Technical Efficiency in Rice Production of Farmers in Cooperatives in Chau Thanh District, Kien Giang Province, Vietnam

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Business Administration in Agribusiness Management

Prince of Songkla University

2017

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Academic Year	2016

ABSTRACT

Kien Giang is the largest rice production province in Mekong Delta, Vietnam. There is very limited research on rice production in the agricultural cooperatives as well as issues regarding technical efficiency and factors affecting technical efficiency in rice production of the cooperative farmers. Therefore, this study aims to assess characteristics of the rice farmers and problems in rice production in the cooperatives in Kien Giang Province, Vietnam. The study also estimates technical efficiency in rice production and analyzes the factors affecting technical efficiency in rice production in the cooperatives. The data were obtained from 276 rice farmers under four selected cooperatives in Chau Thanh District under Kien Giang Province. Descriptive Statistics and Cobb-Douglas stochastic frontier model were applied to analyze the data. The results show the mean technical efficiency in rice production of cooperative farmers was 92.4%. The findings revealed that farm size, quantity of seed, active potassium and labor hours significantly affected the technical efficiency in rice production. However, experience in rice production, technical training classes, years of joining cooperative, number of rice crop per year and variety significantly affected the technical inefficiency. The study also suggests some measures to improve technical efficiency in rice productions. The farmers should reduce the quantity of seed, increase active potassium, and visit rice fields regularly. The cooperative management should have at least one member with a "business mind". The government should have policy to gather small rice fields to establish the large field. In the Law of Cooperatives, the government should remove the limitation of providing services outside the cooperative not exceed 32%.

ACKNOWLEDGEMENTS

This study was supported by the Higher Education Research Promotion and the Thailand's Education Hub for Southern Region of ASEAN Countries Project Office of the Higher Education Commission, and the Faculty of Economics Research Fund, Prince of Songkla University, Thailand.

To accomplish this study, I sincerely appreciate to several people. First, I am thankful to Assoc. Prof. Dr. Sutonya Thongrak and Asst. Prof. Dr. Sirirat Kiatpathomchai for their inspiring guidance, generous assistance, critical comments, and encouragement during the entire study. I am also thankful to the committee Assoc. Prof. Dr. Somboon Charernjiratragul and Dr. Ferdoushi Ahmed for the valuable feedback.

I am thankful to the lecturers and staffs of the Faculty of Economics, Prince of Songkla University, who provide basic knowledge and all necessary helps to conduct the study.

I am thankful to Mr. Le Quoc Viet, Dean of Chau Thanh Agricultural Division and the office's staffs, who provided all necessary information about rice production and agricultural cooperative activities in the District.

I am thankful to my students Nguyen Bao Trang, Nguyen Van Thien, Nguyen Phat Dat and Tran Minh Tam, who helped me to collect the primary data.

I am thankful to the rice farmers, who were enthusiasm to answer the questionnaire.

I am thankful to my colleagues in College of Economics, Can Tho University, who mobilized me to finish the program.

Finally, I am thankful my parents, siblings, friends and all relatives always encouraged and supported about physical and mental during my life and the study.

Cao Minh Tuan

CONTENTS

CONTENTS (Continued)

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1
Introduction

1.1 Problem Statement

Vietnam had about 4.1 million ha of rice land and total rice output reached about 45 million tons in 2014. Mekong Delta is the largest rice production region, which contributed about 56% of total rice output and 90% of total rice export in Vietnam.Kien Giang is the largest rice production province under Mekong Delta, which produced about 4.5 million tons of rice in 2014 (General Statistics Office of Vietnam, 2015). Chau Thanh is one of large rice production districts in Kien Giang Province, which is affected by flood and salinization as it is a neighboring sea district. Several anti-flood and salty water boundary systems were built to protect rice production in the district.

However, when there is a continuous heavy rainfall and the outside water level is higher than the inside of rice field, an individual farmer cannot protect his field by continuously pumping water out of the field. In order to solve the problem, a number of farmers in a region link together and establish cooperatives. Currently, Chau Thanh district has 10 rice cooperatives and 168 pump collective groups, which meet water-pumping requirements for 82% of the flood affected rice production area (Chau Thanh Agricultural Division, 2016). The cooperatives help farmers store and supply water in drought and salinity intrusion period. Besides, the cooperatives offer other services such as land plowing, seed providing, harvesting and transferring technology for the members. In this way, the cooperatives help the members sow at right season schedule, limit pesticide usage, reduce production costs, and increase productivity in their rice production (Chau Thanh Agricultural Division, 2016).

The cooperatives provide basic conditions for the members to produce three rice crops per year. However, this type of intensification in rice production degrades soil fertility seriously. Moreover, closed boundary served for producing three rice crops limits alluvial reception from flood. This leads to reduce essential nutrients for rice production and increase the toxics in soil (Dang & Danh, 2008). As a result, the farmers use large amount of fertilizers and pesticides to get high productivity. However, this excessive use of fertilizers and pesticides reduce technical efficiency in

the farmers in rice production. The estimation of rice production efficiency is essential for planning of local socio-economic policies because it provides quantitative efficient measures and assesses possibilities of inefficient factors in rice production (Huy, 2009). It is worthwhile to mention that in Chau Thanh District the summer-autumn crop had lowest productivity among the three rice crops, about 5.56 tons/ha in 2015 (Chau Thanh Agricultural Division, 2016).

There is very limited research on characteristics of the rice farmers and problems in rice production in the cooperatives in Kien Giang Province, Vietnam. Moreover, there is no research in estimating technical efficiency of the farmers in rice production and analyzing the factors affecting technical efficiency in rice production in the cooperatives. Therefore, this study aims to assess characteristics of the cooperative's farmers and problems in rice production in the summer-autumn crop in Kien Giang Province, Vietnam. The study also estimates technical efficiency in rice production and analyzes the factors affecting technical efficiency in rice production. Based on the findings, the study suggests some recommendations that might help the farmers, cooperative managers and the government to improve technical efficiency in rice production in the cooperatives.

1.2 Research Objectives

Purpose of the study is to access technical efficiency in rice production of the farmers in cooperatives in Kien Giang Province, Vietnam. To fulfill the purpose, the study has taken the following specific objectives:

1) To access the characteristics of rice farmers in the cooperatives in Chau Thanh District, Kien Giang Province, Vietnam.
2) To access the characteristics of rice production and its problems in the study area.
3) To estimate the technical efficiency in rice production of the cooperative farmers.
4) To analyze factors affecting the technical efficiency in rice production in the cooperatives.
5) To propose some recommendations that may be helpful inimproving technical efficiency in rice production in the cooperatives.

1.3 Research Scope

1) Research area

The research area is rice cooperatives in Chau Thanh District, Kien Giang Province, Vietnam. According to Chau Thanh Agricultural Division, Chau Thanh has 10 rice cooperatives, which is located into two regions. The study selects two cooperatives in each region. Particularly, the four selected cooperatives are Hoa Thuan-1 and Kenh-18 cooperative in the region 1, Tan Hung and Minh An cooperative in the region 2.

2) Research population

The population of this study are623 rice farmers in the four selected cooperatives in Chau Thanh District, Kien Giang Province, Vietnam.

3) Research period

This research was conducted in October 2016. The data about the summer-autumn rice crop, which produced during June to October 2016 were used in this study.

4) Research content

The research estimates the technical efficiency in rice production and factors affecting technical efficiency in the cooperative's farmers in the summer-autumn crop in 2016 by using Stochastic Frontier Analysis (SFA) model.

1.4 Research Benefits

The research findings might have some benefits for rice farmers, the cooperatives and the government as follows:

1) Rice farmers

The study estimates the technical efficiency in rice production and factors affecting technical efficiency. Thus, rice farmers could have some adjustments to increase the technical efficiency in rice production.

2) The cooperatives

From the results, the cooperatives understand more about the needs of the members. Therefore, the cooperatives could offer some more services to the members, which help improve the profit and technical efficiency in rice production.

3) The government

The study recognizes the difficulties and problems in rice productions of the farmers and cooperative's operation. From these findings, the government may propose some measures for rice production activities and cooperative operations in the region.

1.5 Organization of the Research

The research consists of five chapters. The first chapter is Introduction, which includes problem statement, research objectives, research scope, research benefits, and organization of the research. The second chapter is Literature Review, which consists of the overview of Chau Thanh District, agricultural cooperative in Vietnam and study area, theoretical background and related researches. The third chapter is Research Methodology, which includes data and data collection, and data analysis. The fourth chapter is Results and Discussions, which describes characteristics of rice farmers, characteristics of rice production and its problems, estimation of the technical efficiency in rice production, and factors affecting the technical efficiency. The last chapter is Conclusions and Recommendations.

CHAPTER 2
Literature Review

This chapter has four sections. The first section introduces about the natural features, rice production situation, working serve for rice production and some problems in rice production in the district. The second section describes some basic information about agricultural cooperative in Vietnam and study area. The third section consists of some theories of production function, technical efficiency and the two techniques to determine the technical efficiency: DEA and SFA. The last section contains some related researches on agricultural cooperatives and technical efficiency in rice production.

2.1 Overview of Chau Thanh District

According to Chau Thanh Agricultural Division (2016), Chau Thanh District has some appropriate natural conditions for agricultural production as well as rice production. This section describes some natural features, rice production situation, working serve for rice production and some problems in rice production in Chau Thanh District.

2.1.1 Natural Features

Chau Thanh is a district of Kien Giang Province under the Mekong River Delta region, Vietnam. Chau Thanh is famous for fishing and rice farming. The total land area of Chau Thanh District is about 28,544.19 ha. The district's population was about 150,000 people in 2015. Chau Thanh District has 10 administrative units, including 9 communes: Thanh Loc, Mong Tho A, Mong Tho, Mong Tho B, Giuc Tuong, Vinh Hoa Hiep, Phu Vinh Hoa, Binh An and Minh Hoa, and 1 town: Minh Luong (Chau Thanh Statistical Office, 2016).

Chau Thanh District is under the tropical monsoon climate region, which is hot and humid throughout the year. The average temperature is about 27.6 °C. Sunny hours are about 2,563 hours per year. The average moisture content is about 81.5%. The district has two distinct climate seasons: rainy and dry season. The rainy season is from May to November, and the dry season is from December to April of the year

after. The district's climate and weather is favorable for agricultural development (Chau Thanh Statistical Office, 2016).

Chau Thanh District has relatively flat terrain. The land surface elevation is from 0.2 to 0.6 m, some places have higher elevations, from 0.9 to 1.3 m. The height in the residential area is from 0.87 to 1 m. However, the average traffic roadbed is 1.6 m and the district's irrigation dike systems help prevent floods. The south communes have Cai Be river and Cai Lon river, which help drain quickly. Thus, the flooded areas in the district are different about flooding time and deep level (Chau Thanh Agricultural Division, 2016).

2.1.2 Rice Production Situation

In 2015, the total cultivated rice area in Chau Thanh was 49,768 ha (Table 2.1). In particular, the area of high quality rice for export was 32,324 ha, accounted for 64.95%. The average rice productivity in 2015 was 6.245 tons per ha. The total rice production of the district was 310,793 tons in 2015. The rice land area in the winter-spring crop (the main crop) was 19,616 ha and the yield in this crop was highest, about 7.28 tons per year. The area in the summer-autumn crop was 19,759 ha and the yield in this crop was lowest, about 5.56 tons per ha. In this crop, farmers in Minh Hoa commune changed some pineapple land area and mixed farming into rice land production. The rice land area in the autumn-winter crop was lowest because some communes as Vinh Hoa Hiep, Vinh Hoa Phu, Binh An and Minh Luong town did not produce in this crop (Chau Thanh Agricultural Division, 2016). The yield of the autumn-winter crop was about 5.6 tons per ha.

Table 2.1 Rice land area and rice yield in Chau Thanh District in 2015

Sub-District	Winter-Spring Crop		Summer-Autumn Crop		Autumn-Winter Crop		Total Output
Indicator	Area	Yield	Area	Yield	Area	Yield	
Unit	ha	tons/ha	ha	tons/ha	ha	tons/ha	tons
Mong Tho A	3,070	8.07	3,029	6.21	3,087	6.00	62,110
Thanh Loc	2,381	8.07	2,381	6.21	1,334	5.50	41,345
Mong Tho B	1,437	7.36	1,437	5.62	1,000	6.00	24,642
Mong Tho	1,333	8.07	1,333	5.62	1,333	5.60	25,710
Giuc Tuong	3,240	6.83	3,240	5.81	1,140	5.20	46,889
Vinh H. Hiep	1,090	6.89	1,090	4.44	-	-	12,354
Vinh H. Phu	867	6.69	867	4.44	-	-	9,653
Binh An	1,375	6.70	1,355	5.02	-	-	16,013
Minh Hoa	3,440	7.20	3,644	5.02	2,500	5.20	56,058
Minh Luong	1,383	5.78	1,383	5.81	-	-	16,019
Total	19,616	7.28	19,759	5.56	10,394	5.60	310,793

Source: Chau Thanh Agricultural Division, 2016

2.1.3 Facilities for Rice Production

In 2015, Chau Thanh District had 94 combine harvester, 4 rowing harvesters, 274 plowing machines and cultivators, 10 fertilizer machines, 3,478 pesticide spraying machines, 422 row-seeding instruments and 150 drying rice ovens, which served for rice production. The district has implemented dredging 27 major irrigation systems in 2015 with length of 82,394 m. Twenty four infield irrigations was dredged with length of 29,203 m for rice production. There were 10 rice cooperatives and 168 water-pumping groups, which served to pump water for 14,116 ha of rice land, accounted about 82% of rice land area affected by flood of the district. The district had 58 electric pumping stations, with 88 electric motors, provided for 3,954 ha of rice land (Chau Thanh Agricultural Division, 2016).

In 2015, Chau Thanh Agricultural Division and Agricultural Extension Center conducted 20 technical training classes for 577 rice farmers, 12 producing certified rice seed classes for 300 rice farmers, 2 classes about “1 Must 5 Reduce” process (1 Phai 5 Giam) for 37 rice farmers, and 6 class about “large field” (canh dong mau lon) for 270 rice farmers. Besides, there were five workshops with 280 rice farmers joining

in 2015 (Chau Thanh Agricultural Division, 2016). These activities helped to improve the production technology of the farmers, and rice quality and productivity.

2.1.4 Problems in Rice Production

There were 1,416.25 ha of rice land must re-sow, with 529.08 ha damaged from 30-70%, and 887.17 ha damaged over 70% to 100% in 2015. The heavy rain in long time and the storm number 3 in June 2015 affected rice land in Mong Tho A, Mong Tho B, Mong Tho, Thanh Loc, Giuc Tuong, Minh Hoa and Vinh Hoa Hiep. Specially, 2.8 ha of rice were lost all. In July 2015, it was dry with high temperature in long time, which made salinization 249.37 ha of new sowing rice land (15-25 day-old rice) in Binh An and Vinh Hoa Phu communes. There were 147.92 ha of rice damaged over 70% area of rice field (Chau Thanh Agricultural Division, 2016).

The implementation of the infield irrigation in some places do not conducted well, plans are not realistic. Therefore, the result in successful implementation was low. The electrical pumps slowly widen due to many reasons, but the most significant reasons were limitation of capital and rural electricity network system.

Rice consumption was difficult with many intermediaries. The rice price was not stable and mainly depended on market. Several farmers used low quality rice variety as IR50404 because of high yield and easily consuming. The rice variety IR50404 accounted about 35.05% of total cultivated rice area in 2015 (Chau Thanh Agricultural Division, 2016).

2.2 Agricultural Cooperative in Vietnam and Study Area

This section introduces about some features of agricultural cooperative in Vietnam and a brief description about the four surveyed cooperatives.

2.2.1 Agricultural Cooperative

This part presents the definition of agricultural cooperative and some characteristics of agricultural cooperative in Vietnam.

1) Agricultural cooperative definition

According to Law on Cooperatives, the cooperative is a collective economic organization, co-ownership with legal entity, and voluntarily established by at least

seven members and mutually cooperate and aid in the production, sales and job creation to meet the general needs of all members, based on self-control, self-responsibility, equality and democracy in cooperative management (Vietnam National Assembly, 2012).

From the above concept, an agricultural cooperative is an economic organization, in which farmers, farming households have common needs and interests, voluntary contribution of funds and efforts, set up in accordance with Law on Cooperatives to promote the collective strength of each member participating cooperatives and help each other effectively carry out the activities of production, agribusiness and raise living standards, spirit, contributing to social-economic development of the country."

2) Characteristics of agricultural cooperative

According to the Southern Center for Support Development of Cooperatives, Small and Medium Enterprises (2012), agricultural cooperatives in Vietnam have some characteristics as follow:

Agricultural cooperative is an economic organization active in the field of agriculture. Agricultural cooperative conducts agricultural production operations, business and services. It is an economic organization of farmers, characterized tied to farmers.

Agricultural cooperative is economic organization with high social. Agricultural cooperative primarily meet the needs and expectations of farmers in agricultural production, trading and services. Farmers join cooperatives because they need services and help by cooperatives, what they cannot do or do ineffective oneself; overcome the disadvantages and limitations in single production business. Agricultural production activities, trading and services of cooperative are the tools to increase the benefits and efficiencies of farmers' production business. Cooperative goal is serving the common needs and interests of members, not for profit. Thus, cooperative is an economic organization with deep social and cooperative feature, supports farmers to increase competition in the market economy.

Cooperative is a democratic and high society organization of farmers, in which the members are equal and promoted their role in agricultural community in society and business management.

Participating cooperative subjects cover all farmers, farming households and legal persons. When joining the cooperative, the members are required to contribute capital. Contributing effort depends on the type of cooperative and the members' aspirations.

Cooperative establishment purely based voluntary, deriving from the common needs and interests. Members linked together to promote the collective strength of each member, help each other along the effective implementation in production business and improve high material and spirit life of each member.

Cooperative has legal personality and shall be responsible to repay only within the limit of its charter, accumulated and other capital resources of the cooperative at the time of declaring bankruptcy. Members are only responsible for the debts within their capital.

2.2.2 The Surveyed Cooperatives

1) Kenh-18 Agricultural Cooperative

Kenh-18 cooperative was founded in 2013 with 200 million VND charter capital and 160 members. The cooperative's rice land area is 222 ha, which located in Hoa An and Hoa Tho hamlet (Kenh-18 Agricultural cooperative, 2016). The irrigation system is well structure, ensuring water for agricultural production in the region. The closed dike system covers all cooperative area. The cooperative built three permanent sluice gate and 3-phase power stations to serve the pumping operation. The cooperative has four electrical pumping motors and three diesel-pumping machines.

The cooperative only offers water pumping service for the members and outside farmers although demand for other products and services as tillage, seed supply, agricultural materials supply, harvested services and product consumption of the cooperative farmers are very high. The cooperative cannot provide these services because of lacking capital. However, the cooperative helps to find the outside machines for the members with the stable price.

Kenh-18 cooperative produces three rice crops per year. The average yield in 2015 was 6.8 tons per ha (Table 2.2). Winter-spring crop had highest yield, about 7.2 tons per ha. The yield of summer-autumn and autumn-winter crops were 6.8 tons per

ha and 6.3 tons per ha, respectively. The total rice output in 2015 of Kenh-18 cooperative was nearly 4.5 thousand tons.

Table 2.2 Rice area, yield and output in Kenh-18 cooperative in 2015

Crop	Rice Area (ha)	Yield (tons/ha)	Output (tons)
Winter-Spring	222.0	7.2	1,589.5
Summer-Autumn	222.0	6.8	1,509.6
Autumn-Winter	222.0	6.3	1,398.6
Total	666.0	6.8	4,497.7

Source: Kenh-18 Agricultural Cooperative, 2016

2) Hoa Thuan-1 Agricultural Cooperative

Hoa Thuan-1 cooperative was established in 2006 with 136 million VND charter capital and 190 members. The cooperative's rice land area is 380 ha (Hoa Thuan-1 Agricultural Cooperative, 2016). The cooperative only provides water-pumping service for the members. The plan of the cooperative is signing contracts to buy fertilizer, land plowing, harvesting and selling products for the members. The cooperative has 16 electric water pumping motors and four diesel pump machines, which served for producing three rice crops per year.

The cooperative mobilizes the members sowing follow the schedule of Agricultural Extension Center. Besides, the cooperative combines with Agricultural Extension Center to conduct several technical training classes and workshops to transfer advanced science and technology to the members.

Hoa Thuan-1 cooperative covers 409 ha of rice land with 223 rice households. There are 33 households do not join the cooperative. These farmers do not give capital because they can use the service of cooperative without joining.

3) Tan Hung Agricultural Cooperative

Tan Hung cooperative was founded in 2007 with 260 million VND charter capital and 141 members. Most of cooperative members is Khmer ethnic, about 95%. The cooperative's rice land area is 320 ha (Tan Hung Agricultural Cooperative, 2016). The cooperative only provide water-pumping service to the members.

Tan Hung cooperative produces three rice crops per year. The average yield in 2015 was 6.0 tons per ha (Table 2.3). Winter-spring crop had highest yield, about 6.9

tons per ha. The yield of summer-autumn and autumn-winter crops were equal to 5.6 tons per ha. The total rice output in 2015 of Tan Hung cooperative was over 5.1 thousand tons.

Table 2.3 Rice area, yield and output in Tan Hung cooperative in 2015

Crop	Area (ha)	Yield (tons/ha)	Output (tons)
Winter-Summer	283.0	6.9	1,952.7
Summer-Autumn	283.0	5.6	1,584.8
Autumn-Winter	283.0	5.6	1,585.0
Total	849.0	6.0	5,122.5

Source: Tan Hung Agricultural Cooperative, 2016

Besides supporting knowledge and technique about rice production, the cooperative also mobilizes the member take part in several social activities such as building rural roads, bridges, assisting members in trouble, protecting the environment and say no to the packaging on field.

The plan of Tan Hung cooperative is providing rice seed, agricultural materials, and services about land plowing, harvesting and consumption.

4) Minh An Agricultural Cooperative

Minh An cooperative was founded in 2005 with 70 million VND charter capital and 132 members. The cooperative's cultivated area is nearly 105 ha (Minh An Agricultural Cooperative, 2016). The cooperative has two electric water pumping motors and one plowing machine to serve for rice production. However, capacity of one plowing machine does not meet the need. Therefore, the cooperative contacts with the outside to serve for the members. The irrigation system ensures water for the field in dry season and drainage in rainy season. Some farmers, however, who have less collective consciousness, do not close the ditch leading to waste energy in water pumping in or out of the cooperative.

Besides combining with Agricultural Division and Agricultural Extension Center to conduct technical training classes, the cooperative also contacts with fertilizer companies or pesticide companies to introduce products and the right using method. The cooperative encourages the members to use new rice varieties with

insect resistant ability and high quality for exporting such as OM5451, OM6976, and OM7347.

Minh An cooperative produces two rice crops per year, except in years 2011, 2012 and 2014. The yield of rice is stable, about 11.5 tons/ha for two crops (winter-spring and summer-autumn crop).

The general information and services of surveyed cooperatives are summarized in Table 2.4.

Table 2.4 General information of surveyed cooperatives

Item	Kenh-18	Hoa Thuan-1	Tan Hung	Minh An
Foundation year	2013	2006	2007	2005
Rice land area (ha)	222	380	320	105
Number of member	160	190	141	132
Number of rice crop per year	3	3	3	2
Technical training	Y*	Y	Y	Y
Water pumping service	Y	Y	Y	Y
Land plowing service	-	-	Y	Y
Harvesting service	-	-	Y	-
Rice purchasing	-	-	Y	-

Remark: * Y means that the cooperative provides this service

2.3 Methodological Background

This section introduces the methodological background of the study in which includes the Cobb-Douglas production functions, theory of technical efficiency and techniques of determining technical efficiency (DEA and SFA).

2.3.1 The Cobb-Douglas Production Functions

In economics, the Cobb-Douglas production functions wasusuallyapplied to illustrate the relationship between one output and many inputs. This production function was proposed by Knut Wick sell and tested again by Charles Cobb and Paul Douglas in 1928 with statistical evidence (Cobb & Douglas, 1928).

Charles Cobb and Paul Douglas considered a simplified view of the economy in which production output was determined by the quantity of labor and capital investment (Cobb & Douglas, 1928).The function form was as follow:

$$P(L,K) = bL^{\alpha}K^{\beta}$$

Where,

P = Total production in a year (USD)

L = Labor input in a year (hour)

K = Capital input (USD)

b = Total factor productivity

α =The output elasticity of labor

β=The output elasticity of capital

These values of α and β are constants determined by obtainable technology. Output elasticity assess the responsiveness of output to change of either labor or capital used in production, with all other factors remaining constant(Coelli et al, 2005).

2.3.2 Technical Efficiency

Farrell (1957) defined two types of production efficiency: technical efficiency and allocative efficiency. Technical efficiency evaluates the ability to obtain a higher level of output from a given set of inputs, while allocative efficiency measures the extent to which farmers make efficient decisions by using inputs up to level at which marginal contribution to production value equal to the factor cost, assuming no risk.

Technical efficiency is just one component of overall economic efficiency. However, a firm must obtain technically efficient if it want to get economic efficiency. In order to obtain profit maximization, a firm must got technical input allocative and output allocative efficiencies (Kumbhakar& Lovell, 2003).

Technical efficiency relates to rate of the maximum output from a given of inputs, or uses the minimum amount of inputs to produce a given of output. These two explanations of technical efficiency lead to output-oriented and input-oriented efficiency measures. These two measures of technical efficiency will coincide when the technology displays constant returns to scale (Coelli et al., 2005).

We assume that the farmer uses two inputs X_1 and X_2 to produce rice under the assumption constant returns to scale (Figure 2.1). The SS' curve that represents the isoquant of full efficient farms could allow measurement of technical efficiency. If input price information is available, the model can measure the allocative efficiency. It is the point E, which is tangential of the isoquant line (SS') and the iso-cost line

(HH'). If all farms face the same relative prices reflected by the iso-cost line, farm E is producing at minimum cost, while the other farms are not. Thus, even though farm B is technically efficient, the cost is inefficiency because it is allocative inefficiency. It does not use the inputs in optimal proportions and hence does not produce at minimum possible cost. Farm A is both technical inefficiency and allocative inefficiency. The allocative efficiency measured by the ratio 0C/0B, and the cost efficiency by the ratio 0C/0A. Then, cost efficiency is equal to the product of the technical and allocative efficiency scores (0C/0A = 0B/0A x 0C/0B) (Coelli et al., 2005).

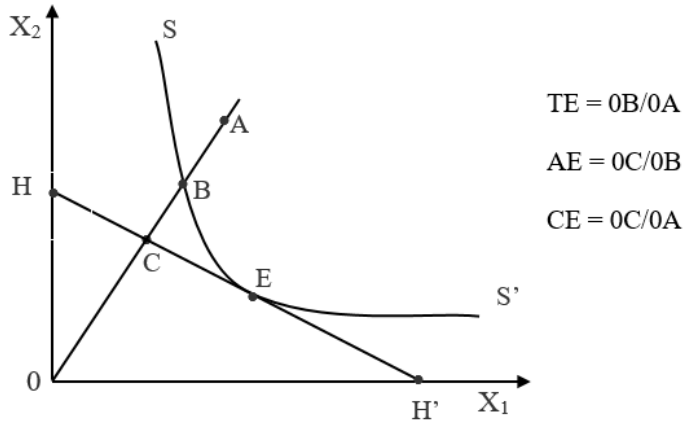

Figure 2.1 Technical, allocative and cost efficiency

2.3.3 Techniques of Determining Technical Efficiency: DEA and SFA

Two popular techniques were applied to estimate the technical efficiency are the Data Envelopment Analysis (DEA) (Charnes et al. 1978) and the Stochastic Frontier Analysis (SFA) (Aigner et al. 1977; Meeusen and van den Broeck, 1977). The DEA uses mathematical linear programming methods, whereas the SFA uses econometric methods (Coelli et al, 2005).

1) Data envelopment analysis

Data Envelopment Analysis (DEA) was proposed by Charnes, Cooper and Rhodes in 1978 (Charnes et al., 1978) to evaluate the relative efficiency with multiple inputs and outputs. The efficiency is the ratio of the total of weight outputs and inputs.DEA is a mathematical technique that allows the determination of efficiency based on inputs and outputs of a unit, and compares it to other units in the

examination. The efficiency of a Decision Making Unit (DMU) is calculated to all DMUs with the simple limit that all DMUs lay on or under the extreme frontier. DEA is a non-parametric method because it does not require any assumption about functional form (e.g. a regression equation, a production function). The DEA separately evaluates each DMU and computes the maximum ration for each unit (Martić et al., 2009).

2) Stochastic frontier analysis

Stochastic Frontier Analysis (SFA) was independently proposed by Aigner et al. (1977), and Meeusen and Van Den Broeck (1977). They proposed the production function had an error term with two components: random effects and technical inefficiency.

The proposed model is as follows:

$$Y_i = X_i\beta + (v_i - u_i)$$

Where,

Y_i = logarithm of the output

X_i = k×1 vector of transformation of the input quantities

β = vector of unknown parameters

v_i = random error, and independent of the u_i

u_i= non-negative random variable accounting for technical inefficiency

The quality of the data, the suitability of several functional forms, and the probability of making assumptions seriously affect the fitness of DEA and SFA. The DEA does not oblige any specific functional form. However, DEA is a deterministic approach, which does not account for noise in the data (Martić et al., 2009). Thus, all deviations from the frontier are accounted as inefficiencies. However, the SFA accounts for random errors and has the advantage of making implication probable. (Coelli et al, 2005).

2.4 Related Researches

This section introduces some researches about agricultural cooperative and technical efficiency in rice production.

2.4.1 Research about Agricultural Cooperative

Tuan (2009) studied the operation efficiency of agricultural cooperatives in Bac Lieu province, Vietnam. The results showed that the farmers faced with many challenges such as the status of small farm, fragmented land, and laggard infrastructures. Cooperation in agricultural production helped farmers get the large amount of goods and cut cost. The cooperatives ensured the consumption market for members. The members can approach extension training programs and new production technologies. Therefore, farmers in cooperative got higher technical and profit efficiency than outside farmers. The cooperatives in Bac Lieu lacked of good infrastructures, production facilities, capital and had poor management skill.

Phuc (2011) studied the operation efficiency of agricultural cooperatives in Hau Giang province, Vietnam. The results showed that cooperatives promoted agricultural production and rural development. Cooperatives assisted members to response to the natural difficulties, pressure of economic market, and protect their economic interests. The study proved that a cooperative was not only the organization of economic development but also the institution of economic democracy, with political and social responsibility.

De (2013) studied about operation efficiency of cooperatives in Tra Vinh province, Vietnam. The results showed that the general education and professional of cooperative board chairpersons were low. The ability to link to input and output market was restricted. There were limitation in cooperatives' capital, land area and official credit sources. Result from regression correlation analysis showed that output market, land area serving production, business activities and charter capital positively affect to cooperatives' profit.

Lerman and Parliament (1991) judged the size and industry effects on financial presentation of agricultural cooperatives. The financial ratios of 43 agricultural cooperatives in the United States between 1970 and 1987 were analyzed. The results showed that large cooperatives obtained higher efficiency in using their properties to generate trades. However,the small cooperatives got greater profitability. The emphasis on development was not always create valuable outcomes. In the four industries, the dairy cooperatives performed strongest, while the food marketing cooperatives were considered as the weakest performers. The dairy and food cooperatives employed in value-added process. The dissimilarities in routine

challenge to get perfect assumptions. Tendency examination showed that the cooperatives' profitability in all industry and size groups dropped due to the depression in agriculture after 1980. However, the profitability decrease at the same rate for both large and small cooperatives.

Fukuyama et al. (1999) applied DEA method to estimate the overall efficiency and productivity growth of credit cooperatives in Japan between 1992 and 1996. Overall efficiency was divided into output technical and input allocative efficiencies. Twenty percent of all credit cooperatives in Japan were foreign owned with more than 90% of those owned by Koreans. The history of institutional discrimination against Koreans in Japan suggested that ownership might affect efficiency. The empirical findings suggested that foreign-owned cooperatives were more efficient and experienced better productivity growth during the period.

Jones, D. C. (2007) analyzed the data of 51 conventional firms and 26 producer cooperatives in the Italian construction industry between 1981 and 1989. The cooperatives were comparable to conventional firms, excepting the organizational form. The estimation model results showed that there were no significant productivity advantage of cooperatives in comparing with conventional firms. The findings also indicated that productivity of the cooperative was lower than of conventional firm.

Guzmán and Arcas (2008) studied the presentation of agricultural cooperatives. The data of 247 observations made over three accounting years from 2001 to 2003were used. The findings of the DEA model determined that the mean efficiency obtained by the cooperatives was 95%. The inputs such as staff and fixed capital elements were combined into the model, taking again revenues as the output. The results showed a significant reduction in the performance levels. The input orientation models revealed that there was a strong decrease in productive elements of around 70% of real consumption. It means that cooperatives need to rearrange the rates of human application and fixed capital elements. This included growing the revenues by 75% according to the efficiency dealings achieved on the output optimization.

Deacon et al. (2008) studied profit sharing harvesters' cooperative in the Chignik Salmon fishery in Alaska. The economic model predicted that the cooperative would centrally coordinate its members' activities, resulting in more

efficient effort deployment than in the independent fleet. Empirical analysis of relevant data supported these predictions. The results showed that, in contrast to the independent fleet, the cooperative concentrated effort among its most efficient members, fished closer to port, spread harvesting over a longer time span, and shared information on stock locations.

Maietta and Sena (2010) analyzed the nature of the relationship between financial constraints and technical efficiency in a panel of Italian conventional and producers' cooperatives dedicated in wine production between 1996 and 2001. The findings showed that cooperatives performance was more efficient than of conventional firm. The dispersion of the efficiency indicator was quite small, unlike conventional firms. The cooperatives and conventional firms used technologies with different capital-labor ratios. The output elasticity of materials was relatively higher for cooperatives than for conventional firms. The cooperatives experienced an improvement in technical efficiency following an increase in the financial constraints.

Abate et al. (2014) used the data of household survey in Ethiopia to evaluate the influence of agricultural cooperatives on technical efficiency of smallholders. The research applied tendency of score matching to compare the average difference in technical efficiency between farmers inside and outside cooperatives. The findings revealed that agricultural cooperatives were effective in providing support services, which significantly contributed to technical efficiency of farmers. The findings were found to be unresponsive to hidden bias and consistent with the idea that agricultural cooperatives enhanced efficiency of members by easing access to productive inputs and facilitating extension linkages. Therefore, increasing participation in agricultural cooperatives should further improve efficiency gains among smallholder farmers.

In conclusion, agricultural cooperatives have some positive impacts to improve the technical efficiency, profit and social life of the members.

2.4.2 Research about Rice Production Efficiency

Coelli et al., (2002)analyzed the data of 406 rice farmers in Bangladesh. The technical, allocative, cost and scale efficiencies were calculated by using DEA methods. The findings revealed that 406 rice farms produced inefficiency methods, which differed substantially from the outcomes of yield and unit cost. For the dry

season, the mean of technical, allocative, cost and scale efficiencies efficiency were 69.4%, 81.3%, 56.2% and 94.9% respectively. The wet season outcomes were similar, but a few points lower. Allocative inefficiency was due to over employment of labor, suggesting population pressure, and fertilizers. Second step regressions indicated that small households were more efficient.Whereas farmers with better accessed to input markets and did less non-farm works were more efficient.

Hien et al. (2003) applied the stochastic frontier production function to estimate the technical efficiency of 120 rice farmers in the Mekong River Delta. The study showed the technical efficiency across seasonal and land holding were dissimilar. The technical efficiency, on average, in winter-spring crop was 86.23%, in spring-summer crop was 79.55%, and in summer-autumn crop was 80.24%. Quantity of active nitrogen, seed and pesticide cost negatively affected rice productivity. While quantity of active potassium and phosphate, and hired machine cost positively affected the technical efficiency. However, the allocation of all inputs was inefficient. The results also showed that the dummy variables of rice land size, variety, IPM adoption, sowing technique and availability of credit affected the technical inefficiency.

Rahman (2003) studied production efficiency of rice farmers in Bangladeshi by using the SFA model. The data contained within seven inputs and several other background factors affecting rice production or high yielding varieties of rice spread across 21 villages in three agro-ecological regions of Bangladesh in 1996. The findings revealed that there were high levels of inefficiency in modern rice production. The profit efficiency was 77% on average, suggesting that an estimated 23% of the profit is lost due to a combination of technical, allocative and scale inefficiency in modern rice cultivation. The differences in efficiency were explained mostly by infrastructure, soil fertility, experience, extension services, tenancy and share of non-agricultural income.

Krasachat (2004) measured the technical efficiency in rice production in Thailand. The data of farm-level cross-sectional survey of Thai rice farms in 1999 were analyzed by using the DEA method. The findings showed that the overall technical efficiency, scale efficiency and pure technical efficiency were 0.71, 0.96 and 0.74, respectively. To explain the likelihood of inefficiency changes, the research the

Tobit regression. The results revealed that there were wide diversity of efficiencies. The findings also suggested that the diversity of natural resources affected on technical efficiency in rice production in Thailand. The results indicated that pure technical inefficiency in rice production in Thailand provided a greater influence to overall inefficiency. Therefore, improvement extension services could help increase the technical efficiency in rice production in Thailand.

Tijani (2006) assessed technical efficiency in rice production of farmers in Osun State, Nigeria, and recognized some socio-economic characteristics affecting technical efficiency. The stochastic frontier production function was applied to estimate technical efficiency. A translog production function was used to represent the production frontier of rice production. The results illustrated that the technical efficiency was 86.6% on average, which suggested that the technical efficiency could improve 13.4%. The findings also revealed that technical efficiency was positively and significantly correlated with the traditional preparation methods, and non-farm income.

Nhut (2007) measured household allocative efficiency and cost efficiency of two types of productive land area: non-flooded and flooded areas in Cho Moi and Tri Ton districts in the An Giang province. Non-flooded areas were in irrigated boundary systems and flooded areas were outside these systems. The study applied the data envelopment analysis to cross-sectional data obtained for the 2005 agricultural year to estimate household allocation and cost efficiency. The empirical results indicated that farmers using the crop rotation pattern are more efficient than farmers who use the continuous rice pattern in terms of allocation and cost efficiency in both the non-flooded and flooded areas.

Abedullah and Mushtaq (2007) applied the SFA model to determine the future investment strategies to improve rice production in Punjab, Pakistan. The data of 200 farmers in Sheikhupura District were collected and analyzed. The results showed that the technically efficient in rice production was 91%. The findings also indicated that coefficient of pesticide was non-significantly while fertilizer negatively affected rice production because of improper combination of N, P, and K nutrients. The unsuitable mixture of input illustrated poor dissemination of extension services. Thus, the role of extension department should be strengthened to improve rice productivity and protect

natural resource, ground water. The inefficiency model proposed that investment on tractors significantly contributed to increase the technical efficiency, and the role of credit institutes should be redefined.

Idiong (2007) estimated farm level technical efficiency by stochastic frontier approach. Its determinant used data obtained from 112 small-scale swamp rice farmers in Cross River State in Nigeria. The results indicated that, the rice farmers were not fully technically efficient. The mean efficiency obtained was 77% indicating that there was a 23% allowance for improving efficiency. The results also showed that farmers' educational level, membership of cooperative association and access to credit significantly influenced the farmers' efficiency positively. The implications were that policies that would encourage educated persons to form and join cooperatives and provide them with easy access to formal credit should be implemented in the State.

Huy (2009) used both data envelopment analysis and stochastic frontier analysis methods to estimate the technical efficiency of 261 rice farmers in Soc Trang and Can Tho provinces. The findings revealed that the mean technical efficiency was above 76% in both the constant and the variable returns to scale. The scale efficiency score for these rice-producing households was nearly one. The mixed rice production (i.e., vegetable-rice and fish-rice) acquired higher technical efficiency than rice monoculture, for the most part because of decreasing in utilization of fertilizers and pesticides. The technical efficiency significantly related with the plot size, seed, and hired labor cost. The technical inefficiency significantly depended on the experience and advanced farming practice adoption of farmers.

Rahman et al. (2009) assessed the factors of switching to Jasmine rice and its productivity. The model exposed that serious bias exists, justifying use of a sample selection framework in stochastic frontier models. Results from the probit variety selection equation revealed that the revenue access to irrigation and education were the main elements of choosing Jasmine rice. The SFA model revealed that land, irrigation and fertilizers significantly affected productivity of Jasmine rice. Lower productivity in Phitsanulok and Tung Gula Rong Hai provinces were significantly influenced by biophysical and environmental factors. The technical efficiency was estimated at 63%on average. Some policy suggestions such as measures to retain

Jasmine rice price high, upturn access to irrigation and fertilizer availability, as well as investment in education to farmers will synergistically increase adoption of Jasmine rice and the productivity.

Khai and Yabe (2011) used the Vietnam Household Living Standard Survey 2005-2006 to estimate technical efficiency by using stochastic frontier analysis method in the Cobb-Douglas production function. The authors applied the Tobit model to analyze factors affecting the technical efficiency. The study estimated technical efficiency in rice production in Vietnam was 81.6%. The technical efficiency was highly different among the farmers. The results found that the intensive labor in rice production, irrigation, and education has positive impacts on technical efficiency. The sex of household header did not affect the technical efficiency in this study.

Linh (2012) estimated technical efficiency by using both DEA and SFA methods. The data of Vietnam Household Living Standard Survey 2003-2004were analyzed. The technical efficiency was 70.4% under constant returns to scale, 76.5% under variable returns to scale for output-oriented data envelopment analysis and 78.5% under variable returns to scale for input-oriented data envelopment analysis. The outcome of stochastic frontier estimation was 63.4%. The results showed that the education and regional factors significantly influenced technical efficiency. The analysis indicated that increasing land holding and farm size had real benefits for efficiency improvement. Many farms in Vietnam were operating with less than optimal scale of operation. Non-farm ratio and extension support factors did not significantly affect rice production technical efficiency.

Gedara (2012) examined the factors affecting the technical efficiency in irrigated rice production within the village irrigation systems in Sri Lanka. The data were collected from 460 rice farmers in the Kurunagala District, Sri Lanka. The stochastic translog production frontier was applied to estimate the technical efficiency in rice production. The technical efficiency of rice production in village irrigation was 72% on average, and over 63% of farmers obtained higher this mean. The factors affecting technical efficiency were number of members inorganizations and the participatory rate in collective actions. The results proposed that improvement of

cooperative arrangements by increasing the membership of organizations was important to improve the technical efficiency in rice production in irrigation systems.

Koirala et al. (2013) measured the technical efficiency of rice production and identified determinants of technical efficiency of rice farmers in Philippines. The Loop Survey of the Institute of Rice Research Institute (2007-2012) was analyzed using stochastic frontier production method in the Cobb-Douglas functional form. The technical efficiency of Filipino rice production was 54.6% on average. The result showed that fuel, fertilizer, land rent, planting season, and land area were the factors that affect both production and technical efficiency of rice production.

Tu and Trang (2016) estimated the cost efficiency of 199 rice farmers in An Giang, Mekong River Delta by applying Stochastic Translog variable cost. The study showed that the mean cost efficiency score was 90%. Overuse of inputs in rice production results in not only lower profit but also environmental pollution. The overused cost was 3,651 thousand VND per ha (equal to the sales of 702.24 kg of rice). Farmers who cultivated three rice crops per year have higher cost efficiency than those who cultivated two rice crops per year. Using collective pumping services could also improve cost efficiency. Irrespective of output price, Jasmine and IR50404 rice varieties and the numbers of rice plot negatively affected the cost efficiency. The farmers with more plots of paddy land have lower cost efficiency scores than those with few plots because of high transportation cost.

In conclusion, the two estimation methods for production efficiency are stochastic frontier analysis and data envelopment analysis. The stochastic and parametric approach has the ability to separate the noise effects with inefficiency components, and create good results for single output and multiple inputs (Kebede, 2001). Rice production based on farmer side is the single output and multiple-input production. Therefore, this study will apply stochastic frontier analysis method to estimate the technical efficiency of rice production and the affecting factors.

CHAPTER3
Research Methodology

This chapter has two parts. The first part is data and data collection, which includes primary data and secondary data. The second part is data analysis, which consists of descriptive analysis and quantitative analysis.

3.1 Data and Data Collection

This research used both secondary and primary data. Details are presentedin the following sub-sections.

3.1.1 Secondary Data

Secondary data were collected from various sources such as General Statistics Office of Vietnam (about rice land area, rice yield, export rice in Vietnam, Mekong Delta and Kien Giang Province); Chau Thanh Agricultural Division (about rice land area, rice yield, facilities for rice production and number of agricultural cooperatives in Chau Thanh District);the Reports of annual operation results of the four selected cooperatives (about rice land area, rice yield, number of members of the cooperative). Besides, this study also used the secondary data from the literatures, including public documents, journals about the technical efficiency of rice production in Vietnam as well as in Mekong Delta.

3.1.2 Primary Data

1) Research area

According to Chau Thanh Agricultural Division, there are three rice production regions in the district. Region 1 is early affected by flood and extending in short period. After went through region 1, the flood influences region 2 and extending in long period. Region 3 is often affected by salinization.

Chau Thanh District has 10 agricultural cooperatives, which only located in region 1 and 2. The study selected four cooperatives according to some criteria such as location, year of foundation, rice land area, numbers of rice cropping per year, and provided services. Moreover, some cooperatives operate ineffectively, so the

cooperative management does not allow to survey at these cooperatives. Therefore, the four selected cooperatives are Kenh-18 cooperative (Thanh Loc sub-district) and Hoa Thuan-1 cooperative (Mong Tho A sub-district) in region 1, Tan Hung cooperative (Giuc Tuong sub-district) and Minh An cooperative (Minh Luong Town) in region 2 (Figure 3.1). There are 1,027 ha of rice land in these cooperatives (Table 3.1).

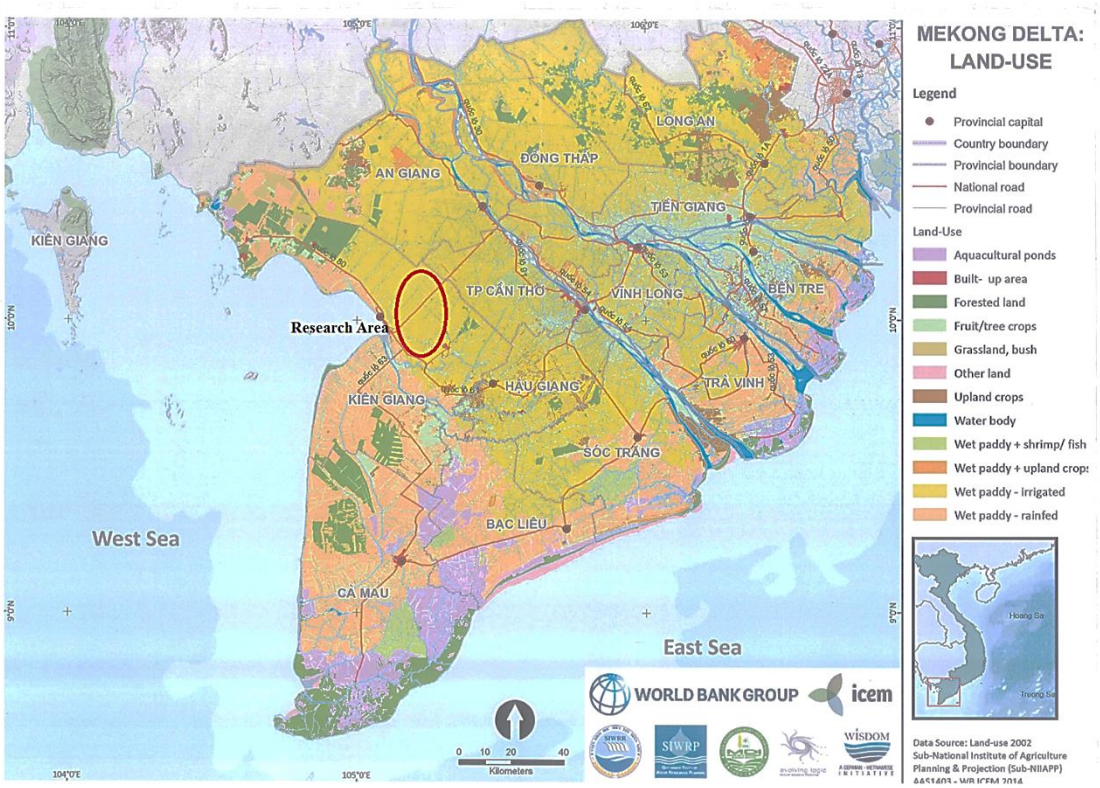

Figure 3.1 Map of Mekong Delta and the research area

Source: World Bank Group, 2016

2) Population and sample

Within these four selected cooperatives, there are 623 rice farmers (Table 3.1).To determine the sample size, the research uses Taro Yamane (Yamane, 1967) formula (the confidence level is 95%) as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size and e is the level of error. With the population size N = 623 and the level of error e = 5%, the representative sample size will be 243 observations. The research surveyed 70 rice farmers in each cooperative. However, there are four incomplete observations. Therefore, the real sample size is 276 observations (Table 3.1).

Table 3.1 Rice area, number of members and observations in the selected cooperatives

Cooperative	Rice area (ha)	Members (farmer)	Observations (farmer)	Percent
Hoa Thuan-1	380	190	68	24.6
Kenh-18	222	160	70	25.4
Tan Hung	320	141	70	25.4
Minh An	105	132	68	24.6
Total	1,027	623	276	100.0

The study used the stratified random sampling technique to choose observations. The member list of each cooperative provides information about rice land area of each member. The cooperative's members are divided into 3 groups: the first group includes the farmers have lower 1 ha of rice land; the second group collects the farmers have rice land size from 1 to lower 2 ha; and the last group in which the farmers have equal or over 2 ha of rice land. To support the data collection, addresses of the cooperative farmers were provided by the cooperative management. However, the main rice labor is usually absent during the day. Therefore, for convenience, the accidental sampling was used to select the respondents (the main rice labor in household) in each group of land size of the cooperatives.

3) Data collection

To collect primary data, structured questionnaire (Appendix) was used to personally interview 276 rice farmers. Before data collection, structured questionnaire was pretested and revised accordingly.

3.2 Data Analysis

The descriptive statistics and stochastic frontier analysis methods were applied to analyze the data.

3.2.1 Descriptive Analysis

Descriptive statistics such as mean and percentage were used to examine the characteristics of rice farmers, rice production and its problems.

3.2.2 Quantitative Analysis

The Stochastic Frontier Analysis (SFA) method was appliedto assess the technical efficiency in rice production of the cooperatives' farmers. This method also help identify and examine the factors affecting the technical inefficiency in rice production.

1) Technical efficiency analysis

Several functional forms were used to estimate the input-output relationship. However, if the model has more than three independent variables, the Cobb-Douglas function is preferable to the others (Hanley and Spash, 1993). Therefore, this study used the Cobb-Douglas stochastic frontier model with seven input independent variables: rice land size, quantity of rice seed, active nitrogen, active phosphorus, active potassium, active pesticides and labor hour.

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + v_i - u_i$$

Where,

Y = Total quantity of rice output of the largest rice plot in cooperative of farmers (kg)

X_1 = Total area of the largest rice plot in cooperative of farmers (ha)

X_2 = Total quantity of rice seed using for the largest rice plot in cooperative (kg)

X_3 = Total quantity of active nitrogen (N)using for the largest rice plot in cooperative (kg). Quantity of active nitrogen is calculated by the formula: $Q_N = Q_{Urea}*46.3\% + Q_{DAP}*18\% + Q_{NPK20\text{-}20\text{-}15}*20\% + Q_{NPK16\text{-}16\text{-}8}*16\%$

X_4 = Total quantity of active phosphorus (P_2O_5)using for the largest rice plot in cooperative (kg). Quantity of active phosphorus is calculated by the formula: $Q_{P2O5} = Q_{DAP}*46\% + Q_{NPK20\text{-}20\text{-}15}*20\% + Q_{NPK16\text{-}16\text{-}8}*16\%$

X_5 = Total quantity of active potassium (K2O) using for the largest rice plot in cooperative(kg). Quantity of active potassium is calculated by the formula: $Q_{K2O} = Q_{Kali}*61\% + Q_{NPK20\text{-}20\text{-}15}*15\% + Q_{NPK16\text{-}16\text{-}8}*8\%$

X_6 = Total quantity of active pesticide using for the largest rice plot in cooperative (g). Quantity of active pesticide is calculated by the formula: $Q_{AP} = Q_{Pi} * \%_{APi}$

X_7 = Total quantity of labor using for all stages in rice production for the largest rice plot in cooperative (hour)

v_i = random error

u_i= non-negative technical inefficiency effect

Where,

Q_N = Quantity of active nitrogen(kg)

Q_{P2O5} = Quantity of active phosphorus (kg)

Q_{K2O} = Quantity of active potassium (kg)

Q_{Urea} = Quantity of Urea 46-0-0 fertilizer (kg)

Q_{DAP} = Quantity of DAP 18-46-0 fertilizer (kg)

Q_{Kali} = Quantity of Kali 0-0-61 fertilizer (kg)

$Q_{NPK20-20-15}$ =Quantity of NPK 20-20-15 fertilizer (kg)

$Q_{NPK16-16-8}$= Quantity of NPK 16-16-8 fertilizer (kg)

Q_{AP} = Quantity of active pesticides (g)

Q_{Pi} = Quantity of pesticide *i*-th (g or ml)

$\%_{APi}$ = Percentage of pesticide *i*-th (% or g/l)

The *t*-test is used to test hypotheses concerning a single coefficient. Let $\beta_k$denote the *k*-th element of the vector β. To test H_0: $\beta_k = 0$ against H_1: $\beta_k \neq 0$. We reject H_0 if the test statistic is greater than the critical value $t_{1-\alpha/2}$(I-K).

2) Factors affecting technical efficiency

Besides calculating the technical efficiency in rice production, the SFA model also estimates the factors affecting technical efficiency. These factors can be divided into two group: input factors and inefficiency factors. The input factors have seven variables as above.

The technical inefficiency (u_i) is assumed to be independently distributed as truncation at zero of the $N(\mu_i,\sigma_u^2)$ distribution, where $\mu_i$in inefficiency factors are defined by eight variables.

$$\mu_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + e_i$$

Where,

Z_1 = Educational level of the rice farmer (years of schooling)

Z_2 = Experience in rice production of the farmer (years)

Z_3 = Income dummy variable; Z_3 = 1 if rice production is main income of household and 0 otherwise

Z_4 = Credit dummy variable; Z_4 = 1 if farmer have loans for rice production and 0 otherwise

Z_5 = Time of joining the cooperative of farmers (years)

Z_6 = Technical training classes farmer joined in 2016 (number of classes)

Z_7 = Rice crop dummy variable; Z_7 = 1 if farmer produces 3 rice crops per year and 0 otherwise

Z_8 = Rice variety dummy variable; Z_8 = 1 if farmer uses rice variety IR50404 and 0 otherwise

δ_i = unknown parameter to be estimated

The model parameters (β andδ) are based on the maximum likelihood estimation with variance parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$ (Aigner et al., 1977) and $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$ (Battese & Corra, 1977). The γ parameter lies between zero and one. If γ = 0 then all deviations from the frontier are due to noise, while γ = 1 means all deviations are due to technical inefficiency (Battese & Corra, 1977). The study applied Frontier 4.1 program written by Coelli et al. (2005) to estimate the stochastic frontier model.

The *t*-test is used to test hypotheses concerning a single coefficient. Let δ_k denote the *k*-th element of the vector δ. To test H_0: $\delta_k = 0$ against H_1: $\delta_k \neq 0$. We reject H_0 if the test statistic is greater than the critical value $t_{1-\alpha/2}$(I-K).

CHAPTER 4
Results and Discussions

This chapter presents the research results. It has have four sections. The first section describes the characteristics of rice farmers. The second presents the characteristics of rice production and its problem. The third section illustrates the estimation of the technical efficiency in rice production. The last section explains the factors affecting the technical efficiency in rice production.

4.1 Characteristics of Rice Farmers

This section describes some so socio-demographic characteristics of the rice farmers in the surveyed area and linkages between the farmers and cooperatives.

4.1.1 Socio-Demographic Characteristics of the Farmers

Table 4.1 shows the socio-demographic characteristics of the surveyed cooperatives' farmers. The results illustrate the average age of farmers was 48.3 years. Most of them (68.5%) are 41 to 60 years old. Around 94% of the farmers are male. For some households, the main rice farmers are female because there is no adult man in the family. The female farmers often hire labors for rice production works. As for education, most of the farmers (88.1%) obtained at primary and secondary levels. Moreover, there were some 4.3% illiteracy farmers.

The average household members are 4.5 people. However, the members over 15 years old are 3.7 people on average. The rice labors in each household were only 1.7 people. Most of the households (55.1%) had only one rice labor. The farmers have engaged in rice production for24.7 years on average.

Rice production is the main source of income for most of the households (93.1%). However, a small portion of the households (15.6%) has loans for rice production. These farmers borrow money from Bank of Agricultural and Rural Development. The average amount of loan per household was 66.7 million VND (about 100,000Baht). Especially, there were two households borrowed 500 million VND to buy harvester.

Table 4.1 Socio-demographic characteristics of the surveyed farmers

Item	Frequency (n = 276)	Percent
Age (years)		
- ≤30	6	2.2
- 31-40	57	20.7
- 41-50	96	34.8
- 51-60	93	33.7
- >60	24	8.6
Mean	48.3	
Gender		
- Male	260	94.2
- Female	16	5.8
Education		
- Illiteracy	12	4.3
- Primary school	134	48.6
- Secondary school	109	39.5
- High school	21	7.6
Mean (years)	5.6	
Household members (people)		
- 1-3	47	17.0
- 4-6	221	80.1
- >6	8	2.9
Mean	4.5	
Members over 15 years old (people)		
- 1-3	121	43.8
- 4-6	153	55.4
- >6	2	0.7
Mean	3.7	
Number of rice labors (people)		
- 1	152	55.1
- 2	70	25.3
- >2	54	19.6
Mean	1.7	
Experience in rice production (years)		
- ≤10	26	9.4
- 11-20	83	30.1
- 21-30	98	35.5
- 31-40	59	21.4
- >40	10	3.6
Mean	24.7	
Main income source of household		
- Rice	257	93.1
- Non-rice	19	6.9

Table 4.1 (Continued)

Item	Frequency (n = 276)	Percent
Loans for rice production		
- Yes	43	15.6
- No	233	84.4
Amount of loans (million VND*)	(n = 43)	
- 5-20	14	32.6
- 21-35	8	18.6
- 36-50	12	27.9
- > 50	9	20.9
Mean	66.7	

Remark: * 1 million VND ≈ 43.77 USD ≈ 1,615 Baht

4.1.2 Linkages between Farmers and Cooperatives

Table 4.2 shows the linkages between farmers and the cooperatives. The results show that the farmers have joined the cooperative for 5.7 years on average. It can be mentioned that farmers must contribute capital to the land use services of the cooperatives to be a member of a cooperative. The amount of capital depends on area of the rice land (about 200,000 VND per ha).

The surveyed cooperatives provide various types of services to their members such as water pumping, land plowing, harvesting and rice purchasing. Tan Hung cooperative provides all these four services for the members (Table 2.4). However, purchasing output rice for the members was only applied for this crop by contracting with a company. It is worthwhile to mention that the price of water pumping service provided by the cooperatives are lower than that of private service (lower about 200,000 VND per ha). Besides water pumping and land plowing services, the managers of Minh An cooperative often contact with the hosts of harvester to serve for the members with the committed price.

However, the respondents reported that they need more supports and services from the cooperatives. Half of the surveyed farmers (50%) said that they want the cooperative selling fertilizer with low price, followed by harvesting (49.3%), rice purchasing (34.1%), seed providing (26.8%), and land plowing (25.7%). The farmers in Hoa Thuan-1 and Tan Hung cooperatives hoped that the cooperatives selling fertilizers for the members with original price. To explain for this requirement, for

example, if farmers buy fertilizers in cash, they would pay at the market price of fertilizers. However, the farmers often pay money after harvesting (i.e. nearly three months later from buying the product) due to lack of capital. At that time, they have to pay 3-10% higher price than the original purchase price. Therefore, farmers would like the cooperatives to supply fertilizers with the original price.

In 2015, Hoa Thuan-1 cooperative supplied fertilizers for the members with original price. When the agricultural stores recognize that, they will sold fertilizers for farmers with the price lower than of cooperative. The members complained about the cooperative's fertilizer price and they changed to buy fertilizers from agricultural stores. Therefore, the cooperative stopped this business because it could not compete with the agricultural stores.

Moreover, the farmers in Hoa Thuan-1 and Minh An cooperatives complained that there was often lacking of harvester at the harvest time. Most of farmers in one cooperative often use the same rice variety and sow at the same time. Therefore, the cooperative farmers also harvest their rice at the same period. This leads to lacking of harvester in harvesting period.

Tan Hung farmers want the cooperative to provide rice seed with high quality for their production. Quality of seed has an important role in agricultural production as well as rice production. Quality seeds guarantee the germination rate and high yield. Therefore, farmers would like the cooperative to provide certified rice seed.Kenh-18 farmers suggest the cooperative buys a plowing machine to serve for rice production of the members and helps them sell their output rice.

It is also mandatory for the members to join technical training classes. In 2016, nearly 70% of the respondent farmers joined at least one technical training class. These technical training classes were conducted by cooperatives combining with the Extension Center or agricultural companies. However, 30.4% of the respondents did not join any technical training class in 2016. Rice land area of these farmers is rather small and rice production is not main source of their income.

Table 4.2 Linkages between farmers and cooperatives

Item	Frequency (n = 276)	Percent
Years of joining cooperative		
- 1-5	145	52.5
- 6-10	122	44.2
- >10	9	3.3
Mean	5.7	
Existing services provided by cooperatives$^{\Psi}$		
- Water pumping	276	100.0
- Land plowing	87	31.5
- Harvesting	70	25.4
- Rice purchasing	70	25.4
Other services needed$^{\Psi}$		
- Selling fertilizer	138	50.0
- Harvesting	136	49.3
- Rice purchasing	94	34.1
- Seed providing	74	26.8
- Land plowing	71	25.7
Technical training classes joined in 2016		
- 0	84	30.4
- 1	119	43.2
- 2	63	22.8
- >2	10	3.6
Mean	1.0	

Remark: $^{\Psi}$ one farmer can give more than one answer

4.2 Characteristics of Rice Production and Its Problem

This section has two parts. The first part presents some information about the features of rice production such as rice land area, types of variety, source of seed, applied techniques, input and output quantity, cost, revenue and net revenue. The second part indicates some problems in rice production in the surveyed cooperatives.

4.2.1 Characteristics of Rice Production

Table 4.3 shows the profile of rice land. The data show that a household in the study area occupied1.9 ha of rice land on average. The average rice plots were 1.8 plots. However, the rice land area in the cooperatives was 1.6 ha per household on average. The average rice plots in cooperative were 1.5 plots. However, 67.8% of

farmers had only one rice plot in the cooperative region. The own rice land area in cooperative was 1.5 ha on average.

Table 4.3 Profile of rice land area

Item	Frequency (n = 276)	Percent
Total rice land area (ha)		
- <1	92	33.3
- 1-2	94	34.1
- >2	90	32.6
Mean	1.9	
Total rice plots		
- 1-2	221	80.1
- 3-4	41	14.8
- >4	14	5.1
Mean	1.8	
Rice land area in cooperative (ha)		
- <1	101	36.6
- 1-2	115	41.7
- >2	60	21.7
Mean	1.6	
Rice plots in cooperative		
- 1	187	67.8
- 2	64	23.2
- >2	25	9.1
Mean	1.5	
Own rice land in cooperative (ha)		
- <1	105	38.0
- 1-2	120	43.5
- >2	51	18.5
Mean	1.5	

Table 4.4 shows the profile of rice production. Majority of the farmers (97%) produced two main rice varieties (i.e. IR50404 and OM5451) in summer-autumn crop. All farmers in Kenh-18 and Hoa Thuan-1 cooperatives used variety IR50404. This variety originated from the International Rice Research Institute (IRRI). It is a nearly-harvest(harvested after 90-95 days of sowing)and low quality rice variety. However, rice variety IR50404 yields high productivity and can be easily consumed. This rice is often used for producing powder or noodle. The average yield of this rice variety 6.67 tons/ha in summer-autumn crop.

Farmers in Tan Hung cooperative used only variety OM5451. In Minh An cooperatives, farmers used some other varieties such as OM5451, OM4900, OM6976, and OM7347.The varieties with the initials are two letters "OM" originating from O Mon Rice Research Institute (or Mekong Delta Rice Institute in Can Tho City).The rice variety OM5451 is also an early-harvest variety (harvested after 90-95 days of sowing). However, its rice products are eligible for exporting. The average yield of varieties OM is 6.65 tons/ha in summer-autumn crop, which is a little lower than the yield of rice variety IR50404.

Majority of the farmers collected rice seed from two sources: owned seed (47.8%) and purchasing from the breeding center (43.1%). Some farmers purchased the original seed for one crop. After harvesting, they used the rice output as certified seed for the next crop. Other farmers bought the certified seed directly from the breeding center, which has lower price than foundation seed. The rice yield from using owned seed (6.68 tons/ha) is higher than from using seed purchasing from breeding center (6.66 tons/ha).The farmers said that, according to their experience, the weight of each rice bag producing form original seed is lighter than the weight of rice bag producing from certified seed. A low portion of the farmers (7.3%) collected the seed from their neighbors at the market price of rice, when they clearly know about the productivity and quality of the neighbor rice field.

Most of the surveyed farmers (96.7%) applied the scattering method for sowing rice. The reason is that scattering method uses less labor hours than row seeding method. However, the scattering method need more seed than the row seeding method. The quantity of seed for scattering and row seeding methods are 198 kg/ha and 125 kg/ha respectively. However, the average yield of scattering and row seeding methods are 6.65 tons/ha and 6.87 tons/ha respectively. Moreover, using less seed leads to reducing other inputs such as fertilizers and pesticides. Besides, applying row seeding method helps farmers easily take care their rice field because rice plants grow in line.

Similarly, majority of the farmers (96.7%) followed the “1 Must 5 Reductions” (1 Phai 5 Giam) applied program in rice production. “1 Must” means must use the certified seed and “5 Reductions” are reducing seeds, fertilizers (nitrogen), pesticides, water utilization, and post-harvest losses. However, most of

farmers really follow only “1 Must” is using certified rice seed. For “5 reductions”, only some farmers applied these practices.

A low portion of the farmers (19.9%) applied the “3 Reductions, 3 Gains” (3R3G) program. The 3R3Gproject was established by the International Rice Research Institute, and introduced to farmers in South Vietnam in early 2000 (Huelgas et al., 2008). “3 Reductions” are the reduced use of seeds, nitrogen fertilizer, and pesticides. Besides, “3 Gains” are gain high yield, better rice quality and economic efficiency.

The Integrated Pests Management (IPM) program was practiced by 24.6% of the surveyed farmers. They planted flowers on the rice field dike, and used light traps. Several farmers reported that they have joined the IPM class but they did not apply it because chemical utilization immediately shows efficacy.

The farmers visit their rice field 3.6 days per time on average. Most of farmers (over 90%) had water pumping machine and pesticide sprayer. The water-pumping machine was also used for moving with boat. About row seeding machine, most of farmers said that they have this machine but they do not use in long time and it was broken. A few of farmers had four-wheel plowing machine (1.1%) and three-wheel plowing machine (0.7%). Besides using for their rice land, these farmers also supplied land-plowing service for other farmers.

Table 4.4 also provides information about the number of rice crops in a year. Majority of the cooperative’s farmers (75%) produce three rice crops per year. The farmers in Minh An cooperative produce two rice crops per year, which constitute 25% of the total respondents. According to the instructions of Chau Thanh Agricultural Division, the farmers in Minh An cooperatives produced three rice crops per year in 2011, 2012 and 2014. However, the efficiency of third crop was found to be low. As a result, the cooperatives decided to produce two rice crops only per year.

Table 4.4 Profile of rice production

Item	Frequency (n = 276)	Percent
Rice variety		
- IR50404	138	50.0
- OM5451	132	47.8
- OM7347	4	1.4
- OM4900	1	0.4
- OM6979	1	0.4
Source of seed		
- Owned seed	132	47.8
- Purchasing from breeding center	119	43.1
- Purchasing from neighbor	20	7.3
- Purchasing from businessman	4	1.4
- Purchasing from extension center	1	0.4
Source of IR50404	(n = 138)	
- Owned seed	63	45.7
- Purchasing from breeding center	58	42.0
- Purchasing from neighbor	14	10.2
- Purchasing from businessman	2	1.4
- Purchasing from extension center	1	0.7
Source of OM5451	(n = 132)	
- Owned seed	66	50.0
- Purchasing from breeding center	59	44.7
- Purchasing from neighbor	6	4.5
- Purchasing from businessman	1	0.8
Type of sowing rice		
- Scattering	267	96.7
- Row seeding	9	3.3
Applied program$^{\Psi}$		
- 1 Must 5 Reductions	267	96.7
- Integrated Pests Management	68	24.6
- 3 Reductions 3 Gains	55	19.9
Rice field visit (days/time)		
- 1-2	75	27.2
- 3-4	126	45.7
- 5-6	66	23.9
- > 6	9	3.3
Mean	3.6	
Rice production machines (owned and used)$^{\Psi}$		
- Water pumping	257	93.1
- Sprayer	256	92.8
- Row seeding	9	3.3
- Plowing 4-wheel	3	1.1
- Plowing 3-wheel	2	0.7

Table 4.4(Continued)

Number of rice crops in 2016		
- 3 crops	207	75.0
- 2 crops	69	25.0
Mean	2.8	

Remark: $^{\Psi}$ one farmer can give more than one answer

Table 4.5 shows that most of farmers (81.2%) sold wet paddy. After harvesting, the farmers immediately sold their rice on the field. It helps to save the labor, transport and drying cost. The price of wet paddy was about 4,100-5,200 VND/kg. Some farmers (18.8%) sold dry paddy. They transported their rice to the drying kiln or using sunshine to drain their rice. After that, they sold dry paddy with higher price, from 5,500 to 6,000 VND/kg.

For distribution of paddy, most of paddy yields (97.8%) were sold. The rest of rice was used for household consumption (1.3%) and seed for next crop (0.9%). The proportion of rice for household consumption is rather low because most of farmers who produce the variety IR50404 sold all their rice output. They will buy a better quality rice for family consumption.

Table 4.5 Selling and utilization of rice yield

Item	Frequency(n = 276)	Percent
Type of paddy sell		
- Wet paddy	224	81.2
- Dry paddy	52	18.8
Distribution of paddy (percentage)		
- Sell	97.8	
- Household consumption	1.3	
- Seed for next rice crop	0.9	

Table 4.6 presents the inputs and output per ha of rice production. The results present that cooperative's farmers used 196 kg of rice seed per ha on average. According to the recommendation of the Extension Center, farmers should use 100 kg of seed per ha and not use more than 150 kg/ha. However, the result shows that only 5.4% of farmer used lower than 150 kg of seed per ha. Most of farmers (94.6%) used over 150 kg of seed per ha. The average rice yield of these two groups (under and over 150 kg of seed per ha) are 6.57 tons/ha and 6.66 tons/ha respectively. Farmers

use large quantity of seed because they are afraid about the rate of germination, golden apple snail, rat and replanting labor. Similarly, farmers use large amount of nitrogen for branching because of sowing with high density. However, using so much nitrogen leads to several diseases and pests (Chau Thanh Agricultural Division, 2016).

In rice production, farmers use five types of fertilizer: Urea 46-0-0, DAP 18-46-0, Kali 0-0-61, NPK 20-20-15 and NPK 16-16-8. The main ingredients in the fertilizers are active nitrogen (N), active phosphorus (P_2O_5) and active potassium (K_2O). According to the recommendation of the Chau Thanh Agricultural Division, the formula of fertilizer use in summer-autumn crop is 80-90 kg of N + 50-60 kg of P_2O_5 + 30-40 kg of K_2O. However, the average real use of active nitrogen, active phosphorus and active potassium per ha were 101.9 kg, 69.5 kg and 48.0 kg respectively. Applying large amount of fertilizers partly affected by using large amount of seed. Farmers often apply fertilizers four times each crop. The first and second times is after sowing 7-10 days and 18-22 days respectively. The third time is depended on the color of rice leaves. After sowing 60-70 days, farmers apply fertilizers the last time.

Many kinds of herbicide and pesticide were used. Chemical active was used nearly 1,959.4 g per ha for rice production. Each type of pesticides contains the information about chemical percent on the package. For example, the liquid of pre-germinated herbicide named Sofit 300EC, which contains 300 gam Pretilachlor per litter. Farmers often use it at 1 lit/ha, thus the chemical active for this herbicide is 300 g/ha. Another example, the pellet of golden snail cure named Toxbait 120B, which contains Metaldehyde 120g/kg. For one ha of rice, farmers use 5 kg of Toxbait 120B. Therefore, the chemical active of this cure is 600 g/ha.

Besides, the total labor hours were calculated at 140.4 hours per ha. The average rice yield was estimated at 6.66 tons per ha in summer-autumn crop. The rice yield in the cooperatives is higher than the general rice yield in Chau Thanh District (5.56 tons/ha in summer-autumn crop, see Table 2.1).

Table 4.6 Input and output per ha of rice production

Item	Mean	Minimum	Maximum	Std. Deviation
Input				
- Seed (kg)	196.0	100.0	306.7	32.8
- Active nitrogen (kg)	101.9	64.8	210.8	13.4
- Active phosphorus (kg)	69.5	33.8	127.8	10.5
- Active potassium (kg)	48.0	6.4	92.3	14.3
- Active pesticide (g)	1,959.4	351.9	8,180.8	941.5
- Labor (hour)	140.4	51.0	397.4	57.9
Output (kg)	6,656.9	4,615.4	7,758.6	510.9

Table 4.7illustrates the cost, revenue and net revenue of rice production of the cooperatives' farmers. The total cost of rice production per ha was estimated at 17.7 million VND. The results show that the cost for pesticides contributed the greatest portion (25.8%) of the total variable cost, followed by fertilizer cost (20.2%). Using large amount of pesticides and fertilizers negatively affects the sustainability in rice production and quality of rice products. Therefore, farmers should minimize the use of pesticides and fertilizer in their rice production to reduce cost and increase rice quality. The next high proportion was labor cost (19.2%). Harvest and post-harvest cost also accounted for a considerable portion (14.1%) of the total cost.

Table 4.7 Cost, revenue and net revenue of rice production

Item	Value (thousand VND)	Percent
Total variable cost per ha	17,704.2	100.0
- Land preparation	1,301.6	7.4
- Seed	1,645.9	9.3
- Herbicide	216.0	1.2
- Fertilizer	3,577.8	20.2
- Pesticide	4,574.9	25.8
- Watering	490.2	2.8
- Harvest and post-harvest	2,501.7	14.1
- Labor	3,396.1	19.2
Revenue	30,365.5	
Net revenue	12,661.3	

It can be mentioned that some farmers sell their wet paddy on field, so they do not pay for post-harvest cost. The farmers spend significantly lower amount of money for watering the rice field, which constitute 2.8% of the total cost. In summer-autumn crop, farmers can use the natural outside water by opening the small groove when the level of outside water is higher than the inside field. Later when the level of outside water becomes lower, farmers close the groove and save water in their field. The value of rice produced per ha was estimated at 30.4 million VND. The net revenue in summer-autumn crop was about 12.7 million VND per ha.

Table 4.8 indicates the distribution of labor hours used in rice production by activities. It was found that farmers used a total of 140.4 hours of labor (including family labor and hired labor) for per ha rice production in summer-autumn crop. However, visiting field time was the largest proportion (28.2%) of total labor hour used among the activities. Visiting field time depends on frequency of visiting and the distance of the rice field from house. The farmers also spent a considerable time on spraying the pesticides (23.3 hours/ha), replanting (22.7 hours/ha) and preparing land (19.0 hours/ha). Time for spraying pesticides was comparatively higher because farmers applied pesticides several times in summer-autumn crop. Farmers must embankment and dig the waterways by workers besides using plowing machine. Time for replanting depends on the death rate of rice field.

The farmers spend 7.6 hours per ha for sowing the seed on average. The findings show that weeding constitutes the significantly lower portion (1.5%) of the total labor hour used by the farmers. For weeding, farmers spray pre-germination herbicide on the rice field after 1-4 days of sowing. Similarly, watering the rice field comprise of significantly lower portion (2.8%) of the total labor hour used for rice production. However, the farmers spend a considerable time (on average, 15.1 hours per ha) to utilize fertilizers in the rice field. The lowest proportion of total labor hour is allocated to drying the rice (1.2%) because most of farmers sell wet paddy.

Table 4.8 Distribution of labor hours used in rice production by activities

Item	Value (hours)	Percent
Total hours per ha	140.4	100.0
- Land preparation	19.0	13.5
- Sowing	7.6	5.4
- Replanting	22.7	16.2
- Weeding	2.1	1.5
- Manure	15.1	10.8
- Spraying	23.3	16.6
- Watering	3.9	2.8
- Harvesting	5.5	3.9
- Drying	1.7	1.2
- Visiting field	39.6	28.2

4.2.2 Rice Production Problems

Table 4.9 focuses on the problems in rice production in the study area. The farmers encountered many problems in rice production. All of farmers (100%) faced the problem of climate fluctuation in rice production. The main factors in climate problem are murky weather, poor sunshine and unseasonal rain, which lead to development of brown back hopper and many microorganisms such as fungi, bacteria, viruses. These microorganisms cause wide range of diseases in rice.

Price fluctuation is another big problem faced by majority of the farmers of (74.3%). Most of the farmers sell their rice through the middleman. Before harvesting period, the middlemen make a contract with farmers at the current market price of rice and deposit a portion of total price of rice to the farmers. If the market price of rice is higher than the contract price at the time of harvesting, the middlemen buy rice from the farmers. However, if the market price is lower than the contract price, the middleman postpone to harvest. They wait for increase in price. Consequently, late harvest leads to yield losses. In some cases, middlemen withdraw their deposit if there is no increase in the market price of rice. In this circumstance, farmers try to sell their rice at a lower price because they need money to pay for the agricultural store. Moreover, farmers need to pay middleman commission which reduces the farmers' profit more.

A considerable portion of the farmers (25.4%) (in Kenh-18 cooperative) suffered from salinization at the first stage of crop. Salinization leads to lack of fresh

water for rice production. The farmers said that this was the first time rice production in the region was affected by salinization. According to Chau Thanh Agricultural Division, building many hydroelectric power dams in some countries in upstream Mekong River (China, Laos, and Cambodia) leads to water shortage in Mekong Delta. Moreover, the sea level rise leads to salinization in this region. However, the closed boundary of the cooperative can protect their members' rice field. The farmers can use reserved water in the cooperative's canal for rice production during the salinization period.

A comparatively lower portion of the farmers (15.6%) suffered from lack of capital at the initial stage of production. Due to lack of capital, the farmers purchase pesticide and fertilizer on credit from the agricultural stores and pay the money after selling their rice. However, the farmers have to pay 3-10% higher than the current market price of pesticide and fertilizer.

At the time of harvest, a small portion of the respondents (12.3%) faced the problem of shortage of harvesting machine. All of the farmers in a cooperative sow and harvest at the same time. However, the number and operational capacity of harvester are limited and cannot serve all the member farmers at the same time.

Table 4.9 Problems in rice production

Item$^{\Psi}$	Frequency	Percent
Climate fluctuation	276	100.0
Selling	205	74.3
Salinization	70	25.4
Lack of capital	43	15.6
Lack of harvesting machine	34	12.3

Remark: $^{\Psi}$ one farmer can give more than one answer

4.3 Estimation of Technical Efficiency in Rice Production

Table 4.10 provides information on technical efficiency in rice production among the cooperatives' farmers. The results show that the member farmers of the cooperatives achieve 92.4% technical efficiency in rice production on average. It indicates that the farmers in cooperatives can improve their technical efficiency in rice production up to 7.6%. It was also found that majority of the respondents (70.3%)

achieves at least 90% of technical efficiency. However, only 2.5% of the respondents obtained lower than 80% of technical efficiency.

Table 4.10 Frequency distribution of technical efficiency in rice production

TE level (%)	Frequency	Percent
90-100	194	70.3
80<90	75	27.2
<80	7	2.5
Mean TE	92.4	
Minimum TE	69.9	
Maximum TE	99.0	

Source: Calculated by using Frontier 4.1 program, 2016

The findings of this study can be compared with the previous studies conducted in Mekong Delta, Vietnam. The technical efficiency in rice production of the cooperative's farmers is higher than that of general rice farmers (about 80% technical efficiency on average) in Mekong Delta, Vietnam (Hien et al., 2003; Nhut, 2007; Huy, 2009; Tuong, 2010; Thong et al., 2011; Khai and Yabe, 2011). One of the reasons is that most of farmers in a cooperative apply the same formula for input and technique in their production. However, the technical efficiency in rice production in Mekong Delta tends to increase year by year (Tung, 2013).

Table 4.11 Frequency distribution of technical efficiency according cooperative

Cooperative	Technical efficiency			Total
	<80	80 < 90	90-100	
Hoa Thuan-1	2	28	38	68
Kenh-18	0	0	70	70
Minh An	3	6	59	68
Tan Hung	2	41	27	70
Total	7	75	194	276

Table 4.11 shows the frequency distribution of technical efficiency according cooperative. The findings reveal that all farmers in Kenh-18 cooperative (100%) got over 90% technical efficiency in rice production. Most of farmers in Minh Anand Hoa Thuan-1 cooperatives also obtained over 90% technical efficiency in rice production, 86.8% and 55.9% respectively. The technical efficiency in Tan Hung Cooperative is

lower than in other cooperatives. Most of farmers (58.6%) in Tan Hung cooperative got between 80% and 90% technical efficiency in rice production.

4.4 Factors Affecting the Technical Efficiency in Rice Production

Table 4.11 presents the factors that affect technical efficiency in rice production in the selected cooperatives. It is important to note that the findings of this study are consistent with some results of Hien et al. (2003), Huy (2009), Khai and Yabe (2011) and Linh (2012). The γ parameter associate with the variance of technical inefficiency effect in the stochastic frontier is significantly different from zero. This means that technical inefficiency in the rice production frontier of farmers in cooperatives exists. The findings illustrate that farm size, quantity of seed, active potassium and labor hours significantly affected on technical efficiency in rice production.

The coefficient of farm size (X_1) positively affected technical efficiency at significant level 0.01. It means that if the rice land area increase 1%, the rice yield will increase 0.92%with all other factors remaining constant. Therefore, gathering small rice fields to build the large rice field could help improve technical efficiency in rice production.

The variable quantity of seed (X_2) negatively affected technical efficiency at significant level 0.1.With all other factors remaining constant, if farmers increase the quantity of seed 1%, the rice yield will decrease 0.047%. Therefore, farmer who use large quantity of seed should reduce the amount of rice seed use.

The factor quantity of active potassium (X_5) positively affected technical efficiency at significant level 0.05. It means that if farmers increase the amount of active potassium in fertilizer 1%, the rice yield could increase 0.025% with all other factors remaining constant. Therefore, farmers who applied active potassium lower than 30 kg/ha should increase this proportion in fertilizer. However, the magnitude of potassium coefficient is rather small. Previous studies reported that fertilizer utilization for rice production in the Mekong Delta is higher than other countries and negatively affect the environment and fertility of soil (Hien et al., 2003; Dang & Danh, 2008).

The coefficient of quantity of labor hours (including family labor) in rice production (X_7) positively affected technical efficiency at significant level 0.01. With all other factors remaining constant, if farmers increase the labor hour 1%, the rice yield could increase 0.057%. Therefore, farmers should regularly visit their rice fields, which help them timely response and quickly deal with pests and diseases.

The factors of active nitrogen (X_3), active phosphorus (X_4) and active pesticide (X_6) are positive but non-significant. It means that these coefficients do not have significant effect on technical efficiency in rice production. In other words, the use of active nitrogen, active phosphorus and pesticide has reached to the frontier. Increasing active nitrogen, active phosphorus and pesticide cannot bring higher productivity.

Table 4.12 Estimation of the stochastic frontier function and factors affecting technical efficiency in rice production

Variable	Coefficient	Standard error	t-ratio
Stochastic frontier			
- Constant	8.493***	0.247	34.419
- Farm size (X_1)	0.920***	0.049	18.629
- Seeds (X_2)	-0.047*	0.028	1.700
- Active nitrogen (X_3)	0.017	0.035	0.481
- Active phosphorus (X_4)	0.023	0.024	0.951
- Active potassium (X_5)	0.025**	0.012	2.086
- Pesticide (X_6)	0.011	0.009	1.219
- Labor (X_7)	0.057***	0.017	3.295
Inefficiency model			
- Constant	-0.019	0.071	0.263
- Education (Z_1)	-0.004	0.004	1.116
- Experience (Z_2)	-0.004***	0.001	2.872
- Income dummy (Z_3)	-0.021	0.034	0.628
- Credit dummy (Z_4)	0.006	0.024	0.231
- Years of joining cooperative (Z_5)	0.022***	0.006	3.564
- Technical training in 2016 (Z_6)	-0.029**	0.013	2.181
- Crop dummy (Z_7)	0.199***	0.047	4.216
- Variety dummy (Z_8)	-0.138***	0.037	3.708
Sigma-squared	0.008***	0.002	3.742
Gamma	0.854***	0.054	15.730
Log likelihood function = 377.5			
LR test of the one-sided error = 101.4			

Remark: * significant at 0.1, ** significant at 0.05 and *** significant at 0.1

Source: Calculated by the author using Frontier 4.1 program, 2016

For technical inefficiency, the factors experience in rice production, years of joining cooperatives, attending technical training class in 2016, numbers of rice crop per year and type of rice variety significantly affected.

The coefficient of farmer's experience in rice production (Z_2) negatively affected technical inefficiency at significant level 0.01. With all other factors remaining constant, if experience in rice production of farmer increases 1 year, the technical inefficiency will decrease 0.004. In other words, farmers who have higher experience in rice production obtained higher technical efficiency.

The variable years of joining the cooperative (Z_5) positively affected technical inefficiency at significant level 0.01. It mean that if year of joining cooperative increases 1 year, the technical inefficiency will increase 0.022 with all other factors remaining constant. In other words, farmers who have joined cooperative in longer period obtained lower technical efficiency in rice production. Some farmers joined cooperatives for a long time but they did not take part in any activity of the cooperatives. Therefore, joining cooperatives could not help these farmers improve their technical efficiency.

The factor of technical training classes in 2016 (Z_6) negatively affected technical inefficiency at significant level 0.05. With all other factors remaining constant, if farmers join one technical training class in 2016, the technical inefficiency will decrease 0.029. It means that farmers take part in many technical training classes will get higher technical efficiency. Therefore, the farmers should join technical training classes to update new production techniques more often.

The coefficient of numbers of rice crop per year(Z_7) positively affected technical inefficiency at 0.01. It means that if farmers produce three rice crops per year, the technical inefficiency will be higher 0.199 in compare with farmers produce two rice crops per year with all other factors remaining constant. In other words, farmers producing two rice crops per year obtained technical efficiency higher than those producing three rice crops per year. Production of three rice crops per year needs more utilization of input materials (such as fertilizers and pesticides) for each crop. Therefore, farmers should limit producing the third crop for sustainable production.

The variety variable (Z_8) negatively affected technical inefficiency at significant level 0.01. With all other factors remaining constant, if farmers usethe rice variety IR50404, the technical inefficiency will decrease 0.138. In other words, farmers produce the rice variety IR50404 will get technical efficiency higher than those produce other rice varieties.

The results illustrate that the coefficients educational level, income dummy and credit dummy are non-significant in the estimation model of rice production of farmers in cooperatives.

CHAPTER 5
Conclusions and Recommendations

This chapter is a conclusion. It has four parts. The first section summarizes the research results. The second part proposes some recommendations for rice farmers, cooperative managers, and the government. The third and fourth parts present limitations of the research and recommendation for further research, respectively.

5.1 Conclusions

This research aims to: study the characteristics of the farmers in cooperatives in Chau Thanh District, Kien Giang Province, Vietnam; examine the features of rice production and its problems; estimate the technical efficiency in rice production of the cooperative's farmers; analyze factors affecting the technical efficiency in rice production; and propose some recommendations for farmers, cooperatives and the government to improve technical efficiency in rice production. Data were collected from 276 rice farmers in four cooperatives, focusing on the summer-autumn crop in 2016. To analyze the data, descriptive statistics and stochastic frontier analysis (SFA) were applied. The results are concluded as follow.

5.1.1 Characteristics of Rice Farmers

The average age of the farmers is 48 years old. Most of them (94.2%) are male. The average educational level of farmers is lower than 6 years. There are 4.5 people in each household. Most of the households (55.1%) have only one rice labor. The farmers have experienced in rice production for nearly 25 years. Most of the households (93.1%) obtained major income from rice. Some 15.6% of the farmers used loans for rice production. The average amount of loan was 66.7 million VND.

The farmers have joined the cooperatives for 5.7 years on average. All agricultural cooperatives have provided water-pumping service for the members. Besides, the cooperatives provide other services such as land plowing, harvesting, and rice purchasing. The farmers would like the cooperatives to provide more services such as providing fertilizers (50%), harvesting (49.3%), rice purchasing (34.1%), seed

providing (26.8%), and land plowing (25.7%). In 2016, nearly 70% of rice farmers in the study joined at least one technical training class.

5.1.2 Characteristics of Rice Production and Problems

The results show that the farmers in the cooperatives occupy 1.6 ha of rice land on average. Most of the households (97%) produce two main rice varieties namely IR50404 and OM5451 in summer-autumn crop. The main sources of rice variety are own-kept seed (47.8%) and the breeding center (43.1%).

Most of the farmers (75%) produce three rice crops per year. The farmer used nitrogen, phosphorus, and active potassium 101.46 kg, 69.51 kg, and 48.04 kg per ha per crop respectively. They also applied chemical actives 1,959.43 g per ha per crop. They utilized a total 140.4 labor hours on average. The average rice production was 6.66 tons per ha per crop.

Total cost of rice production was 17.7 million VND per ha. The revenue from rice production was 30.4 million VND per ha. The net revenue was about 12.7 million VND per ha. However, the farmers are facing many problems in rice production such as climate and price fluctuation, salinization, lacking of capital and harvesting machine.

5.1.3 Technical Efficiency in Rice Production

The results indicate that the farmers in the cooperatives achieved 92.4% of technical efficiency in rice production on average. Most of them (70.3%) achieved at least 90% of technical efficiency. Especially, all farmers in Kenh-18 cooperative (100%) got over 90% technical efficiency in rice production.

5.1.4 Factors Affecting the Technical Efficiency

Farm size, active potassium, and labor hours affect positively the farmer's technical efficiency in rice production. The results also reveal that the farmers who have higher experience in rice production and attended more technical training classes, obtain higher technical efficiency. The farmers who grew the rice variety IR50404 get higher technical efficiency than other rice varieties. On the other hand, the coefficient of seed is negative at 10%.This implies that using large amount of seed

reduces the technical efficiency. Farmers who produce three rice crops per year have lower technical efficiency than those produce two crops per year. Similarly, farmers who have joined the cooperatives for a long time but have not participated in the cooperatives' activities do not improve their technical efficiency.

5.2 Recommendations

Based on the results, the author proposes some recommendations for rice farmers, cooperatives and the government as follow.

5.2.1 Recommendation for Rice Farmers

1) Since using great amount of seed reduces the technical efficiency, the farmers who used too much seed (over 200 kg/ha) should consider reducing the quantity of seed use (to 150-200 kg/ha) to enhance technical efficiency.

2) Active potassium affects positively the farmer's technical efficiency in rice production. Therefore, the farmers who applied active potassium less than 30 kg/ha should use more active potassium proportion in fertilizers to increase technical efficiency.

3) Since labor hours affect positively the farmer's technical efficiency, the farmers should visit their rice fields regularly. This will not only help the farmer timely response all problems on rice plant but they can also manage the rice fields more intensively.

4) The results reveal that the farmers, who attended many technical training classes, obtained higher technical efficiency. Thus, the farmers should join the technical training classes to update new production techniques more often.

5) The findings illustrate that producing two rice crops per year got higher technical efficiency. Therefore, farmers should limit producing the third crop for sustainable production.

6) The rice variety IR50404 obtained higher technical efficiency. Thus, farmers in some regions can grow this rice variety for its own market.

7) Some farmers reflected that they lack of capital for rice production. They should come to the bank to ask for some loans with low interest rate.

8) The results shows that pesticide cost account over a quarter of total variable cost. Therefore, farmers should apply other method instead of pesticides to for sustainable production and reducing cost.

5.2.2 Recommendation for Cooperatives

1) Most farmers pointed out that they have problem for selling rice. Therefore, the management of the cooperatives should contact with the companies to purchase rice for the members.

2) Farmers in Kenh-18 cooperative want the cooperative to provide land-plowing service for the members. Therefore, the cooperative may think to invest a plowing machine to serve for rice production in the cooperative.

3) The farmers in Tan Hung and Hoa Thuan-1 cooperatives hoped that the cooperative sells fertilizers to the members at a purchasing price. To solve this problem, the cooperative can link the members together to buy a large amount of fertilizers with cheaper price.

4) In Minh An and Hoa Thuan-1 cooperatives, lacking harvester often occurred at harvest time. Thus, the cooperative may think about investing this machine.

5) The results reveal that some services of the cooperative cannot compete with the businessman (i.e. selling fertilizer). Therefore, the cooperative management should have at least one member with a "business mind".

5.2.3 Recommendation for the Government

1) The results illustrate that larger size of rice land can get higher technical efficiency. Therefore, the government should have some policy to gather small rice fields to establish bigger field.

2) Producing two crops per year get higher technical efficiency. Thus, the government should not encourage produce third rice crop.

3) The government encourage farmers growing high quality rice varieties for exporting and discourage them producing the rice variety IR50404 although it get higher technical efficiency. Therefore, the government must provide information for the farmers regarding the profit or net revenue from producing other high quality rice.

4) In the Law of Cooperatives, particularly the article about providing services outside the cooperative not exceed 32%, limits the capacity of the cooperatives. Therefore, the government should revise this rule to enhance the efficiency of the cooperatives in providing services.

5) Middlemen reduce the profit of farmers. Therefore, the government should create a direct bridge between farmers and company for selling rice.

5.3 Limitation of the Study

The study only researches about technical efficiency in rice production in one crop at one district in the Mekong River Delta, Vietnam.

5.4 Recommendation for Further Research

The next study may be comparing the technical efficiency in rice production between the farmers inside and outside cooperatives.

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APPENDIX

QUESTIONNAIRE

Name household: ……
Address: …… Sub-district: ……
Cooperative: ……
Phone No: ……..
Interview day: ……/…..…/2016

Thank you for agreeing to take part in this important study. My name is Cao Minh Tuan, a student in Master of Business Administration program in Agribusiness Management, Faculty of Economics, Prince of Songkla University, Thailand. I am doing the study about Technical Efficiency in Rice Production of Farmers in Cooperatives in Chau Thanh District, Kien Giang Province, Vietnam. This survey will take your 20-30 minutes to complete. Your responses will be kept in the strictest confidentiality.

The questionnaire has six pages and is divided into three sections:

Section 1: Characteristics of rice farmer and link to cooperative

Section 2: Characteristics of rice production

Section 3: Problems in rice production

I. Characteristics of Rice Farmer and Link to Cooperative

Q1. Age of main rice producer: …… Years

Q2. Gender: ☐ 1. Male ☐ 2. Female

Q3. Education level of main rice labor:…….. (Year of schooling; intermediate = 14; college degree = 15; bachelor degree = 16; master degree = 18; doctor = 21)

Q4. Number of family's members: …… person. In there, number of members over 15 years old:…… person and number of members working for rice: …… person

Q5. Is rice production main source of family income? (If answer is "Yes", go to question 8; if answer is "No", go to question 7)

❑ Yes ❑ No, the main source is …….

Q6. What is the job of main rice producer?

❑ 1. Farmer ❑2. Workers

❑ 3. Official ❑4. Self- business

❑ 5. Teacher ❑8. Others:……..

Q7. The total non-rice production incomes?……. VND/year, which accounts……..% of the total income.

Q8. Did you have any loans from official and nonofficial credit institutions to produce rice in 2016?

Source		**Amount (VND)**	**Interest (%/month)**
Official credit			
Nonofficial credit			

Q9. How long have you joined the cooperative? ..... Years

Q10. What services do you obtain from the cooperative for rice production? (Many options)

❑ 1. Seed providing ❑2. Land plowing

❑ 3. Water pumping ❑4. Supporting capital

❑ 5. Consulting production technique ❑6. Harvesting

❑ 7. Drying ❑8. Selling rice

❑ 9. Others:……

Q11. What other services do you want the cooperative provide to the members?

.....

.....

Q12. What are the problems of joining the cooperative?

.....

.....

Q13. Do you have any suggestions for improving cooperative operation?

.....

.....

II. Characteristics of Rice Production

Q1. Experience in growing rice: …… Years

Q2. Rice land area of your household?

	Total area (công)	**Source of rice land (công = 1.000 m^2)**		
		Own land (công)	**Renting land (công)**	**Renting price (VND/công)**
Inside Cooperative				
Outside Cooperative				

Q3. Kinds of rice varieties you are using? .....

.....

Q4. Source of rice varieties?

❑ 1. Breeding by yourself ❑2. Supporting by Extension Center

❑ 3. Purchasing from Breeding Center ❑4. Purchasing from acquaintance

❑ 5. Others: .....

Q5. How many technical training classes have you taken part in since you joined the cooperative? …….. Classes

Q6. How many technical training classes have you taken part in 2016?……Classes

Q7. The rice production techniques you are applying? (Many options)

☐ 1. Row seeding ☐2. Scatting

☐ 3. 3 Reductions 3 Gains ☐ 4. 1 Must 5 Reductions

☐ 5. Others: .....

Q8. Do you apply IPM in your rice production?

☐ 1. No☐ 2. Yes, Detail: ……

Q9. Besides fertilizing, spraying, and weeding time, how long do you visit rice farm once? ……. days/time

Q10. Production machine, which you have? (Many options)

☐ 1. Water pumps ☐2. Plows, cultivators 4 wheels

☐ 3. Plows, cultivators 3 wheels ☐4. Spraying machine

☐ 5. Row seeder ☐6. Combine harvester

☐ 7. Threshing machine ☐8. Others:…….

Q11. Production machine which you use in summer-autumn crop 2016? (Many options)

☐ 1. Water pumps ☐2. Plows, cultivators 4 wheels

☐ 3. Plows, cultivators 2 wheels ☐4. Spraying machine

☐ 5. Row seeder ☐6. Combine harvester

☐ 7. Threshing machine ☐8. Others:…….

Q12. How many rice crops you produce per year?……Crop/year

Q13. How many rice plots inside the cooperative in summer-autumn crop 2016? ……. Plots

Q14. The area of the biggest rice plot inside the cooperative: ……. m^2

Q15. Information about quantity and cost of inputs of **the biggest rice plot** inside the cooperative in summer-autumn crop 2016

Expense item	**Hè Thu (summer-autumn) Crop 2016**		
	Quantity	**Price**	**Total Cost (VND)**
1. Soil preparation (plowing, shaft, ...): The cost of hiring machine			
2. Sowing			
2.1 Seed (first time and additional time)	kg	VND/kg	
2.2 Additional plating rice (if any)	X	X	
3. Take care			
3.1 Weeding and herbicide			
3.1.1 Manual weeding			
3.1.2 Herbicides			
- Liquid herbicides	lit	VND/lit	
- Powder herbicides	kg	VND/kg	
3.2 Fertilizers			
Urea	kg	VND/kg	
DAP	kg	VND/kg	
Kali	kg	VND/kg	
Phosphate	kg	VND/kg	
NPK 1: ……	kg	VND/kg	
NPK 2: …….			

Expense item	Hè Thu (summer-autumn) Crop 2016		
	Quantity	Price	Total Cost (VND)
Others: ……..			
3.3 Agricultural chemicals (pesticides, diseases, pests, snails, mice, growth ... in the process of care)			
-	lit	VND/lit	
-	lit	VND/lit	
-	lit	VND/lit	
-	lit	VND/lit	
-	lit	VND/lit	
-	lit	VND/lit	
-	kg	VND /kg	
-	kg	VND /kg	
-	kg	VND /kg	
-	kg	VND /kg	
-	kg	VND /kg	
3.4 Watering			
Hiring irrigation			
Fuel cost (gasoline, oil, grease)	lit	VND/lit	
Electricity cost (do by yourself)			
Irrigation fee			
4. Harvesting			
Mowing			
Threshing			
Combine harvester			
Drying			
Transportation			
5. Visiting farm cost (fuel for traveling)	lit	VND/lit	
6. Others:…….			

Q16. Labor hours in rice production of the **biggest rice plot** inside the cooperative in summer-autumn crop.

Expense item	Hè Thu (summer-autumn) crop 2016		
	Quantity (hours)	Times	Price (VND/day)
1. Soil preparation			
2. Sowing			
3. Re-planting			
4. Weeding			
5. Manuring			
6. Spraying			
7. Irrigation			
8. Harvesting			

Expense item	Hè Thu (summer-autumn) crop 2016		
	Quantity (hours)	Times	Price (VND/day)
9. Post harvesting			
10. Transportation			
11. Monitoring			
12. Others: …….			

Q17. The output quantity of the biggest rice plot inside the cooperative in summer-autumn crop 2016 …… tons

Q18. The way you sell your paddy?

❑ 1. Wet paddy at farm ❑2. Dry paddy ❑3. Tied together for selling

❑ 4. Waiting until high price ❑5. Others:…….

Q19. Information about the price and total revenue in summer-autumn crop 2016?

Type	Quantity (kg)	Price (VND/kg)	Revenue (VND)
1. Wet paddy			
2. Dry paddy			
3. Saving for using			
3. Saving for seeding			

III. Problems in Rice Production and Consumption

Q1. Difficulties often encounter in rice production activities?

.....

.....

Q2. Difficulties in rice marketing?

.....

.....

Q3. Other problems?

.....

.....

Thank you very much for your cooperation!

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