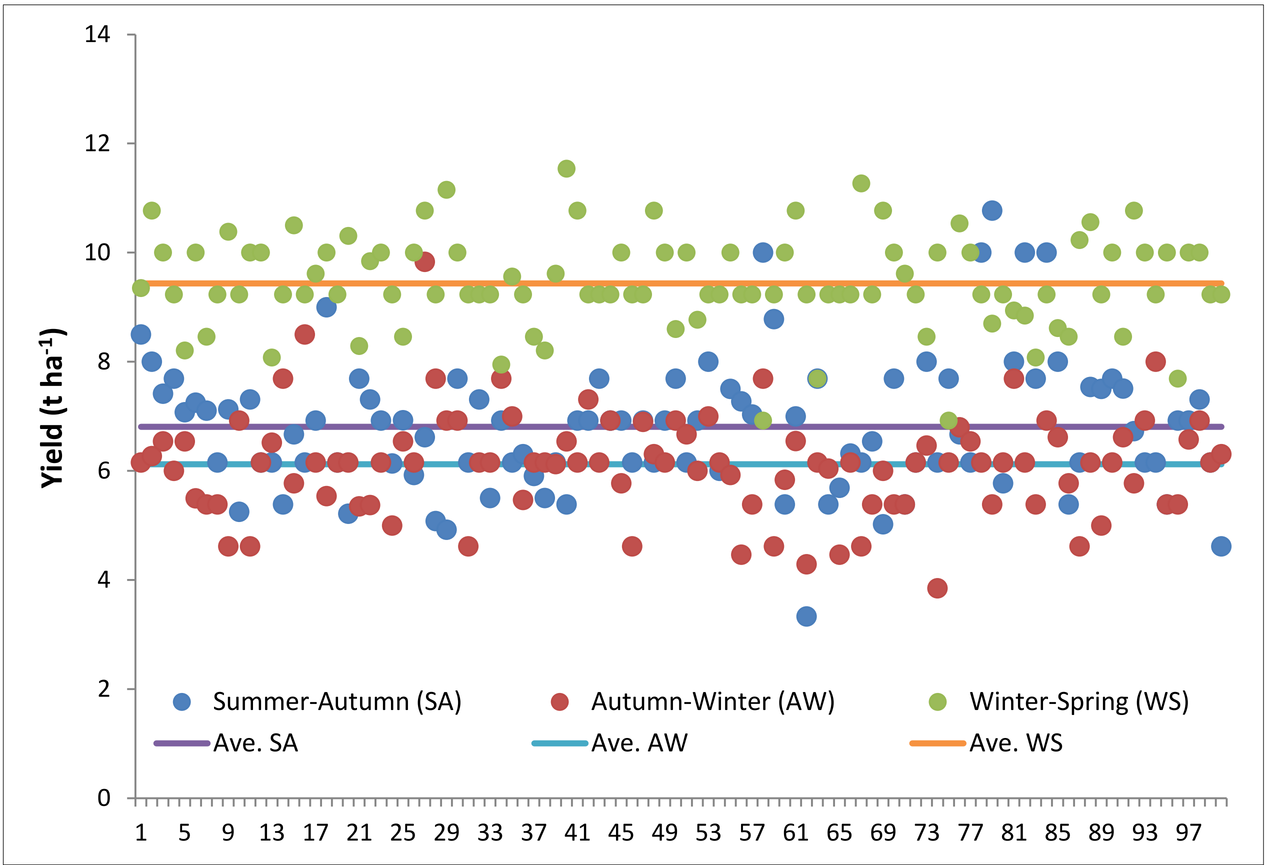

Fig. 3. Scatter diagram of average yield of farmers, by season, Can Tho, Vietnam, 2013.

The mean yield obtained from the current survey was significantly higher than the average yields observed during high- (5.86 t ha^{-1}) and low-yielding (3.86 t ha^{-1}) seasons in previous RTDP sites in Can Tho in 1999 (Moya et al., 2004). Except for AW yield, which was slightly lower, dry paddy yields in SA and WS were also substantially higher than the reported 5.79 t ha^{-1} (average yield in Can Tho in 2013) (GSO, 2014a). This result suggests great yield improvement in intensively cultivated irrigated areas over time in the province.

The price of paddy reported by the respondents ranged from US$196 to US$224 t^{-1} across seasons. The harvest in WS crop received the highest farmgate price of US$224 t^{-1}. It had a price advantage over SA and AW of about US$28 and US$24 t^{-1}, respectively. The better price received by farmers during WS was primarily due to lower moisture content of paddy, better quality of harvest, and better eating quality of the grain (e.g., Jasmine85) relative to those in other cropping seasons.

Table 3. Cost and returns of paddy production, by season, Can Tho, Vietnam , 2013.

Item	SA[a] 2013 (n=100)	AW[b] 2013 (n=100)	WS[c] 2014 (n=100)	Difference[d] (AW-SA)	Difference (WS-SA)	Difference (WS-AW)
Returns						
Yield (t ha^{-1})	6.8	6.1	9.4	-0.7***	2.6***	3.3***
Paddy price (US$ t^{-1})	195.9	199.9	223.8	4.0**	28.0***	23.9***
Gross revenue (US$ ha^{-1})	1,333.6	1,223.5	2,112.5	-110.1***	778.9***	889.0***
Costs (US$ ha^{-1})						
Seeds	67.7	68.2	79.1	0.5	11.4***	10.9**
Fertilizers	241.7	223.6	193.8	-18.1**	-47.9***	-29.8***
Chemicals	140.9	140.9	140.1	0.1	-0.8	-0.8
Hired labor	78.7	73.9	70.4	-4.9	-8.3	-3.4
OFE labor	127.1	128.5	135.3	1.4	8.2	6.8
Animal, machine, fuel & oil	136.9	127.0	127.7	-9.9***	-9.2***	0.6
Irrigation	16.0	8.8	16.1	-7.2***	0.1	7.3***
Food	0.7	0.1	0.2	-0.6***	-0.5**	0.1
Transportation	6.9	5.4	6.8	-1.5	-0.1	1.4
Tax	0.0	0.0	0.0	0.0	0.0	0.0
Land rent	238.1	242.0	241.8	3.9	3.8	-0.2
Interest on capital	19.2	11.3	7.1	-8.0***	-12.1***	-4.1**
Other Inputs	13.3	12.3	17.8	-1.0**	4.5***	5.5***
Total cost (US$ ha^{-1})	1,087.2	1,042.0	1,036.3	-45.2	-50.9	-5.7
Cost per unit (US$ m^{-1})	159.7	170.3	109.8	10.6**	-49.9***	-60.5***
Net income (US$ ha^{-1})	246.4	181.5	1,076.3	-64.9	829.8***	894.8***
Farmer's income (US$ ha^{-1})	630.8	563.3	1,460.5	-67.6	829.7***	897.3***

[a]SA = summer-autumn; [b]AW = autumn-winter; [c]WS = winter-spring,
[d] = *, **, *** indicate significance at 90%, 95%, and 99% confidence level, respectively.

Due to higher yield and price levels, the WS crop posted the highest gross revenue at US$2,112 ha^{-1} (Table 3). On average, the gross income advantage of the WS crop was 58% over SA and 73% over AW. The gross returns of SA and AW can still be improved through advancement in yield. This is attainable since the Ministry of Agriculture and Rural Development (MARD) has made huge investments in rice production during these seasons (Thanh et al., 2013).

Input use, cost, and management

This section describes seed, variety, crop establishment, fertilizer, pesticides, labor, irrigation and drainage, land, interest cost on capital, and other inputs used.

Variety, seed, and crop establishment

Many varieties have been developed in Vietnam. For example, there are now 89 varieties developed by IRRI alone. This is in addition to those that are locally bred by the public and private sectors. However, a remarkable finding on varietal usage is the fact that only 10 varieties were used in the three seasons under study. Even when accounting for varietal replacement within the last 10 years, farmers reported changing their varieties only three times.

Table 4. Popular varieties (%) planted by farmers, by season, Can Tho, Vietnam , 2013.

Variety	Summer-autumn (n=100)	Autumn-winter (n=100)	Winter-spring (n=100)
IR50404	73	74	70
OM10424	3	2	
OM1960	1		
OM2718	1	1	
OM4218	22	20	4
OM5451		1	
Jasmine85		1	23
AP2010		1	1
AP2100			1
CP4(504)			1

Manual broadcasting of rice seeds in field with small water ditches for drainage.

The stable use of fewer varieties could be related to the purpose of maintaining the same quality and volume of rice exports.

With triple cropping done in a year, most farmers planted high-yielding and early-maturing varieties. IR50404, an IRRI-bred rice variety, was the most popular with more than two-thirds of the farmers planting it across seasons due to its yield advantage and high head rice recovery (Thanh et al., 2013) (Table 4). It is followed by OM4218, a local variety, with 22% and 20% of farmers growing it during SA and AW, respectively. For WS, the second most common variety planted by famers (23%) was Jasmine85 as it commands a premium price in the market for its good eating quality.

Table 5. Technology used by farmers, by season, Can Tho, Vietnam , 2013.

Technology	Summer-autumn (n=100)	Autumn-winter (n=100)	Winter-spring (n=100)
Certified and registered seed (%)	31	24	45
Farmer's seed (%)	69	76	55
Direct seeding (%)	100	100	100
Combine harvester-thresher (%)	100	97	100
Irrigation pump (%)	86	84	87

Across three seasons, 55-76% of the farmers used their own seeds. It is notable that registered and certified seed users accounted for almost half of the respondents only in WS (Table 5). The average seeding rate for all seasons was more than 200 kg ha^{-1} (Table 6), way higher than the recommended rates of 70-120 kg ha^{-1} (Huan et al., 2005). With this high seeding rate, total seed cost, which was around US$72 ha^{-1}, was almost the same as the cost of hired labor (Table 3). The higher seeding rate is attributed to the prevalent crop establishment method, which is direct seeding. The use of direct seeding is a strategy to increase cropping intensity from double to triple cropping a year primarily because this method facilitates early establishment and early harvest of the crop (Pandey and Pingali, 1996). In particular, direct seeding leads to shorter growth duration of rice plant due to the elimination of transplanting shock. On average, rice growth duration is shortened by about 5-7 days relative to transplanting (Moya et al., 2004).

Fertilizer use

N usage of Can Tho famers showed no significant differences across the three seasons, except that between SA and WS (Table 6). The amount of N applied ranged from 90 to 100 kg ha^{-1}. On the other hand, varying amount of P usage was observed. The highest P application (31 kg ha^{-1}), which was significantly different from those in the other two seasons, was reported during the SA survey. The least amount of P application was recorded for WS, with only 26 kg ha^{-1}. As to K, the same trend was observed: highest application, 35 kg ha^{-1}, for SA and lowest, 29 kg ha^{-1}, for WS. The most common inorganic fertilizer grades used by farmers in all seasons were urea (46-0-0) with 38-40% of farmers reporting; 25-27% mentioned diammonium phosphate (DAP) (18-46-0); 16-18% reported complete (16-16-8 and 20-20-15); and 11-15% mentioned muriate of potash (MOP) (0-0-60). The reported average prices of fertilizer grades were US$0.72 kg^{-1} for DAP, US$0.66 kg^{-1} for MOP, US$0.60 kg^{-1} for complete, and US$0.50 kg^{-1} for urea. On average, farmers applied fertilizers in four splits per season (Table 7). Given the fertilizer price, quantity used, and frequency of application, farmers spent around US$194-242 ha^{-1} across seasons (Table 3).

Table 6. Inputs used in rice farming, by season, Can Tho, Vietnam , 2013.

Item	SA[a] 2013 (n=100)	AW[b] 2013 (n=100)	WS[c] 2014 (n=100)	Difference[d] (AW-SA)	Difference (WS-SA)	Difference (WS-AW)
Area (ha)	0.9	0.9	0.9	0.0	0.0	0.0
Seeds (kg ha^{-1})	220.8	213.7	205.4	-7.1	-15.4	-8.3
N (kg ha^{-1})	99.3	97.5	93.0	-1.8	-6.3 *	-4.5
P (kg ha^{-1})	30.9	27.9	26.3	-3.1 *	-4.6 ***	-1.5
K (kg ha^{-1})	35.0	34.4	29.1	-0.6	-5.9 **	-5.3 **
Total labor (person-days ha^{-1})	22.0	20.4	21.9	-1.6	-0.1	1.5
Land preparation	2.0	1.2	2.4	-0.7 ***	0.4 *	1.1 ***
Crop establishment	4.8	5.4	6.3	0.5	1.4 **	0.9
Crop care and maintenance	12.4	10.8	11.0	-1.6 *	-1.4 *	0.2
Harvesting and threshing	1.7	1.8	1.2	0.1	-0.5 ***	-0.6 ***
Postharvest	1.1	1.2	1.1	0.1	0.0	-0.1

[a]SA = summer-autumn; [b]AW = autumn-winter; [c]WS = winter-spring,

[d] = *, **, *** indicate significance at 90%, 95%, and 99% confidence level, respectively.

The current survey also revealed that N productivity of farmers ranged from 63 to 102 kg grain kg^{-1} N with the WS crop having the highest value. This level has remarkably risen from 50 and 42 kg grain kg^{-1} N reported for the respective SSNM and farmer's fertilizer practice (FFP) in 1999. Improvement in N productivity of rice farming in previous RTDP sites implies the project's successful introduction of SSNM in the areas. In addition, N productivity has improved over the years due to higher yields.

Table 7. Mean frequency of chemical application by farmers, by season, Can Tho, Vietnam , 2013.

Chemical type	Summer-autumn (n=100)	Autumn-winter (n=100)	Winter-spring (n=100)
Fertilizers	4	4	4
Herbicides	2	2	2
Insecticides	3	2	3
Fungicides	3	4	4
Molluscicides	1	1	1
Rodenticides	1	1	1
Other chemicals	1	1	1

Pesticide use

Heavy use of pesticides was observed during the three cropping periods. This is primarily due to high incidence of pest and diseases as well as the strong desire among farmers to prevent their spread or occurrence in their own farms. Some of the most common pest and disease problems reported were weeds, rats, brown planthoppers, and bacterial leaf blight.

All farmers applied different kinds of pesticide in their farms in all seasons, the most popular being pretilachlor, fenoxsulam+cyhalofopbutyl, butachlor+propanil, glyphosate, and bispyribac sodium for herbicides; quinalphos, fipronil, indoxacarb, chlorantraniliprole+thiamethoxam, pymetrozine, and abamectin for insecticides; metaldehyde and niclosamide for molluscicides; warfarin, zinc phosphate, bromadiolone, coumatetralyl, and cypermethrin+chlorpyrifos ethyl for rodenticides; and

Pesticide application in rice field using power sprayer.

azoxystrobin+difenoconazole, propiconazole+difeconazole, tricyclazole, validamycin A, and hexaconazole for fungicides. In particular, farmers used around 25 different brands of herbicide in all seasons, 69 brands of insecticide and 57 fungicides in SA alone, and 27 molluscicides in WS.

Frequency of pesticide applications did not differ across seasons. The average number of application of pesticides per season was as follows: four times for fungicides, thrice for insecticides, twice for herbicides, and once each for rodenticides, molluscicides, and other chemicals (Table 7). In total, farmers applied pesticides more than 10 times.

This heavy reliance on pesticides resulted in farmers spending an average of US$140 ha^{-1} (Table 3). Looking at total pesticide cost, fungicides got the lion's share, at more than US$58 ha^{-1}. On average, farmers spent US$32 ha^{-1} for insecticides, US$20 ha^{-1} for herbicides, US$16 ha^{-1} for molluscicides, and US$2 ha^{-1} for rodenticides.

Labor and power use

Rice farming is labor-intensive. Rice producers commonly incur huge labor cost for major activities such as land preparation, crop establishment, crop care and maintenance, harvesting, threshing, and postharvest operation. These activities can be done by an operator, family members, and exchange (OFE) and hired labor. Hired laborers are workers paid on a daily or contractual basis. OFE labor, on the other hand, is rendered by the farmer himself, family members, or other unpaid workers. Table 8 shows the total labor used in rice production. On average, labor use did not vary significantly across seasons. AW incurred the lowest with 20 mandays (md) ha^{-1} whereas SW and WS both needed 22 md ha^{-1}. Of total labor use, family labor contributed almost two-thirds of the total md in all cropping seasons. This confirms the finding that family labor comprised the biggest share in labor use (Moya et al., 2004). This was attributed to the relatively equal distribution of land and the correspondingly low number of the rural landless (Moya et al., 2004).

Table 8. Labor inputs in rice farming, by type and season, Can Tho, Vietnam , 2013.

Item	SA[a] 2013 (n=100)	AW[b] 2013 (n=100)	WS[c] 2014 (n=100)	Difference (AW-SA)	Difference (WS-SA)	Difference (WS-AW)
Hired labor (man-days ha^{-1})	7.0	6.9	7.3	-0.1	0.3	0.5
Land preparation	1.2	0.9	1.2	-0.2	0.0	0.3
Crop establishment	1.4	1.7	2.7	0.2	1.2***	1.0**
Crop care and maintenance	1.7	1.4	1.2	-0.3	-0.5	-0.2
Harvesting and threshing	1.7	1.8	1.2	0.1	-0.4**	-0.6***
Postharvest	1.1	1.1	1.0	0.0	0.0	0.0
OFE labor (man-days ha^{-1})	15.0	13.5	14.5	-1.5	-0.5	1.0
Land preparation	0.8	0.3	1.2	-0.5	0.3	0.8
Crop establishment	3.4	3.7	3.6	0.3	0.2	-0.1
Crop care and maintenance	10.7	9.4	9.8	-1.3***	-0.9***	0.4
Harvesting and threshing	0.0	0.0	0.0	0.0	0.0	0.0
Postharvest	0.0	0.1	0.0	0.0	0.0	-0.1

[a]SA = summer-autumn; [b]AW = autumn-winter; [c]WS = winter-spring.
[d] = *, **, *** indicate significance at 90%, 95%, and 99% confidence level, respectively.

Among labor components, crop care and maintenance was the most labor-intensive, requiring an average of 11 md ha^{-1} (Table 6). Crop care and maintenance activities included fertilizer and pesticide application, water management (irrigating and draining of field water), and weeding. These activities were commonly done by family labor. Next was crop establishment, which required an average of 5 md ha^{-1}. Crop establishment activities included manual broadcasting and replanting. Because of mechanization, land preparation, harvesting, and threshing had low labor requirement at an average of 2 md ha^{-1} (Table 6).

In Can Tho, farmers usually prepare the land using rented four-wheel tractors; they practiced minimum tillage, which includes only rotavating and leveling. Harvesting and threshing were fully mechanized, using combine harvesters from service providers. On average, for postharvest, hauling inputs and outputs to and from the farm needed only 1 md ha^{-1}.

The high labor use translates into higher labor cost, which is magnified by the prevailing wage and contract rates. The rates varied according to type of labor activities. The survey indicated that the prevailing daily wage rates in the area ranged from US$7-8 for male laborers to US$4-5 for female workers. Respondents attributed the disparity in wage rate to the greater skills and power required of the male farm workers. The prevailing wage rate was commonly used for crop establishment and crop care and management activities. As to land preparation, average contract rate was more than US$46 ha^{-1}, which included payment for the operator and machine rental. The use of a combine harvester had a contract rate ranging from US$100 to US$105 ha^{-1}.

Rice combine harvester in Can Tho, Vietnam.

Given the total labor requirement and payment rates in rice farming, Table 3 presents an estimation of total labor cost. It averaged US$205 ha^{-1}. Labor cost did not differ significantly across seasons. The AW crop incurred the lowest cost, US$202 ha^{-1}, whereas SA and WS both incurred US$206 ha^{-1}. As in total labor use, more than 60% of the total labor cost was imputed to OFE labor. On average, farmers paid US$70 ha^{-1} for hired labor.

Inasmuch as land preparation, harvesting, and threshing were fully mechanized, farmers spent a considerable amount for power cost (machine, fuel, and oil) with an average of US$130 ha^{-1} (Table 3). Across seasons, the SA crop incurred the highest power cost, at less than US$140 ha^{-1}. This value was higher by almost 8% relative to both AW and WS crops. Key informants said that the main reason for the difference was the longer land preparation time in the SA crop with an additional pass for land rotavating.

Overall, total labor use in rice farming has decreased substantially over the years because of mechanization. The current average labor use of 20-22 md ha^{-1} was significantly lower than RTDP's 68 md ha^{-1} in the 1996 dry season and 91 md ha^{-1} in the 1997 wet season. Accordingly, labor productivity in rice farming has impressively improved as a whole. Average labor productivity was measured at 309 kg grain md^{-1} in 2013 SW, 300 kg grain md^{-1} in 2013 AW, and 432 kg grain md^{-1} in 2014 WS. These estimates were relatively higher than results from the RTDP sites (90 kg md^{-1} in the 1996 dry season and 41 kg md^{-1} in the 1997 wet season). The mechanization of land preparation, harvesting, and threshing activities greatly contributed to the reduction in labor use and improvement of labor productivity in rice farming.

Irrigation and drainage

Irrigation and drainage cost comprised irrigation fees paid to the government and water pump rental, which was inclusive of fuel used for irrigating and draining the field. As Vietnamese farmers do not pay irrigation fees to the government, the main cost comes from the minimal amount incurred for fuel and oil to pump water in and out of their fields. Respondents used water pumps to supplement their primary sources of water. On average, irrigation and drainage cost was US$8-16 ha^{-1} (Table 3). Across seasons, AW had the lowest irrigation and drainage cost because there was rainwater. Although the costs incurred during SA and WS were almost equal to or less than US$16 ha^{-1}, cost coverage was different. In the SA crop, farmers spent a minimal amount for pumping in water to their field from the source. In contrast, farmers during the WS crop incurred expenses to pump out water from their field as a result of heavy rains.

Land use

Land cost consists of rent or, if owned, the opportunity cost of renting out the land, and taxes levied by the government. The land arrangement in Vietnam is unique in that the government has full ownership of the land. However, farmers can secure land rights and can exercise full control over all production decisions (Moya et al., 2004). With this existing system, farmers do not pay any agricultural land tax to the government if their farm area is below 3 ha (Thang and Huong, 2012). On average, farmers have a farm area of less than a hectare; they therefore have zero cost on land tax. Tax exemption is implemented by the government to encourage farmers to continue rice farming.

In this study, land rent refers to the amount paid by the share tenant or lessee to a landowner for the use of land in rice production. For farmers who own their cultivated land or "mortgagers," land rent was calculated using the average land rent of the share tenants and the lessees. On average, land rent was about US$241 ha^{-1} season^{-1} (Table 3). The imputed value of land was relatively higher than the other cost components in rice production. According to Thang and Huong (2012), the growing scarcity of productive rice land due to increasing industrialization (Ya'kub et al., 2012) could be the driving force behind the high land rent in the area. This is supported by fragmented and small-sized farms observed in the survey area. Interviews of key informants also indicated that crop diversification was common, with areas formerly planted to rice now being used to grow maize, fruit trees, and vegetables and to raise poultry and livestock. During the survey periods, the government gave cash support to encourage farmers to continue cultivating rice, and therefore maintain the 3.8 million ha of rice land to ensure national food security (Thang and Huong, 2012).

Interest on capital

Interest on capital used for rice farming consists of actual and imputed interest costs paid by farmers. For farmers who use their own capital, the average of monthly saving rates commonly offered by the banks was used to impute the interest on capital. Based on key informant interviews, an annual interest rate of 6% was used in this study. On average, interest cost on capital fell within the US$7-19 ha^{-1} range (Table 3). Vietnamese farmers commonly borrowed capital from informal moneylenders despite the higher interest rate because of easier accessibility. However, the estimated interest cost on capital remained low because, on average, the interest rate from informal moneylenders ranged from 1 to 3% per month. This rate is relatively minimal compared with that in other Asian countries such as the Philippines with an interest rate of 2-5% per month (Mataia and Dawe, 2006; Dawe et al., 2008).

***Use of other input*s**

The cost of other inputs covers transportation, food, and other materials such as sacks and twine. On average, farmers spent less than US$23 ha^{-1} for these items. This cost item was highest in the WS crop (US$25 ha^{-1}), followed closely by the SA crop (US$21 ha^{-1}); the lowest was US$18 ha^{-1} in AW (Table 3). The higher material cost spent on sacks could explain the seasonal differences of this cost item. Across seasons, more than 50% of other input cost was incurred on materials such as sacks and twine. The price of sack ranged from US$0.20 to US$0.50, depending on quality. The number of sacks depended on the number of output produced, i.e., the higher the output, the higher the sack requirement and, consequently, the greater the cost. Thus, the WS crop incurred a higher input cost than did SA and AW because of its higher output.

Another cost component of other-input cost is transportation. On average, farmers spent a considerable amount, US$ 5–7 ha^{-1}, in transporting inputs to the farm and outputs from the farm to the road network. Food cost was minimal as feeding farm laborers, especially during major activities such as crop establishment, weeding, harvesting, and threshing, was not customarily practiced in the area.

Postproduction and marketing practices

Almost all sample farmers sold their wet paddy harvest directly to buyers. Based on the survey and key informant interviews, drying of paddy after harvest was not commonly done. Drying was practiced for paddies allocated for home consumption and seeds were saved for the next cropping season. Paddy traders or middlemen were the main buyers of all the rice produced. They picked up the paddy from the farm or from designated locations and these were commonly transported in boats. In some instances, farmers transported inputs from the market to the farm using either land or water channels.

Hauling of rice paddy from field to road side using “chain tank”.

In terms of output disposal, more than one-third of the respondents retained some grains for home consumption. Some of them also saved a portion of their harvest for use in the next cropping season. This supported the earlier contention that majority of the farmers used their own available seed for planting.

Cost and profitability of rice production

This section reports on the total cost and net returns acquired in rice farming. The distribution of cost shares and annual net income are also briefly discussed here.

Cost of rice production

Table 3 shows the estimated cost of paddy production across seasons. On average, farm production cost was about US$1,055 ha^{-1}. The SA crop incurred the highest production cost (US$1,086 ha^{-1}), while AW had US$1,042 ha^{-1} and WS had US$1,036 ha^{-1}. Even though the cost difference across seasons was not significant, the main factor responsible for these differences was the higher fertilizer cost of the SA and AW crops.

Although total production cost did not differ significantly across seasons, the cost per unit tells a different story. The estimated per-unit cost varied substantially across seasons with an average of about US$147 t^{-1} (Table 3). The WS crop incurred the lowest cost per unit at US$110 t^{-1}. It has a cost advantage over SA and AW of about US$50 t^{-1} and US$60 t^{-1}, respectively. The lower per-unit cost of WS crop was mainly influenced by the high yield obtained. Thus, the cost per unit of SA and AW crops can still be lowered by improving yield.

On average, for all seasons, decomposing the cost shares of farm production resulted in land rent constituting the biggest share of 23% (Fig. 4). As mentioned earlier, the main reason for this was the increasing scarcity of productive rice land. Fertilizer contributed 21% of total production cost. It is followed by total labor cost with a 19% share: 12% from the imputed value of OFE labor, and 7% from hired labor. Evidently, the imputed family labor constituted the biggest proportion (63%) of labor cost. This result confirms the findings of other studies (Moya et al., 2004; Young et al., 2002)—i.e., that rice farming in this country relies on family labor. Given the high pesticide application of respondent-farmers, it is not surprising that this cost had a significant share of 13%. In fact, considering only paid-out costs, the pesticides cost more than the hired labor cost. Respondents also spent considerable amounts on machine rental and fuel with a 12% share. The seed cost has 7% share, owing to the farmers' high seeding rate practices. The remaining proportions of costs were spent on other inputs (2%), irrigation/drainage (1%), and interest on capital (1%).

Returns to rice production

Similar to gross revenue and cost per unit, net returns in rice production varied substantially across seasons (Table 3). Considering both paid-out and imputed costs, the average net returns during SA were US$246 ha^{-1}; US$182 ha^{-1} in AW; and US$1,076 ha^{-1} in WS. Due to high yield and high prices attained in the WS crop, it has more than a four- and a sixfold income advantage over the SA and AW crops, respectively. These calculations of net returns assume that all rice produced on the farm is sold directly to the market, thereby acquiring an annual net income of about US$1,500 ha^{-1}.

Returning the value of imputed costs (i.e., the farmer owns the land and capital used in rice farming, and he did not pay for OFE labor), income from rice production increased by more than US$380 ha^{-1} per cropping season (Table 3). This led to a more than 150% and 200% increase in net returns obtained respectively during SA and WA crops and only 36% during the WS crop. On average, a typical farmer can obtain an annual rice production income of less than US$2, 655 ha^{-1} or a per capita income of US$530 (for a household with five members).

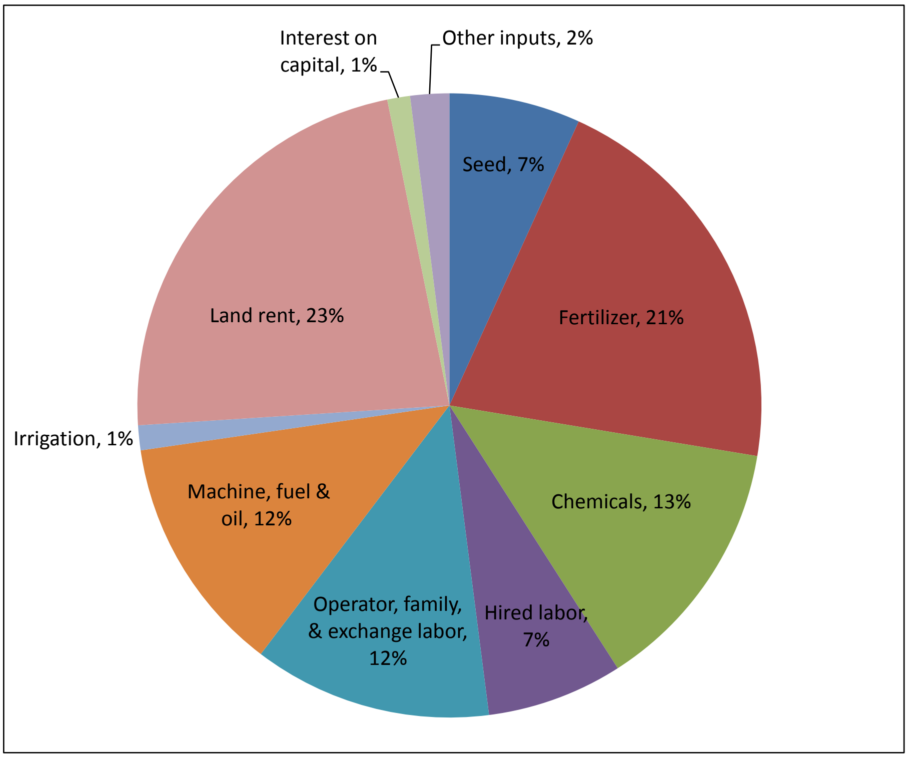

Fig.4. Cost shares in total cost of paddy production, Can Tho, Vietnam, 2013.

The positive net returns strongly suggest that farmers profit from rice farming. More importantly, the income from rice production, including the returns to own land, capital, and labor, will be able to cover (though barely) the basic needs of a farm household with five members. This is compared with the 2012 annual per capita poverty threshold in the rural areas in the MRD of US$326 (VND 6.84 million yr^{-1} or VND 570 thousand $month^{-1}$) (GSO, 2014b). This implies that a farm household in the intensively cultivated irrigated areas, which depends solely on rice production for a living, will be slightly above the poverty level.

Common problems in rice production

Farmers experienced problems in rice production. The commonly reported problems are shown in Table 9. On top of the list was the low and unstable price of paddy. Majority of the respondents claimed that the price of paddy they received was low in spite of the government's floor price policy that aims to ensure a minimum margin of 30% (Thang and Huong, 2012). Farmers asserted that they do not profit much from rice farming. The high cost of inputs ranked second among the common problems identified by farmers. The high cost of inputs, particularly fertilizer cost, would hinder farmers from using the required amount, consequently affecting productivity. The high cost of inputs also translates into higher cost of production and therefore lowers net returns.

Uncontrollable factors such as weather and climate-related issues were also notable. Heavy rains, floods, and typhoons in the area largely reduced their yields. For some farmers, particularly those whose farms are located far from the irrigation canals, insufficiency or lack of water was a major concern. Most of them incurred high costs of fuel and oil in order to irrigate their fields. Another problem highlighted by the farmers was their difficulty in financing their rice production activities. Many farmers were unable to allocate the right amount of capital due to constantly increasing cost of inputs, labor, and power. Not surprisingly, more than half of the respondents borrowed money to be used as capital.

Table 9. Common problems reported by farmers, by season, Can Tho, Vietnam , 2013.

Summer-autumn (n=209)	Freq.	%	Autumn-winter (n=181)	Freq.	%	Winter-spring (n=135)	Freq.	%
Low price of paddy	76	36	Low price of paddy	67	37	Low price of paddy	47	35
High cost of inputs	60	29	High cost of inputs	57	31	High cost of inputs	22	16
Weather/climate problem	16	8	Weather/climate problem	14	8	Weather/climate problem	13	10
Lack of capital for rice production	15	7	Lack of water	7	4	Lack of capital for rice production	7	5
Lack of water	15	7	Lack of capital for rice production	5	3	Lack of water	3	2
Pests and diseases	7	3	Pests and diseases	5	3	Pests and diseases	3	2
Accessibility of the farm (farm inputs, marketing)	5	2	Lack of farm tools and machines	3	2	Output disposal problem	2	1
Poor quality of farm inputs	3	1	Accessibility of the farm (farm inputs, marketing)	2	1	Access to credit	1	1
Lack of farm equipment	2	1	High production losses	2	1	Lack of farm tools and machines	1	1
Lack of labor	2	1	Difficult to access loan/credit	1	1	Lack of labor	1	1
Output disposal problem	2	1	High level of water	1	1	None	35	26
Lack of knowledge in rice farming technology	1	0	Lack of knowledge in rice farming technology	1	1			
Lack of technologi-cal farm model	1	0	Lack of labor	1	1			
Low amount of credit	1	0	Lack of rice land	1	1			
Weed problem	1	0	Output disposal problem	1	1			
None	2	1	None	13	7			

The incidence of pest and diseases was another constraint reported. This claim was highly supported by the higher cost of pesticides incurred and the increasing number of applications. Although majority of the farmer-respondents experienced difficulties in rice farming, still a good number experienced otherwise due to their comparative advantage. Thanh et al. (2013) reported that some farmers have gained a farming advantage through ownership of farm machinery and equipment and good management skills derived from experience.

Government programs in support of rice production

Table 10 presents farmers' perception of government support they received across seasons. In the first-season interviews (SA 2013), almost two-thirds (63%) of the respondents claimed not getting any help from the government. Some farmers reported that they had attended the free rice farming training sponsored by the government (15%) and that they benefited from free irrigation (9%). A few said that they availed of free seeds (7%) and received cash support from the government (4%). For the second season, (AW 2013), the number of farmers who did not receive any government support was reduced to 55%. Although government support was reduced in number, free training (21%), cash support (21%), and free seeds (3%) were still commonly mentioned. In contrast, the last season of survey (WS 2014) told a different story. Except for cash support, no other form of government support was reported by the farmers. Almost all of them (96%) received cash support amounting to less than US$25 physical ha^{-1} yr^{-1} from the government. The remaining 4% were still waiting for the said support.

Table 10. Government support received by farmers, by season, Can Tho, Vietnam , 2013.

Summer-autumn (n=113)	Freq.	%	Autumn-winter (n=100)	Freq.	%	Winter-spring (n=100)	Freq.	%
Cash support	5	4	Cash support	21	21	Cash support	96	96
Credit	1	1	Free seeds (new varieties)	3	3	None	4	4
Free irrigation	10	9	Free training	21	21			
Free seeds (new varieties)	8	7	None	55	55			
Free training	17	15						
Machine loan	1	1						
None	71	63						

Overall, farmers perceived little rice production support from the government. In fact, they only knew of the support once they have availed of it or had received it. Nonetheless, based on key informant interviews and published papers, many government programs were established to directly support rice farming in Vietnam. Thang and Huong (2012) listed some of these: (1) cash support to maintain the rice land area; (2) price support (i.e., floor price) to ensure 30% profit margin for farmers; (3) no charge for irrigation; (4) damage/crop calamity support; (5) machine acquisition support to encourage farmers to buy their own machines; and (6) free land tax for farmers with a land area less than or equal to 3 ha. However, it should be emphasized that the success of any government program depends on its implementation.

Changes in rice farming

Another aim of this paper is to document farmers' perceived changes in rice farming over the last 10 years. Results indicate that more than 91% of the farmers observed higher yields in 2013 compared with those attained 10 years before (Table 11). Respondents also reported using new varieties (75%); applying more fertilizers (76%) more frequently (60%); using more insecticides (69%) with greater frequency (70%); and applying other chemicals (86%) with more instances of other chemical application (75%).

When it came to mechanization, 98% of the respondents indicated that rice farming is more mechanized during the survey period compared with the status a decade earlier, which resulted in labor use reduction. The area planted to rice remained the same but with higher cropping intensity.

Looking at these changes, it can be surmised that some aspects of rice production in Can Tho have improved over the years. One improvement that can still be continued is the promotion of integrated pest management (IPM) (Huan et al., 2005). Beneficial results from IPM can be seen in terms of lowering rice production cost, ensuring farmers' health and safety, and guaranteeing judicious use of agricultural chemicals. As global trends favor good agricultural practices and as Vietnam is a leading exporter, rice importers can also benefit from this change in pest management approach.

Table 11. Farmer's perception of changes in rice farming practices in the last 10 years, Can Tho, Vietnam , 2013.

Yield	Freq.	%	Other chemical amount	Freq.	%
Less	5	4	Less	8	7
More	104	91	More	86	75
Same	5	4	Same	20	18
Fertilizer amount			Other chemical application		
Less	3	3	Less	8	7
More	87	76	More	85	75
Same	24	21	Same	21	18
Fertilizer application			Mechanization		
Less	3	3	Less	1	1
More	68	60	More	112	98
Same	43	38	Same	1	1
Herbicide amount			Labor use		
Less	33	29	Less	102	89
More	40	35	More	2	2
Same	41	36	Same	10	9
Herbicide application			Area planted		
Less	33	29	Less	15	13
More	35	31	More	28	25
Same	46	40	Same	71	62
Insecticide amount			Cropping intensity		
Less	17	15	More	48	42
More	79	69	Same	66	58
Same	18	16			
Insecticide application			Irrigation water		
Less	16	14	Less	33	29
More	80	70	More	42	37
Same	18	16	Same	39	34
			New varieties		
			No	29	25
			Yes	85	75

SUMMARY & IMPLICATIONS

This paper documented the rice production system in Vietnam's Can Tho province which is located in the Mekong River Delta (MRD). It discussed the improvements observed in intensively cultivated irrigated areas with respect to yield, cropping intensity, and tillage practices. Compared with previous results of the RTDP project, yield was found to have remarkably increased over the years as a result of labor and N productivity. These twin factors were the cost-saving and yield-enhancing improvements observed in the study areas. Nitrogen productivity in the area has increased over time due to higher yields. Increased mechanization contributed significantly to reducing labor use, thereby increasing labor productivity.

Good farming practices helped sustain yield enhancement and increase rice production in the study areas. One such practice was the change in cropping intensity. The shift from double to triple rice cropping system in a year (seven crops in 2 years' time) greatly increased rice production. The religious implementation of synchronous planting is also noteworthy since this reduces the potential negative impact of pest and diseases on yield. The use of few varieties also improved production as farmers became aware of the strengths and weaknesses of specific varieties. Over the years, better management practices have been achieved because of this familiarity.

Mechanization proved vital. The mechanization of harvesting and threshing has enhanced production in the country. It did not only reduce labor cost and postharvest losses; it also improved grain quality by shortening the time between threshing and selling. The use of machinery in land preparation and the practice of minimum tillage also helped farmers shrink labor cost, allowing them to increase cropping intensity. The shift from transplanting to direct seeding as a method of crop establishment could further trim down the labor cost. Aside from these good practices, many forms of government support also sustained the gains obtained from their rice production systems.

Nevertheless, there are still areas for improvement. Spending on seeds and pesticides could be minimized to achieve higher returns. Furthermore, the use of high-quality seeds should be intensely promoted to maximize and sustain the yield potential of varieties. The heavy dependence on pesticides, on the other hand, should be lessened to avoid the risk of building pesticide resistance and increasing the incidence of pest outbreaks in the future. High pesticide usage can also be a disadvantage to Vietnam's rice exports, especially if the importing country regularly tests for pesticide residues.

The continued decline in cost could enhance the competitiveness of paddy production in the MRD. Being competitive is critical in maintaining Vietnam's status as a major player in the world's rice export business. Yield advancement should thus be sustained.

The net income per cropping season in intensively cultivated irrigated ecosystem is not that large. However, accounting for all net returns from the three cropping seasons, a higher annual income is noted. This annual income is enough for a household of five to be just above the poverty threshold. This is also true, even for farmers who rent the land, borrow capital, and have limited OFE labor. However, it is unreasonable to expect farm households to make a living entirely from rice cultivation or even from farming, given that farm sizes are getting smaller. Farmers should resort to finding non-farm jobs in order to make ends meet. Given that Vietnamese farmers with less than a hectare of land on triple cropping works for about 60 md yr^{-1}, it is not surprising that other jobs are needed for the family to achieve a reasonable standard of living. Therefore, diversifying sources of income, in addition to rice farming, can be a vital strategy to alleviate poverty in these areas.

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