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Rice Production in the Mekong Delta, Vietnam: Potentialities and Situation Analysis

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베트남 메콩 델타의 쌀 생산: 잠재력 및 현황 분석

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Abstract : Vietnam is one of the largest rice exporters in the world rice market with such a long history in rice production. In Vietnam, the Mekong Delta (MD) is considered as "rice bowl" not only of the country but also of the Asian region. The delta counts for more than 50% total rice production and 90% of rice export in the volume of the country (2015). The delta has its own advantageous natural and economic-social features for rice production such as high soil fertility, tropical climate with high temperature, copious rainfall and experienced labor force in rice production, etc. Thanks to these favorable conditions, rice production is a significant sector in the economy of the delta and continuously increasing in rice planted area, yield and output. However, at present, rice production in the MD has been confronted with many problems such as the decrease of rice cultivated area due to climate change, soil erosion, rapidly increasing input costs, lack of infrastructure and technology, high loss rate in harvest and post-harvesting time, low rice quality and fluctuated price, etc. This paper focuses on analyzing potentialities and recent status of rice production in the MD in order to identify and minimize constraints for sustainable development rice production in the near future. This research finds out that despite rice production is an important economic sector of the MD, the present status of rice production is still not corresponding to its great potentialities, then it needs to be improved as sustainable trends.
Key Words : Vietnam, Mekong Delta, Rice production, Potentialities, Situation

요약 : 베트남은 오랜 벼 재배의 역사를 가진 세계에서 가장 큰 미곡 수출국 중 하나이며, 그 중에서도 메콩델타(메콩강 삼각주) 지역은 베트남의 쌀 생산량의 50%, 쌀 수출량의 90%를 차지할 정도로 쌀 생산량이 많아 '아시아의 쌀 그릇'이라는 별명을 가지고 있다(GSO, 2015). 이러한 메콩 델타 지역은 메콩강의 영향을 받은 비옥한 토양, 고온다습한 기후, 많은 인구, 그리고 쌀 농사 경험이 많은 숙련된 노동력 등의 유리한 조건의 영향을 받아 벼 재배 면적과 쌀 생산량 등을 지속적으로 늘려왔다. 그러나 메콩 델타가 과거 누려왔던 환경들이 점차 변하면서 메콩 델타에서 과연 앞으로도 지속가능한 농업이 가능할 것인지에 대해 의문이 제기되고 있다. 대표적으로 메콩 델타 일대의 기후변화, 농업 인프라와 도정기술 부족으로 인한 쌀의 품질 문제 및 수확 과정에서의 높은 손실률, 국제 시세에 지나치게 영향을 받아 변동성이 높은 쌀의 가격 등이 현재 메콩 델타의 농업이 직면한 문제로 꼽히고 있다. 본 연구는 이러한 문제들을 어떻게 하면 최소화할 수 있을지, 우선 메콩 델타 쌀 생산의 잠재력과 현황을 분석하고자 한다. 본 연구 결과에 따라서 쌀 생산은 메콩 델타의 중요한 경제 부분이지만 잠재력에 상응하지 않는다는 것을 알게 되며 앞으로 지속 가능성 경향으로 개선될 필요가 있다고 생각한다.
주요어 : 베트남, 메콩 델타, 쌀 생산, 잠재력, 현황

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I. Introduction

Thanks to the success of Renovation in 1986 (or Doi Moi), Vietnam emerged from a near famine state to stand in the rank of the world's 3rd rice exporter. During two decades, Vietnam's annual growth rate has surged to an average of 6-7%, of which agricultural GDP growth rate was around 4%, contributing 20% of total GDP. Although the shares of agriculture in GDP and in total employment has gradually decreased over years, agriculture sector still plays an important role in economic development of Vietnam.

In agriculture, rice is the most important crop and the main food in the daily of Vietnamese people. Rice land area covers for 4 million hectares (ha), accounting for 40% of total agricultural land and rice products contributes more than 80% of food grain output. Rice cultivation is the main source of income for more than 10 million households that account for nearly 70% of the total agricultural households. The rice production and export has increased steadily thanks to the restructuring of the economy, improved technology, irrigation systems and availability of inputs. Vietnam has become the largest rice exporter in the world market with rice export volume of 7.56 million tons in 2012.

The Mekong Delta (MD) region is the largest rice granary of Vietnam. The region is considered as Vietnam's 'rice bowl' which accounts for more than 50% total rice production and 90% of the rice export in volume (2014) (GSO, 2015). Thus, rice production of the MD not only significantly contributes the national food supply but also plays significant role in the international food security. The natural and socio-economic features in the MD are advantageous to rice production. The delta is formed by a huge amount of silt brought by the Mekong River. The Mekong River and canal systems supply a huge amount of water that irrigate for paddy field in the delta all year round. The tropical monsoon climate is suitable for rice cultivation due to particular features such as average temperature of about 26°C, 2,500 sunny hours, and rainfall of about 2,000mm, etc. The MD has a large population of 17.5 million, of which the total labor force (from 15 to 60 age) was 10.322 million people, occupying 19.4% of a total labor force of the country (GSO, 2015). About 75% of the population are living in rural area and engaging in agricultural activities. The infrastructure system and rice production technology are being improved. However, at present the rice production in the MD has been confronted with many problems, such as: decreasing of rice cultivated area due to climate change, soil erosion, the rapid increase of input costs, lack of infrastructure and technology, low rice quality and fluctuated price. These issues are concerning sustainable development in rice production.

The goal of this paper is to analyze the natural as well as socio-economic potentialities for rice production in the MD. It also summarizes the progress of rice production in Vietnam and in the MD. In particularly, the paper aims to evaluate the current situation and problems in the sustainable development of rice production in the MD.

II. Overview of Rice Production in Vietnam and in the MD

1. A Brief of Rice Production in Vietnam

Vietnam rice production performance has changed depending on historical and/or policies events of the country that can be summarised in four periods (Bui, 2010).

During the war period (1945-1975), Vietnam was known as an agricultural country but the rice cultivated area of the whole country only fluctuated around 4.7-5.1 million ha due to low-quality seed varieties, insufficient equipment and investment for agriculture. Rice production was low ranging from 9 to 11 million tons, and rice volume per capita was around 165 kg per year, which were not sufficient for necessary consumption of the country. Hence, during this time, Vietnam imported

a large quantity of rice with more than 1 million tons per year.

The period of post- war (1975-1985), after reunification in 1975, the Vietnamese Government drove a command of the economic system to the whole country, in which almost all of individual agricultural land and labor were collectivized into cooperative farms (or called Hợp Tác Xã) under the management of the state. This centralized economic system could not improve agricultural production due to a lack of encouraging farmers' potentialities and inadequate in production distribution. As a result, rice production had not much increased and the country had still imported rice until 1986. However, the most significant achievement in this period was the rapidly increasing of rice sown area through a large-scale land reclamation and irrigation construction for rice cultivation, especially in the MD region. In the end of this period, from 1981, the application of "Contract 100" policy[1] (or called "Khoán 100") which applied an individual-oriented contract system to replace collectivized production in the north region, led to a gradual increasing of rice production.

The period during Doi Moi (1986-1999), the successful of Doi Moi[2] policy in 1986 has deeply transformed agricultural economy of Vietnam toward a complete liberalization of input and output market. Since the end of the 1980s, series of important market institutions were established to enhance agricultural. For example, the "Contract 10"[3] policy was introduced in 1986, which recognized farm household as basic units of rural economy and gave them a more stable long-term land using. Farmers were expected to make their best of using land and existing technical facilities. They were allowed to make decisions on resource allocation, crop choices, and crop management. In addition, the government increased investment in infrastructure and technology for agriculture and rural development. Therefore, rice production increased in term of rice sown area, yield and output volume (see table 1). These dramatic successes created a landmark in the history of rice production of Vietnam: from 1987, the country rapidly shifted from importing rice to become one of the world's largest rice exporters.

Rice production in recent period: From 2000, rice production in Vietnam has started a new trend that decreased rice land due to the process of industrialization and urbanization, but increased production through increased yield. Rice sown area had increased from 2005 through increasing crop intensity in some areas supported by the expansion of the irrigation systems and increasing to 3 crops per year in the MD. Rice production volume had increased steadily from 32.5 million tons in 2000 to 45 million tons in 2014. It is a result of increasing rice yield through improvement of irrigation system and application of high-yield rice varieties as well as other agricultural technology. The average rice yield during 2000-2014 was 4.0 tons/ha, and the highest yield recorded at 5.76 ton/ha in 2014.

Currently, Vietnam is the second-largest rice exporting nation in the world only after Thailand. According to Vietnam Food Association (VFA) report, rice exports in 2012 hit the record of 7,563 thousand tons with the value of US $3,376 thousand, surpassed Thailand to become the biggest rice exporter. Vietnamese rice has currently exported to about 120 countries around the

Table 1. Rice area, yield and production and import/ export in Vietnam (1970–2014)

Year	Area (1,000 ha)	Yield (ton/ha)	Production (1,000 tons)	Import (-)/Export (1,000 tons)
1970	4,724	2.15	10,173	-1,260
1975	4,856	2.12	10,283	-910
1980	5,600	2.08	11,647	-350
1985	5,718	2.78	15,874	-336
1986	5,703	2.80	16,002	-132
1990	6,042	3.18	19,225	1,642
1995	6,765	3.69	24,963	1,988
1999	7,653	4.11	31,394	4,508
2000	7,666	4.24	32,529	3,476
2005	7,329	4.90	35,832	5,250
2010	7,518	5.30	40,005	6,754
2012	7,761	5.64	43,737	7,563
2014	7,813	5.76	44,975	6,361

Source : Bui, 2010; GSO, 2015.

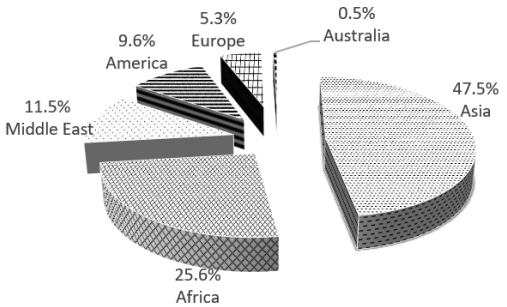

Fig. 1. Vietnam's rice export markets during 1990–2014 (%)

world, of which, Asia and Africa are the two main export markets, corresponding to 47.5% and 25.6% of total rice export volume during the period of 1990-2014.

Though Vietnam's rice export has developed distinct steps in increasing rice export volume, it still exhibits low efficiency. In practice, Vietnam trade more but earned less hard currency from rice, compared with other countries, for example, in 2012, Thailand rice export fell to the third place in term of volume with 6.73 million tons but earned US $4.63 billion, while Vietnam exported 7.56 million tons with revenue of US $3.4 billion. In addition, Vietnam's rice price for a particular rice variety is lower than those of other leading rice exporting countries. For example, the price of Vietnam 5% broken rice in 2015 was 347 USD/ton, lower than 396 USD/ton of Thai 5% and 407 USD/ton of Thai white 100%. During past years, more than 50% of exported rice was low-quality varieties (more than 25% broken rice), while the type of high quality of 3-10% broken rice and special ricevarieties accounted for a small ratio. Vietnam's rice export has been being faced with competition from India, Thailand and other countries in the world rice market.

2. A Brief of Rice Production in the MD

MD is "rice bowl" of Vietnam with 45.3% of all the rice land and 50% of total rice output of the country (2014). The history of rice production in the MD started with floating rice system when Vietnamese migrants from the northern and central regions began land reclamation in the MD in the 18th century. The history of rice production in the MD could be summarized as five periods.

At the end of the 19th century, the MD was colonized by the French. The French colonial administration wanted to develop rice production for purpose of exploitation. They forced to a dig canal and drainage system as well as expand the land reclamation. Hence, the expansion of rice cultivation in Cochin China[4] increased dramatically four times after 60 years under the French colonial regime. In those days, MD was one of the three major rice-exporting in the Indochina region with about 1 million ton of white rice shipped out every year. However, in this period, rice production growth mainly based on area expansion and labor intensity. The strong social polarization with the heavy taxation and high- interest rate limited the efficiency of the rice production (Son, 1997; Huynh, 2000).

From 1945 to 1954, agricultural production declined due to the Southern Resistance War (or called "Nam Bộ Kháng Chiến"). After 1940, by the downfall of the French colonial power following the Japanese invasion and the expansion of Viet Minh[5]organization, landlords could neither claim their land rents nor recover their loans from tenants and then they began to move away. As a consequence, some tenants were free from land rents and achieved better living conditions. But because of the war, majority of production, hydraulic network, and key infrastructure were almost destroyed. Hence, rice production declined as a result of decreasing cultivated area in this period (Le Cod, 2001).

From 1955 to 1975 were the period of land reform and intensification in rice production.

In 1954, the war ended and the country was split into two parts: the southern became the Republic of South Vietnam and the northern became the Democratic Republic of Vietnam. In the south, to gain the support of the rural population, both the northern and the southern government carried out land reforms in the areas under their respective control. The government seized land from landlords and sold it to farmers, all

the land that was not directly cultivated by his owner was given to farmers who cultivated it. During the early 1970s, thanks to the introduction of the Green Revolution, rice production of the MD increased rapidly.

After reunification in 1975, Vietnam government has made a substantial effort to develop the economy in the southern, particularly in the agricultural sector. In 1976, the process of land redistribution took place, following that land of landlords were distributed for poor and landless peasants. In addition, with the introduction of double cropping systems of high-yield varieties, and completion of the expansion of the irrigated agro-ecosystem, rice production in the MD increased during this period, reached at 6.8 million tons of paddy in 1985.

From 1986 to recent, thanks to the launch of the Doi Moi policy and reorientation of paddy production for exports, the imports of mineral fertilizers and pesticides increased dramatically. Thus, rice intensification has rapidly expanded in the whole country. Moreover, as the government recognized the role of "ownership" in the economy, farmers could be able to use their all capacity to increase rice production by using more equipment, fertilizers, and pesticides. Consequently, from an average yield of 5 tons per ha with 2 crops per year, they are now harvesting around 10 tons of paddy per ha with 3 crops per year.

III. Natural and Socio-economic conditions impacting on rice production in the Mekong Delta, Vietnam

1. Natural Features

Geography location and topographic: The MD is the last section of the Mekong River basin, lies in the southwest of Vietnam. The delta is a plain zone with a natural area of 40.576 km^2, occupying 12.3% of the national area. Except for some minor hilly areas, the delta is flat with an average altitude about 2.0 meters above sea level. It is located between longitudes 104°30' to 106°47' E and latitudes 8°32' to 11°2' N. To the north, the delta borders with Cambodia, to the east with the East Sea (also known as South China Sea), to the North-East with the Southeast economic region, and to the west with the Gulf of Thailand. The MD includes 13 cities and provinces, namely Can Tho, Long An, Tien Giang, Dong Thap, An Giang, Kien Giang, Vinh Long, Ben Tre, Hau Giang, Soc Trang, Tra Vinh, Bac Lieu and Ca Mau.

This geographical position plays a very important role in domestic as well as international exchanges for the MD. The eastern is adjacent Southeast - the most developed economic region in Vietnam - where there are a lot of food processing companies which are considered as large consumption market for rice products of the MD. In addition, situated adjacent Cambodia and common Mekong River, located in a region of maritime transportation, international air transport between South Asia and Southeast Asia as well as Australia and other islands in Pacific, the MD holds an important transport hub that givesmany comparative advantages in the rice market over the world,

Fig. 2. Administrative map of the Mekong Delta

particularly in the current globalizing world.

Climate: The MD has a monsoon tropical semi-equatorial climate which is suitable for rice cultivation. The average temperature is about 27°C while the favorable temperature for rice plant is from 20°C to 40°C. The annual average sunny hour is about 2,500 hours and the radiations distribute equally in the months of the year at a full level estimated about 450 calories/cm^2/day. Depending on these factors of the sunshine, temperature, and radiation, rice crops in the delta can be grown all year, possible to harvest 2-3 times per year. The annual average rainfall is about 1800 mm, but unevenly distributes throughout the year. The rainy season is from May to October, covers 90% of the whole year rainfall while there is nearly no rain in the dry season from November to April. However, the monsoon tropical climate causes lots of difficulities for rice cultivation, such as the rapid growth of insects and illness, flooding in a rainy season, and drought and saline intrusion in the dry season, etc.

Water resource: In the MD, main fresh water sources are from rainfall, the Mekong River, and Vam Co river systems and underground water. Irrigation system for rice farming is dense with the network of river courses, canal, and ditches. The Mekong River flows into the MD and separates into two main branches, namely Tien River and Hau River, with a total water volume of Mekong River is about 500 billion cubic meter. The system of canals in the MD was constructed during the past centuries with the primary purpose to develop agriculture and transportation with 15,000 km of principal and primary canals, 27,000 km of secondary canals and 50,000 km of tertiary canals (Chu *et al.*, 2010).

Soil and land use: Soils in the MD are characterized by multiform, but it can be classified into three main groups: alluvial soil, acid sulfate soil, and saline soil. Alluvial soil mainly concentrates in coastal areas of Tien and Hau River, occupy 1.18 million ha, accounting for 30% of the region's natural land area and about 1/3 of whole country's alluvial soil area. This soil group is formed on river sedimentary material with high fertility, suitable for rice crops, fruit trees, and short-term industrial trees. Acid sulfate soil which is rich in pyrite (FeS_2), covers the largest area about 1.6 million ha, occupies more than 40% of the MD. It can be classified into three sub-types as severely acid sulfate soils, medium acid sulfate soils, and slightly acid sulfate soils. The soil's characteristic is the high concentration of acid and weak mechanical property, thus posing constraints to rice cultivation. Saline soils cover an area of 808,749 ha, accounting for 21% of MD area, distributing along the coastal, upland and mountain regions. The soils are rich in fertility but high in salt content. Despite acid sulfate soil, saline soil, and sandy soil are not really fertile they could be improved by irrigated and technology methods, thus a rather large agricultural production land can be expanded.

The overall natural area of the MD comprises 4.0 million ha, accounting for only 12.05% of the total country area, while its agricultural land accounted for 3.46%. The majority of land is devoted to agricultural production with 2.6 million ha, accounting for 65% of the total natural land of the region, of which, annual crops land occupies more than 1.3 million ha (accounting

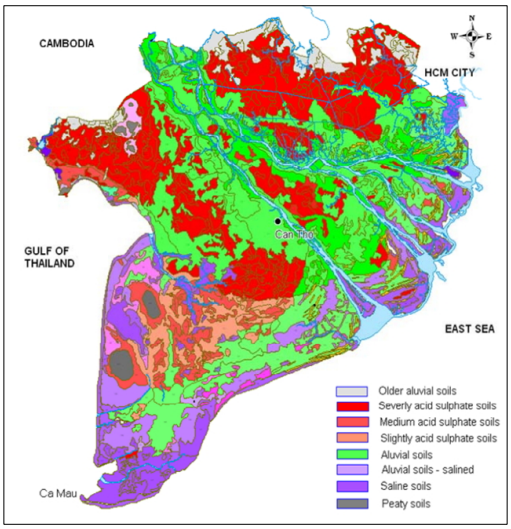

Fig. 3. Map of soils in the Mekong Delta

Source : Vo, 2002.

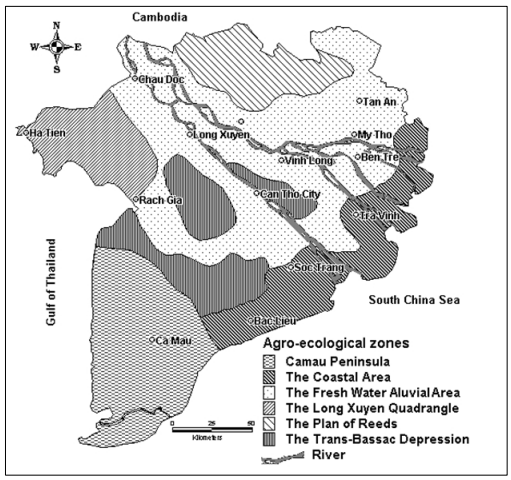

Fig. 4. The Agro–ecological zones of the Mekong Delta
Source : Vo and Matsui, 1998.

for 50% of the total agricultural land) including rice land, fruit and vegetable and other annual crops land. Among 1.3 million ha for annual crops, rice land is estimated to occupy about 90% or 1.17 million ha.

Based on geographic and physical features, the MD can be classified into six important agro-ecological zones with different potentialities for rice production (*figure 4*) (Vo and Matsui, 1998). The freshwater alluvial zone is situated in the central parts of the delta, characterized by freshwater and alluvial soil types, covering an area of about 900,000 ha, thus suitable for triple rice crops, fruit trees, vegetables and/or integrated rice-fish farming. The Plain of Reeds lies in Dong Thap and Long An province, covering an area of about 500,000 ha. This is the upstream but lowest part of the delta (0.5 m below mean sea level). The zone is characterized by acid sulfate soils. The main agricultural activities here are rice farming and integrated rice-aquaculture. The Long Xuyen-Ha Tien Quadrangle zone covers an area of 400,000 ha. It is dominated by acid sulfate soils, suitable for rice and rice-based farming activities. The Trans-Bassac Depression zonelies to the west of Can Tho, covering an area of about 600,000 ha. Natural conditions are suitable for double or triple rice crop cultivation. The Coastal zone is located along the eastern parts of the MD, covering an area of about 600,000 ha. This zone has a sulfate soils and the environmental condition is good for practicing shrimp and rice farming. The Ca Mau Peninsula zone is situated in the southern most part of the delta, covering an area of 800,000 ha. The zone is characterized by season saline- affected soils presenting various rice-based farming systems under raining conditions. Though the physical conditions are different between agro-ecological zones, but it is clear that rice-based farming systems are dominant in the MD.

2. Economic – social situations

Population and labor force: In 2015, the total population of the MD was 17.5 million people, accounting for 19.4% of the national population, and the total labor force (from 15 to 60 age) was 10.322 million people, occupying 19.4% of the total labor force of the country (GSO, 2015). There are about 75% of the region's population living in the rural and engaged in agriculture. The population growth rate is 0.4%, thus about 41,000 people enter the labor force of the delta every year. Though the labor force is abundant, the rice production is lacking available workers. Labors in the MD are experienced and quick to adopt advanced technologies, accustomed to commodity production, and willing to change the cropping and animal raising patterns to get high economic efficiency. However, most of the labors are manual, only 10% are trained, while the average rate of the country is 17.9% (Duong, 2015).

Policy, infrastructure and irrigation system: Evaluated the important role of MD in rice production, the government has applied many policies for development rice economy in this region, e.g., policy to maintain and develop paddy land; support farmers to reduce input cost; support to access and develop rice market; credit support for rice producers, etc. Along with that, the government also invests in improving the infrastructure and irrigation systems in rural areas in the MD. In addition, the development of food processing industry

Table 2. Natural land, agricultural land, population and labor force by province in the Mekong Delta

Region	Natural area (1000 ha)	Agricultural production land		Population	Labor force	
		1000 ha	% of natural area	1000 persons	1000 persons	% of population
Mekong Delta	4057.6	2607.1	64.3	17590.4	10334.6	58.7
Long An	449.5	313.3	69.7	1484.7	893.4	60.2
Tien Giang	250.9	179.2	71.4	1728.7	1080.9	62.3
Ben Tre	236.0	144.0	61.0	1263.7	809.4	64.1
Tra Vinh	234.1	148.0	63.2	1034.6	611.4	59.0
Vinh Long	152.0	117.9	77.6	1045.0	627.6	60.0
Dong Thap	337.9	258.9	76.6	1684.3	1017.5	60.4
An Giang	353.7	278.8	78.8	2158.3	1218.9	56.5
Kien Giang	634.8	460.3	72.5	1761.0	1005.1	57.1
Can Tho	140.9	113.4	80.5	1248.9	693.1	55.5
Hau Giang	160.2	133.8	83.5	770.4	462.9	60.1
Soc Trang	331.2	208.8	63.0	1310.7	704.1	53.7
Bac Lieu	246.9	102.8	41.6	882.0	506.5	57.4
Ca Mau	529.5	147.9	27.9	1218.9	704.1	57.8

Source : GSO, 2015.

in the MD in recent years has affected rice production in term of consumption and enhanced the value of rice products. However, the current state of the road traffic system and capacity of rice milling factories in the delta are still weaker compared to total demand, seriously constraining the commercialization of the agricultural business (Nguyen *et al.*, 2013).

IV. Current Status of Rice Production in the Mekong Delta

1. Rice Land, Yield and Production

Rice product continues a major part of the economy in the MD. The rice land of the delta is about 1.9 million ha, takes 49% of total rice land of the country (2014). In the period of 2000-2014, rice land decreased 6,000 ha due to the changing of land use purpose. However, the planted rice area of the delta has increased steadily due to intensity and improvement of the irrigation system that allowed production of three rice crops per year.

The average size of rice land per household in the MD is about 1.4 ha, which is the largest index in the country, comparing to 0.42 ha of the country and 0.21 ha of the Red River Delta. However, agriculture production of the region still mainly bases on a small scale. According to a statistical report, in the MD, households who have average size of rice land less than 0.2 ha accounting for 36% of total households ; from 0.2 to less 0.5 ha at 27%; from 0.5 to less 1 ha at 23% ; from 1 to 2 less ha at 12%, and more than 2 ha at 4% (GSO, 2011). Such a small and fragmented land holding constraints improving rice productivity through mechanization. Moreover, it also required additional time and labor for farming activities due to geographically distant among plots. Therefore, the Vietnamese government has been promoting what is called 'large field' (cánh đồng mẫu lớn) program, particularly implemented in the MD. Farmers are encouraged to organize together as co-operatives or groups, and establish long-term relationships with companies through contracts involving the supply of inputs by company agents and purchase of farmers' produce at agreed prices.

Table 3 shows the situation of rice production in

Table 3. Area, yield and production of rice in the Mekong Delta (2000-2014)

	2000	2005	2010	2014
Planted rice area (1000 ha)	3,945.8	3,826.3	3,945.9	4,249.5
Rice yield (ton/ha)	4.23	5.04	5.47	5.94
Rice production (1000 tons)	16,702.7	19,298.5	21,595.6	25,224.2

Source : GSO, 2015.

recent years. Rice yield has been remarkably improved. The average yield increased from 4.23 to 5.94 ton/ha from 2000 to 2014, that higher than the average yield of the country (5.75 ton/ha in 2014). This is a result of widespread implementation of technology, significant application of new rice varieties and machines in rice production. The rice production has constantly increased during the 2000-2014 period, from 16,702 thousand tons to 25,224.2 thousand tons. Therefore, the MD occupies for 56.13% total rice production and more than 90% of the total rice export volume of the country.

Though the MD is the most significant granary of the country, rice production capacity is different between provinces, of which Kien Giang, An Giang and Dong Thap are the largest rice production provinces in term both of rice-cultivating area and output. Table 4 presents the area, yield and production of rice by each province in the MD in 2014. The MD accounted for 54% of rice planted area and 56% of rice production of the total country, of which Kien Giang was a province having largest rice planted land and production in the region. The average rice yield of the MD was 5.94 ton/ha, higher than an average amount of 5.76 ton/ha of the whole country, of which An Giang was the province having highest average rice yield in the region.

2. Rice Cropping Systems

There are three main rice seasons in the MD, that governed by hydrology, rainfall pattern, availability of irrigation and variety of rice-base cropping systems

Table 4. Area, yield and production of rice by province in the Mekong Delta (2014)

Region	Planted area (1000 ha)	Paddy yield (ton/ha)	Production (1000 ton)
Whole country	7813.8	5.76	44975.0
MD	4246.6	5.94	25224.2
Long An	519.2	5.51	2861.1
Tien Giang	230.6	5.94	1370.3
Ben Tre	66.6	4.79	318.9
Tra Vinh	235.8	5.63	1326.9
Vinh Long	180.2	6.03	1086.2
Dong Thap	528.7	6.23	3295.6
An Giang	625.8	6.45	4039.3
Kien Giang	753.6	6.00	4522.5
Can Tho	232.2	5.88	1365.7
Hau Giang	205.3	5.85	1201.7
Soc Trang	363.9	6.23	2265.3
Bac Lieu	178.9	5.79	1036.0
Ca Mau	125.7	4.41	554.7

Source : GSO, 2015.

(Tran and Vo, 2014). Winter-Spring crop (WS or Đông Xuân), starts in November/December and ends in late February-early March. During this time, the weather condition is favorable for rice cultivating: no rain in sowing and harvesting time; many sunshine days and high temperature leading to high rice yield. Thus, the winter-spring crop is the main crop with high and very stable yield. In the 2014 year season, the winter-spring area accounted for 36.8% of the total annual rice growing area and the average yield was 7.16 tons/ha, higher than an average of 5.94 ton/ha of the country (GSO, 2015). Summer-Autumn crop (*SA or* Hè Thu), starts planting from May/June and harvests from August/September. It is the second main crop although it is produced in natural condition less favorable compared with the winter-spring. The rice yield is low and unstable because it must be planted during the period of the low current of the MD (in May/June) and harvested in the rainy season (in August/September). In 2014, the summer-autumn rice area was 53.7% of total annual rice growing area, with the average yield of 5.31

Table 5. Planted rice area, yield and production by crops in the MD (2014)

	Total annual crops	Winter-spring	Summer-Autumn	Lua Mua
Planted area (1000 ha)	**4246.6**	1562.7	2292.9	391
Ratio (%)	100	36.8	54.0	9.2
Rice yield (ton/ha)	**5.94**	7.16	5.31	4.81
Ratio (%)	100	120.5	89.4	81.0
Production (1000 ton)	**25244.2**	11191.7	12170	1882.5
Ratio (%)	100	44.3	48.2	7.5

Source : GSO, 2015.

tons/ha (GSO, 2015). *Lúa Mùa* (somewhere called Autumn-Winter or Thu Đông), starts in August/September and ends in December/January. In this crop, farmers traditionally userain-fed rice crop which using local, traditional varieties with a long growth period and high adaptability to the annual cycle of the flood. In 2014, the area under rainy season crop was 9.2% of total annual rice growing area with the average yield of 4.81 tons/ha (GSO, 2015).

Rice crop patterns: Depending on this crop calendar as well as soil characteristic, rainfall regime and/or capacity of irrigation, the rice cropping scheme is various among sub-regions in the MD. Rice cropping systems in the delta can be the single rice crop, double rice crop and triple rice crop system (figure 5) (Nguyen, 2011). The single rice crop system is invariably in the Lua Mua, which using traditionally rain-fed rice cropping system and local rice varieties with a long growth period, from 110 to 120 days. The single crop is grown in the places where either acid or salinity soil is dominating and southern coastal plain. In season 2010, the acreage of the single crop was about 67,600 ha (3.5% of total planted area of rice). The double cropping system is the dominant rice-cropping scheme in the MD, practiced in the vast area, from the Fresh Water Alluvial, Plain of Reeds, Long Xuyen Quadrangle to Trans-Bassac Depression area. The total acreage of the double crop has reached at 1,120,600 ha in 2010 season year (shared 58.4% of total year). This crop scheme may be winter-spring and summer-autumn in alluvial fresh water regions, or summer-autumn and Lua Mua system in saline regions. The triple crop system combines all three rice seasons (Dong Xuan – He Thu – Lua Mua), practiced in limited riverine areas with favorable hydrological conditions and availability of irrigation for the Dong Xuan crop. The total area of the triple crop in 2010 was 731,100 ha (38.1%). In the MD, beside these three main rice crops, depending on ecological condition, farmers could adjust their crops, such as rice-shrimp, rice-fish, rice-vegetable crops.

3. Rice Varieties

In the past, farmers in the MD almost used traditional varieties rice which has long maturity duration and low yield. However, from the 1960s, modern high-yielding rice varieties (HYVs) were adopted in Vietnam, particularly in the MD. The modern high yielding rice varieties are the short duration (around 90-105 days), high grain yield, and stress tolerance traits varieties, such as CS 98, CS

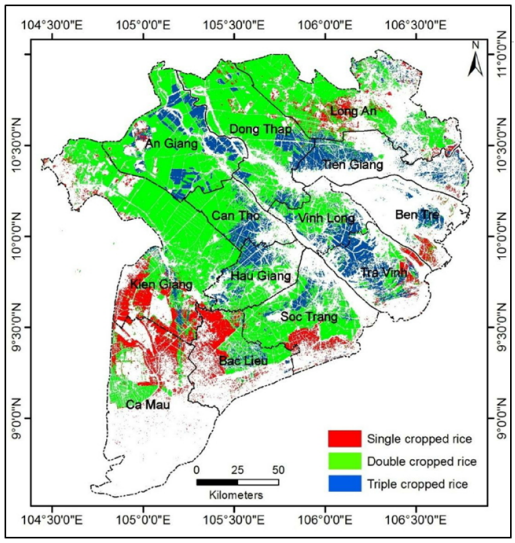

Fig. 5. Rice crop patterns in the Mekong Delta from 2007 to 2011

Source : Nguyen *et al.*, 2015.

97, OM 6162, OMCS 2000, etc. Moreover, HYVs with shorter maturity duration can avoid the early flash flood in the MD. HYVs adoption leads to increased land productivity by increasing rice yield and switching from single crop to double or triple rice crops per year. In the period of 2000-2015, the area under HYV in the MD occupied about 75% of total rice land. However, new variety seeds price is expensive and need more investment for the irrigation system and chemical fertilizer than old types, then the ratio of households using modern varieties is still small. In addition, usage of certified rice seed is still low at 15-25% that effects on rice yield and quality. Farmers mostly get paddy seeds from the own farm from the previous season, sale agents, friends or local market, while the seed bought from universities or research institutes and extension agents accounted for a small number. Therefore, from 2006, the "1 Must Do, 5 Reductions"[6] program was introduced in the MD, that encouraged farmers to use certificated seeds (1 Must Do) as well as reducing seeding rate, fertilizer, pesticide, water use and postharvest losses (5 Reductions).

4. Irrigation, Mechanization and Labor Use

Irrigation is the most important factor in rice production. The existing irrigation in the MD operates as irrigation and transport purpose. A new system of canals and dikes serve both to supply irrigation water and to control flood water. The main irrigation system has been improved by the government with networks of natural rivers, main canals, and inner canals, while the cost for a task of bringing water to the fields such as tertiary canal system and dikes surrounding the fields was contributed by farmers. Nowadays, almost farmers in the delta use machines for irrigation process.

Fig. 6. Drying paddy on the road (in Dong Thap)

Mechanization in rice production: Until 1989, Vietnam started mechanization in agricultural production, speedily developed in the MD. However, the mechanization level in the MD in current is still at low extent. In the detail, until 2014, machinery usage rate for land preparing were 90%, 20% for seeding, 65% for harvesting and 40% for drying. The mechanization level in harvesting has been improved with 12.455 tractors, including 8.919 combine harvesters and 3.536 reapers but reached only 65% of rice area in the whole delta. Mechanization level in drying processing is the weakest stage, reaching for nearly 40% of demand; the remaining number of 60% household dried paddy traditionally under the natural sun heat ray on the field or road. Due to the poor of machine and technology, paddy losses during and after harvest is still high both in quality and quantity. The loss ratio accounted for 13.7% of output, mostly occurred during the drying process, with the highest rate of 4.2% total production.

Labor use: The insufficient of labor for rice production still is a problem in the MD, especially shortage of hired labor in harvesting time. The labor shortage during peak harvest time raises the wage rate and the cost of rice production. Moreover, recently many young labors in rural migrate to cities and towns or industrial areas for getting jobs, education and a higher standard of living further hampering the farm labor situation in the rural areas. The total labor used for one ha of rice per season ranged from 51-62 man-days. Family labor accounts for 61% of the total labor input in the MD, as compared to 50% for Thailand, 30% for the Philippines and 13% for Indonesia (Nguyen, 2010).

5. Fertilizer and Pesticide Application

Most farmers in the MD do not use manure for rice

cultivation because the small scale livestock production could not supply mass amount of manure for farming. Chemical fertilizer and pesticide application for rice production in Vietnam were widespread from 1976. The rate of chemical fertilizer application in rice production more rapidly increased with the expansion of high-yield rice varieties in the MD from 1995. However, from recent years, with the implementation of sustainable development programs, such as "3 Reductions, 3 Gains"[7], "1 Must Do, 5 Reductions"[8], "No early spray" and IPM (Integrated Pest Management), fertilizer and pesticide use rate declined by 13-33% compared to the past. In term of fertilizer application, thanks to the use of leaf color charts for to determine suitable application timing point, farmers save from 20 to 40 kg of nitrogen per ha. For pesticide usage, the farmers reduced pesticide application and change spray time per crop (Fabrice and Cluadia, 2012).

6. Rice Market

The MD supplies more than 50% of rice production and nearly 90% of rice export of the whole country. The data implies that the rice production in the delta is highly commercialized. Rice marketing system in the MD is a complicated process of interaction among numerous market agents involved in various channels. The structure of rice market system in the MD includes eight factors: farmers, paddy trading brokers, traders and collectors, milling and polishing plants, rice trading brokers, domestic distributors and retails, exporters and government. Rice is purchased through a complicated process of interaction among numerous factors from farm gate to abroad. In the detail, farmers produce rice and sold 93.1% of their paddy for collectors and/or traders, often through brokers with rate fee of 20 VND/kg. Traders sold paddy for milling plants (30.3%), or milled to brown rice and sold for companies (47.8%) and sold for polishing plants (10.7%), sold white rice for wholesales/retails (15%). Farmers sold directly rice for companies with a small amount of 4.2% and for milling plants at 2.7% (Vo and Nguyen, 2011). In general, farmers often sell their rice for traders without any contract before. In another way, farmers make a contract with traders at a fixed price, and borrow money or buy seed, fertilizer, and pesticide from traders, then sell all rice for them at harvesting time. Most of the farmers are not satisfied due to low and unstable prices because the prices are usually squeezed by traders.

Moreover, due to the lack of information and inaccurate prediction rice price in the world market, Vietnamese rice price is lower than other countries as the same rice types (see Fig. 7).

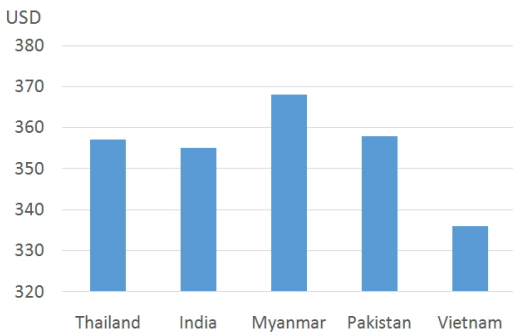

Fig. 7. The Price of 5% broken rice

Source : Vietnam Food Association.

IV. Emergent Issues and Policy Recommendation in the Rice Production in the Mekong Delta

Recent past decades, besides achievements, rice production in the MD is still facing with various problems that have been constraining sustainable development. These problems could be discussed as follow:

Climate change: The MD of Vietnam is considered as one of the regions will be the most seriously affected by climate change, particularly sea level rising due to global warming. Moreover, paddy land would be continuously decreased due to the shifting of agricultural land to non-agricultural purpose, consequently leading to decrease rice productivity. Besides that, many risks

from nature such as flooding, drought, soil acidification and salinization annually effect on rice production.

High and fluctuating input prices: Fertilizer and pesticide for rice production in Vietnam still depend on import resources while the prices of these agricultural chemical products are high and fluctuating. In response, the Vietnamese government attempts to protect farmers from these rising costs by using a system of directed paddy prices. However, this price system has been ineffectual because most of the companies buy mainly from collectors not directly from farmers, thus companies have no way to ensure that farmers are paid the directed price.

The lack of harvesting machines is a difficult issue that affects improving rice quality as well as reducing loss rate in rice production in the MD. At present, the mechanization rate in rice production is still low, especially in harvesting stage. Though the MD is the leader in application mechanical and technological achievement in agricultural production, the ratio of using new types of the machine such as cutting machine, combine harvesting machine as still small. The implementation of machine in rice production in the MD is difficult due to such a small size farm, low standard condition of rice field as well as its expensive purchase.

Another problem is capital shortages, due to limited credit sources, the small amount of loans and complicated accessing process. The main source of credit comes from government banks with lower interest rate comparing to other sources. However, the access to government bank loans is more difficult than to informal sources with high-interest rates.

Shortage of labor is a problem in rice production, especially at transplanting and harvesting period. Lack of labor and high labor wage during peak season raises rice production cost in the delta.

The poor of grading, storage, and processing facilities affects the rice quality and quantity. The lack of storage is another problem for rice production in the MD. In 2014, the delta produces about 25 million tons of paddy a year, but its storage systems have only a total capacity of about 2 million tons, accounting for 8% of the total demand. Due to the shortage of standard store, farmers usually sell rice immediately after preliminary drying with regardless of rice price high or low. If the market price is low, some of the farmers temporarily store rice in jute bags, pile them in the house and cover them with canvas to protect them from the rain and frogs from some weeks to several months at worst. This simple method of storage reduces the quality of rice and causes economic losses.

Quality and price of Vietnam rice are still low comparing to other markets. Due to the lack of certified paddy seed and its high price, farmers mostly use old rice varieties which have low quality and yield. Eventhough Vietnam is now exporting an increased proportion of high-quality rice, it still cannot command price equal to Thai rice, due to poorer taste and weaker branding. Much of the quality issue resulted from weaknesses in port-harvest processing, particularly limited industrial drying capacity.

In order to overcome these constraints and difficulties in rice production of the MD, the research suggest the following policy implications:

Firstly, policies should promote on the management of agriculture land, especially land for rice cultivation. Secondly, policies should concern on increasing investment for infrastructure development in the MD, especially in improving irrigation system, storage facilities and mechanization on all stages of rice production process. Thirdly, the government should invest more to develop new rice varieties with high yield, good quality, adapting to climate change, technical post-harvesting, etc. Government should encourage private enterprises to invest in high-quality rice for both domestic and export markets. Moreover, in order to maintain and develop rice production in the MD, policies should be taken by the concerned authorities for rice farmers, for example, support for rice producers in advantages regions, or insurance policy for food production farmers, etc.

V. Conclusion

The findings of this research illustrated various aspects of rice production in the MD, Vietnam.

In term of history, it is estimated that rice production is a significant agricultural economic sector in Vietnam, especially in the MD. Therefore, during a long history of the country, Vietnamese Government has been trying to exploit natural and social potentialities in order to develop rice production. Particularly, thanks to the successful of Doi Moi policy in 1986, rice production has dramatically increased in rice area, yield and production. Thus, since 1987, Vietnam has become one of the largest rice exporters in the world with rice export volume reached at 6.5 million tons in 2014, of which, 90% is from the MD.

The MD is the largest rice granary of Vietnam from history to present depending on its favorable natural and economic-social features for rice production. This research describes both of advantageous and disadvantageous sides of these features as significant factors impacting on rice production in the MD.

In addition, this research analyses present situation of rice production in term of rice area, yield and output, harvest and post-harvest conditions, rice marketing and export status. According to its result, rice production in the MD has been increasing continuously in planted rice area, yield, and production. However, it still faces various constraints, such as low in quality, low and fluctuating rice price, lack of machines, poor technology, shortage of labor force in peak time, insufficient of credit source, etc.

In the future, these constraints will be more serious due to the climate changing and stronger competition from other rice production countries. The improvement of rice production in the MD should be concentrated to minimize disadvantages of natural features as well as solve remaining issues for sustainable development. Further efforts in research and extension are needed to raise the importance of Vietnamese rice in the world rice market.

Notes

1) "Contract 100" or known as Directive 100, was issued on January 13, 1981 which allowed collectives to make contract with individual households to produce a given amount on their own plots, but surpluses could be sold on the partially liberalize markets.
2) "Doi Moi" was the policy which aimed to increase economic growth and development by liberating the economy and shifting from planned economy system to a market driven one.
3) "Contract 10" or known as Resolution 10 was issued in 1988 which called for the allocation of collective land to farm households, giving them responsibility for production decisions.
4) Cochin China is the name that French colony administration (1862-1954) called for the region of the current southern of Vietnam (Son, 1997).
5) Viet Minh is abbreviated from Viet Nam Độc Lập Đồng Minh Hội (in English "League for the Independence of Vietnam), was a national independence coalition formed at Pac Po on May 19, 1941.
6) "1 Must Do, 5 Reductions" was a program that encouraged farmers to use certificated seeds (1 Must Do) as well as reducing seeding rate, fertilizer, pesticide, water use and postharvest losses (5 Reductions).
7) "3 Reductions, 3 Gains" was a campaign which focused on reducing production costs through decreasing use of seeds, fertilizer and pesticides but still achieve high rice yield, quality and profits.
8) "1 Must Do, 5 Reductions" was a progarm which encouraged farmers to use certificated seeds (1 Must Do) as well as reducing seeding rate, fertilizer, pesticide, water use and postharvest losses (5 Reductions).

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