CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Department of Economic Development

MASTER THESIS

RICE PRODUCTION SYSTEM IN THE MEKONG DELTA, VIETNAM:

SITUATION AND ADAPTATION OF FARMS TO CLIMATE CHANGE

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DECLARATION

I declare that I have written my diploma thesis "Rice production system in the Mekong Delta, Vietnam: situation and adaptation of farms to Climate Change" on my own with the help of literature listed in References.

Prague, 20th April, 2013

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Huynh Nguyen Vu Lam

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Abstract

Rice is one the most important cereals which is planted and consumed around the world. It is reported that 90% of world's rice production is in the Asia and in which Vietnam is one of the top five world rice exporters. During the last three decades, Vietnam government has issued appropriate policies which help rocketing the rice production of the country and becoming a well-known rice exporter country. The Mekong Delta which is known as a granary of the country contributes significantly to the total rice production with more than 70% of the production. However, the last three decades is also known with many natural disasters throughout the world due to climate change or global warming phenomenon. As reported by the Asia Development Bank, the Southeast Asia region is one of the world's most vulnerable to the climate change. Many studies also make projection of the scenarios of climate change in the future and adaptation is required for the food security in 2030. However, there is limited information about how rice production farmers adapt their plantation to the climate change, especially in Vietnam. Therefore, the study aims are to study on how farmers in three agro-eco (floating, irrigation and coastal-saline) areas of the Mekong Delta, Vietnam adapt their production and their perspective to climate change during the last ten years, compare economic efficiency of rice production at household level and understand the practice of rice production system. Data was collected by interviewing with the tool of questionnaire and information from local government. The descriptive method was applied to carry out the results together with the use of ANOVA testing. The results showed that farmers' rice production is commercialized and oriented by the market; and rice production system has changes to adapt with climate change. Rice yield has the increasing trend about 2 tons/ha in the last ten years by applying the improved practices as changing in water management, reducing of fertilizer and chemicals, reducing seed rate, and changing season calendar. The results also indicate that there is significant difference in economic efficiency between the areas. However, it could not be generalized for the whole region because the most important difference is the fluctuation in price of paddy which is manipulated by local traders. Across the study areas, many impacts of climate change are reported by respondents. Among the impacts, there are high percentage of responses for the increasing frequency of drought, saline intrusion and appearance of pest and diseases. Confronting the issue, respondents prefer to

apply new practices such as adjusting cropping calendar, reducing fertilizer, saving water, etc. and use improved rice varieties which is highly adapted to the local conditions.

Participatory technology development (PTD) and participatory plant breeding (PPB) are important approaches and suggested to improve household income and lead green sustainable agriculture by greenhouse gas emission reduction for rice production in the Mekong Delta.

Keywords: rice production, Mekong Delta, Vietnam, climate change, food security, farming systems

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List of Abbreviations

ADB : Asian Development Bank

FAO : Food and Agriculture Organization

FAOSTAT : Food and Agriculture Organization statistical database

GSO : General Statistical Office of Vietnam

IPCC : Intergovernmental Panel on Climate Change

IPM : Integrated Pest Management

IRRI : International Rice Research Institute

MARD : Ministry of Agriculture and Rural Development

MD : Mekong Delta

PPB : Participatory Plant Breeding

PTD : Participatory Technology Development

UNFCC : United Nations Framework Convention on Climate Change

USD : United Stated Dollar

WB : World Bank

WHO : World Health Organization

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1. INTRODUCTION

Food security is a situation "when all people at all times have access to sufficient, safe, nutritious food to maintain healthy and active life" (WHO, 01/2012). It is one of the most essential needs of human being and the need is increasing steadily due to the population explosion. Therefore, food security is usually one of the targets of the national development plans. According to a report of FAO in the World summit of food security in 2009, the prevalent chronic hunger is receded in most of countries but hunger will not disappear. However, the number of undernourished and malnourished people is rising. As estimated by FAO, there are more than one billion chronically undernourished people in 2009 in comparison to around 840 million in the 1990s. In addition, Asian and Africa are the continents suffering badly from this situation. There are many causes contributing to the food insecurity (Polly, 2009). Among the causes, adapting to global environmental change is an important issue which directly affects to food security in both quality produced and quantity.

Although the world has experienced improvement in economic and human development significantly with the decreasing of population living under US$1.25 a day (World Bank, 2005), food security for the world population is still a big problem for countries, especially developing countries where there are livings of more than 75% of world population but food production is almost 50% of the total world production. The evidence for this is that there are about 800 million of people in developing countries and 41 million of people in industrial countries and countries in transition suffering from chronic hunger (FAO, 2002 and Droogers, 2003). If the world's population keeps increasing as a prediction of Food and Agriculture Organization, there will be nine billion people in the year 2050 (FAO, 2009). This situation would make food security more problematic because farmers have to produce more food with fewer resources (Schneider et al., 2009). By existing problem and potential threats, food security is one of the most important concerns nowadays.

For food, rice is one of the most important cereals which is largely consumed by the population on the world accounting for more than 10% of the total world cropland area and

provides food for almost 50% of world's population. South-East Asia produces more than 90% of world rice production (Maclean et al., 2002).

Vietnam is the world leading rice producer and together with Thailand is the top two rice world exporters as well. Mekong Delta, which is known as granary of Vietnam, contributes largely to the total rice production of the country, as between 80% and 85% of exported rice come from this area (Nguyen et al., 2004). However, inappropriate agricultural practices together with climate dynamics, negatively affects the rice production in Mekong delta particularly through decreasing land quality, degradation/pollution of water resources and increasing pests and unusual droughts. For instance, the increasing water level during flood season reduces to the quality of rice production land and increases acid sulfate land (Hoanh el al., 2003). Meanwhile, coastal areas are influenced by higher seawater level, which also reduces land quality and increases the area of saline land.

In other to cope with the issues, there are agricultural extension programs introduced and transferred the improved practices to farmers in order to support them in rice production. The '3 reductions - 3 gains' and "1 must – 5 reductions" are the examples of extension programs which reduce inputs (amount of seeds, fertilizer, pesticide, water supply and loss of post-harvest) in order to improve outputs (yield, rice quality and economic efficiency). In addition, participatory rice-breeding program is introduced and trained so that farmers can cross and select new rice varieties adapting to local condition and high yields, to improve water management or to utilize organic fertilizers (Lang el at. 2006; Tin et al., 2008).

Thus, this paper is to analyze the changes in overall rice production in Mekong Delta as well as the efficiency and sustainability.

2. LITERATURE REVIEW

2.1 Rice production in Vietnam

Vietnam, an S-shaped country, is one of the Southeast Asian countries located on the latitude and longitude of $16^0$0' N and $106^0$0' E. In Vietnam, rice plays an important role in national food security. According to Hai (2010), rice production is an important source of income for the rural population of around 60 million. During the 1990s, the country is known as the second largest world rice exporter with the significant rise in volume of rice export.

The rice production of the country had experienced and overcome many difficulties to achieve the current successes, especially right after the unification of the country in 1975. During the 1970s until the mid 1980s, the country experienced a stagnation in rice yield and total production (Khiem et al., 2002) which made the problem of food security becoming worse. To cope with the problem, the country imported rice from foreign countries with the annual average of 200,000 tons and reached the peak of 400,000 tons in 1986 (Table 1). Realizing the emerging problem, the central government issued and implemented many innovation interventions in all sector, which were known as the "Doi moi" (economic reform policies) starting in the year 1986. With the timely and appropriate interventions, the rice production of Vietnam has been recovered and rocketed in productivity becoming self-sufficiency in 1989.

Table 1: Vietnam rice production and availability, 1976 – 2010

Year	Total production	Population	Rice imports	Rice exports
	1000 mt	Million	1000 mt	1000 mt
1976	11,827	49.2	148	0
1980	11,647	53.7	210	33
1986	16,003	61.1	482	125
1990	19,225	66.2	20	1,624
1995	n/a	71.9	11	1,988

2000	32,529	77.6	n/a	3,476
2005	35,832	82.3	340	5,250
2010	40,005	86.9	983	6,886

Source: General Statistic Office (GSO), Hanoi, and FAO FAOSTAT and Khiem et al. 2002.

Note: n/a = not available

Since the land reform policy "Doi moi", the farmers and private sector were given more incentives in developing their production. More projects on improving irrigation system were implemented and thanks to these projects the rice areas were increased in the whole country (from 6 million ha in 1990 to 7.4 million ha in 2010, General Statistic Office) which directly supported the improvement in rice productivity. In addition, the increasing in rice yield was also effected by other factors such as using high yielding rice varieties, increasing fertilizer application, intensive cropping, etc. In general, these factors had significantly boosted the rice yield of Vietnam and contributed largely to rice exportation making the country the second largest world rice exporter.

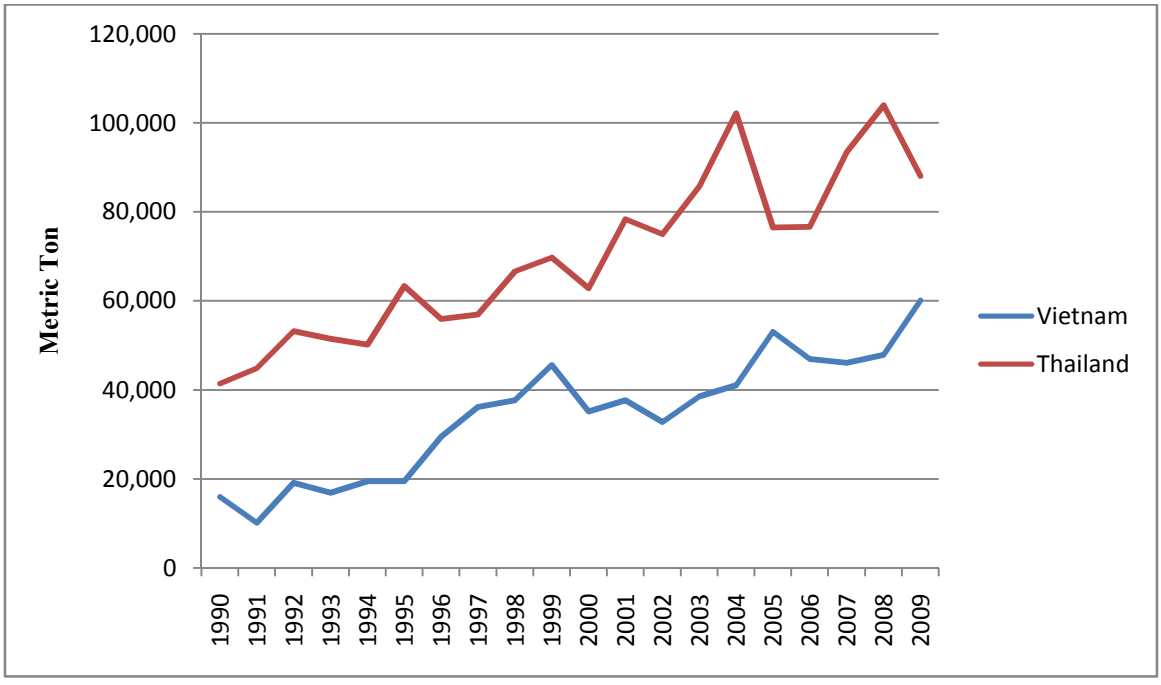

Figure 1: Vietnam rice export

Source: FAO STAT

After the introduction of high yielding rice varieties in to production and improvement of practices and irrigation system, rice production could be carried out in three cropping periods but it is varied among regions. In Vietnam, there are seven different agro-ecological zones in which the Red River Delta in the north and Mekong River Delta in the south are the most important rice production regions.

Table 2: Rice productivity of different agro-ecological zones of Vietnam

Agro – ecological zones	**Annual rice areas**		**Annual rice productivity**		**Average rice yield**	
	2000	2010	2000	2010	2000	2010
	1000 ha		1000 mt		Mt/ha	
Red River Delta	1,261.0	1,150.1	6,762.6	6,805.4	5.36	5.92
Northern Mountainous	638.7	666.4	2,292.6	3,087.8	3.59	4.63
North & South Central Coast	1,244.6	1,214.1	4,972.8	6,152.0	4.0	5.07
Western Highland	176.8	217.8	586.8	1,042.1	3.32	4.78
Southeastern zone	399.4	295.1	1,212.0	1,322.7	3.03	4.48
Mekong Delta	3,945.8	3,945.9	16,702.7	21,595.6	4.23	5.47
Whole country	7,666.3	7,489.4	32,529.5	40,005.6	4.24	5.34

Source: Vietnam General Statistic Office (GSO), 2010.

2.2 Rice production in the Mekong Delta

The Mekong Delta (MD) is one of the two biggest deltas in Vietnam. The delta is located in the southern of Vietnam with the total area is about 40,548 km^2 (GSO, 2011). Although it is formed about 10,000 years ago, the delta has been exploited from 300 years ago (Xuan V. T. et al, 1998). The pioneer farmers started rice production as the main agricultural activity and it had been developing until now from mono-cropping to intensive cropping. The characteristics of the region are alluvial flat land and monsoon climate. These characteristics of the region, in fact, are the best conditions for agricultural production, especially rice production. Therefore,

the delta is also known as the Granary of Vietnam which plays a very important role in the rice export of Vietnam making the country the second largest rice exporter of the world after Thailand. As record from the General Statistical Office of Vietnam, in the year 2011, the rice production area of the region was about 4 million hectare for the whole year with the total production was more than 23 million tons, more than 50% of the total production of the country.

There is a long history of rice production in the Mekong Delta starting since the early time of the exploration. The production had developed from one rice crop (growth period 180 to 210 days with the yield of 1 ton/ha/year) to two or three short duration crops (90 to 100 days) with the yield of 8 to 10 tons/ha/year (Xuan V. T. et al., 1998). Although it is characterized as small-scale rice-based farming with the average landholding of 1.0 to 1.1 ha (De N. N., 2006 and Xuan V. T., 1998), the region has the largest rice production area accounting for more than 50% of the total rice production area of the country. Among the thirteen provinces of the region, An Giang province has the largest rice production area with more than 600 thousand hectares (GSO, 2011).

With the total area around 4 million ha, the delta can be divided into seven agro-ecological zones. The first zone is the fresh water alluvial which covers an area of 900,000 ha. This is the most favorable area for intensive and productive agricultural production. The second zone is the Plain of Reeds covering an area of 500,000 ha and locating in the two provinces of Dong Thap and Long An. This is also the lowest zone in the Mekong Delta with the land elevation of 0.5 m below MSL and is characterized by acid sulfate soils. With the improvement of irrigation and drainage system in the 1990s, the area can apply double rice cropping with improved rice varieties replacing floating rice. The third zone which is named the Long Xuyen Quadrangle covers an area of about 400,000 ha of An Giang and Kien Giang province. Although the region is dominated by acid sulfate soils, rice plantation is carried out with 2 or 3 rice crops per year thanks to the improvement of irrigation system. Aside from rice, *Melaleuca*, cashew, pineapple, etc. are also grown in this region, similar to the Plain of Reeds. The fourth zone is the minor hill and mountainous area which cover less than 200,000 ha on

the border of An Giang and Kien Giang province with Cambodia. This area is characterized rain-fed and small scale farming of upland rice and crops. The main agricultural problems of the area are drought and soil erosion. The fifth zone is known as the Trans-Bassac Depression with the area of about 600,000 ha. The area is very favorable for most of the fruit trees and food crops in the Mekong Delta. The sixth zone is the Ca Mau Peninsula. This zone covers the largest area among the seven zones with about 800,000 ha. With the affect of seasonal and permanent saline-effected soils, the area is rich of mangrove and various rain-fed rice-based farming systems. The final agro-ecological zone of the Mekong Delta is the coastal zone. It covers about 600,000 ha along the coastal line from Ho Chi Minh City to Bac Lieu province and the characteristic is rain-fed saline. Thus, agricultural production relies much on rainwater. On the last two decades, rice production in some part of the area has been improved because of the development of irrigation system. Besides, rice-shrimp farming system is also an outstanding characteristic of this area.

In term of practice, there are three main cropping seasons in the Mekong Delta namely Dong-Xuan (Winter-Spring), He-Thu (Summer-Autumn) and Thu-Dong (Autumn-Winter). Depending on the local conditions, the number of rice crop varies among different zones. Although there are differences and various systems, the major farming systems in the Mekong Delta are double rice cropping for partly irrigated area and triple rice cropping for the areas locating along the main two rivers namely Tien and Hau with good irrigation system and flood control (De et al, 2006). Because of the favorable weather condition, winter – spring has the highest yield among the three cropping seasons and that makes the profit of this season always higher than others (Hai et al, 2012). Asides from the major systems, various farming practices come with different conditions such as two rice crops and one upland crop (maize, sweat potato, soybean or vegetable) or integrated rice crops and aquaculture (fish or shrimp) (De et al, 2006). In the Mekong Delta, farmers tend to use more inputs (fertilizer, seed and pesticide) with the perception of high inputs bringing high yields (Huan et al, 2004). It is reported by Xuan et al, 2004 about the increasing of fertilizer application from 40 kg/ha (1976 – 1981) to 120 kg/ha (1987 – 1988) and 140 kg/ha in 1992. In addition, Khiem et al 2002 calculated the average fertilizer for spring crop as 165 kg of urea, 91 kg of NPK and 112 kg of other fertilizer in 1996.

2.3 Climate change

The climate change is not a new concept; it has been researched and reported in every region of the world. There are different definitions of the climate change from various international organizations. For instance, the Intergovernmental Panel on Climate Change (IPCC) defines the issue as the changes of climate which can be measured in an extended period (decades or longer). Differently, the United Nations Framework Convention on Climate Change (UNFCCC) considers climate change as changes attributed directly or indirectly to human activity altering to the global atmosphere and could be observed in a comparable period of time. In other word, climate change is the changes in the state of climate which are directly or indirectly related to the human activities and can be measured.

Along with the development of the societies, the global climate has been changed gradually. For instance, the temperature of the earth surface increases from 0.76^{o}C over the last 150 years (IPCC, 2007). However, the situation has been changing and it is widely believed that human activities are the major cause in increasing the greenhouse gas (GHG) emission which is the main factor worsening the climate change issue. The GHG includes many kinds of gas such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and halocarbons in which carbon dioxide is the most important (IPCC, 2007). In general, almost all sectors of the global economy contribute to the increasing of GHG and it is reported with the increasing of 80% of CO_2 emission since 1970 till 2004 (IPCC, 2007).

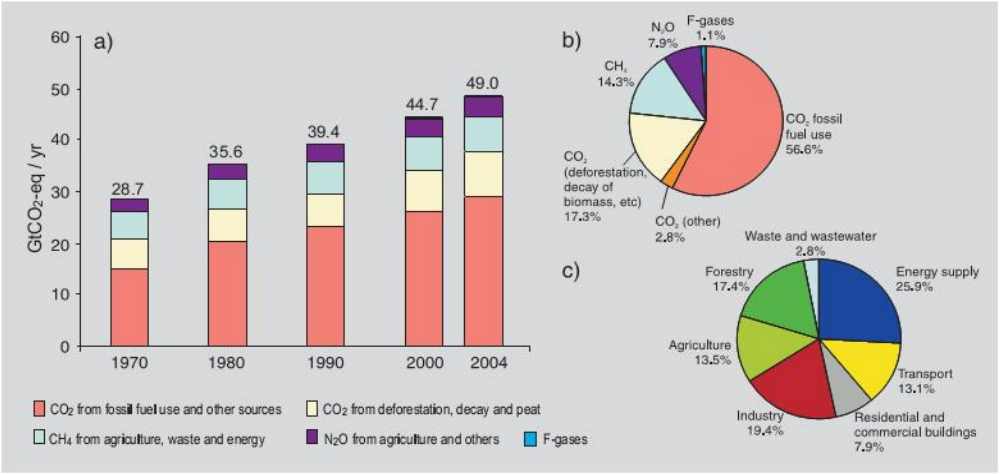

Figure 2: Global anthropogenic GHG emission

a) Annual global anthropogenic GHG emission from 1970 to 2004

b) Share of different anthropogenic GHG in total emission in 2004

c) Share of different sectors in total anthropogenic GHG emission in 2004

Source: Climate change 2007: Synthesis report, IPCC.

With the continuous increasing of GHG emission, the effects of the climate change are getting more serious. It is reported by IPCC that the temperature of the period from 1996 to 2006 is ranked as the warmest years of global surface since 1850. The increasing of global temperature is the start of other climate change related issues. Research from IPCC found that there is a correlation between the warming and sea water level rising. The average rate of rising is recorded at 1.8 mm per year for the period 1961 to 1993 and 3.1 mm per year from 1993 to 2003. Other climate change related issue is the changing of extreme weather events both in frequency and intensity such as increasing heavy precipitation events, more frequent of hot days and hot nights and heat waves, etc (IPCC, 2007). From the research data, the IPCC also carries out projection of future global climate change. The IPCC Special Report on Emissions Scenarios (SRES) forecasted the changes of global temperature and sea level rise with 6 different scenarios for the near future. The result shows different trend of future climate change in which the worst scenario is the increasing of temperature and sea level up to 4.0^{o}C and 0.26 – 0.59 m respectively in the year 2100. If no action is taken, then the impacts will be enormous. In the projected scenarios, climate change will affect all regions and many sectors. For instance, 20 to 30% of plant and animal species will face the risk of extinction; crop productivity will fluctuate and increase the risk of hunger; and millions more of people is

projected to experience yearly floods and affected by extreme events, scarcity of water, increasing tendency of drought, etc (IPCC, 2007).

2.4 Climate change and impacts in Vietnam

Locating in the Southeast Asia, Vietnam is on the region which is considered as one of the world's most vulnerable to the climate change (ADB, 2009). Sharing the same situation, Vietnam is also experiencing the effects of climate change as other regions on the world. It is reported that the annual average temperature of the country increased 0.1^{o}C per decade for the period 1900 to 2000 and 0.7^{o}C from 1951 to 2000 (ADB, 2009). In other study, Hoang and Tran (2006) estimated that the temperature of the country will increase 1.4 – 1.5^{o}C by 2050 and 2.5 – 2.8^{o}C by 2100. Rainfall is also changed throughout the country. The monthly rainfall decreased in July and August and increased in September, October and November (MoNRE, 2003). Besides, projection of World Bank estimated changing in rainfall will lead to the result that the dry seasons will be drier, the wet seasons will be wetter and rainfall will be more concentration leading to an increase in frequency, intensity and duration of floods (World Bank, 2012 and Nguyen et al., 2006). These changes will possibly lead to the increase of damage from floods and drought due to the variation of rainfall and increased evaporation (MoNRE, 2003). Ranked as one of the ten countries most vulnerable to tropical cyclones (UNDP, 2003), the country is expected to experience more frequent extreme events in the future. The study of World Bank (2008) showed that Vietnam was ranked among the top 5 most impacted countries from the 1 meter of sea level rise and the projected rise were 30 cm by 2050 and 75 cm by 2100 under the medium scenario. The study projected that the raise of 1 meter of sea level would affect 10% of Vietnam's GDP and cause the loss of 28% of wetlands and 7% of agricultural land. Among the regions, the Mekong Delta will be the most affected area by sea level rise. With the rise of sea level of 30 centimeters, the region would be affected by salinity intrusion up to 10 kilometers inland (Ratsakulthai et al., 2002). World Bank (2010) estimated that 590,000 hectares of rice area which accounts for about 13% of today's rice production would be lost because of inundation and saline intrusion. Furthermore, Peng (2004) from the International Rice Research Institute found that with the increase of every 1^{o}C rice yield will decrease by 10% and other study from Thailand also reported the same situation.

Thus, these issues will definitely pose serious threats to farmers and agricultural exports as well as national food security.

2.5 Responses and adaptations to climate change in Vietnam

Realizing the situation and likely results, the Vietnam government has taken actions to mitigate the future damage. In order to increase physical protection, thousands of kilometers of river and sea dykes have been maintained and constructed. Besides, mangrove plantation is also used as an effective form for coastal protection in Vietnam (Chaudhry and Ruysschaert, 2007). In addition, system of disaster forecasting and preparedness is considered one of the key to responses to climate change by Vietnam government. With the long support from the UNDP, the system of weather forecasting and broadcasting especially typhoon warning is improved and provided 48 hours through media and loudspeaker for the coastal areas. However, the system is still needed improvement in the future.

In 2012, the Vietnam government promulgated a Decision number 1183 - National program for adaptation to climate change period of 2012 - 2015. The main objectives of the program are building of monitoring and forecasting of impacts from climate change, diffusion of information among communities, carrying out demonstration of climate change adaptation, research and issuing policies to reduce GHG emission. Besides, responses to climate change in agriculture especially rice production are also introduced in Vietnam. In the report of UNFCCC (2007), many adaptation options in several sectors were introduced for developing countries. In agriculture sector, the suggested options are dam construction for irrigation, changing in fertilizer application, using of new crops, changing of planting and harvesting times, changing to different cultivars. In other study, World Bank (2010) found out the adaptation applied by farmers. Firstly, switching to drought tolerant crops was applied by the farmers in the Central Coast region. During the period of 1995 – 2008, the rice areas declined by 100,000 hectares but the area of drought tolerant crops such as cassava and maize increased twice in the same period. Secondly, farmers in some places in the Red River Delta applied technique of reinvigorating and rehabilitating local varieties which is highly tolerant and

adapted to the local conditions. Thirdly, rice-fish rotation is introduced and applied by farmers in some places of Mekong Delta to take the advantage of flood season. In addition, there are more techniques introduced for the adaptation of rice production. In term of water management, water saving and alternative drying and wetting (AWD) technique are introduced to for the plantation with limited water using but ensuring rice yield. Using of different rice varieties is another way to adapt the local condition changes by farmers in the Mekong Delta. The most referred rice varietal traits by farmers are high yielding, adaptability to local condition, short growth duration, resistance to pests, etc (Cuc et al, 2008).

3. OBJECTIVES

Climate change has been a global issue which is seriously concerned not only the developed countries but also the developing world. As reported in literature review, many scientific reports and papers have been carried out to evaluate the impacts of the climate change issue to sectors in different regions. Besides, future projections are also conducted to show an overview of the global climate in the near future so that the countries could prepare alternatives and implement necessary actions. In all regions, the Southeast Asia is one of the most vulnerable areas to the issue and this region contributes significantly to the world food security especially rice. With the forecast of increasing global temperature and sea level rising, the Southeast Asia will definitely face great impacts in many aspects and sectors especially agriculture.

Locating in a vulnerable region, the government of Vietnam also carried out many national reports to know the situation and project possible climate change scenarios for the country. Among all the ecological zones, the Mekong Delta is one of the most sensitive areas to the changes in future along with the coastal area. In addition, impacts to the Mekong Delta will directly effect to the rice production not only of the region but also of the whole country. Therefore the research is aimed at the differences in the rice production practices and farm characteristics in the three different agro-eco areas in relation to their economic performance and how farms in these areas (floating, irrigation and coastal-saline) have adapted their rice production to climate change during the last ten years. Firstly, the study will learn on the current situation in rice production of farmers in three particular agro-ecological areas and compare the economic efficiency between the practices of farmers across the study areas in two main rice production seasons (dry and wet) in order to find out which practice could generate more profit to farmer households. Secondly, the paper also studies on the changes of practice applied by farmers to find out how farmers adapting their production to the climate change during the last decade. Finally, based on the information from respondents, the study could summarize the impacts of climate change that farmers in the study areas are facing and what will they do to cope with the issue in the future.

4. METHODOLOGY

4.1 Study area description

Among the seven agro-ecological zones, three provinces are selected for study namely floating area of An Giang province in the Long Xuyen Quadrangle, basin irrigation area of Hau Giang province in the Trans-Bassac Depression and rainfed-saline area of Tra Vinh province of coastal zone.

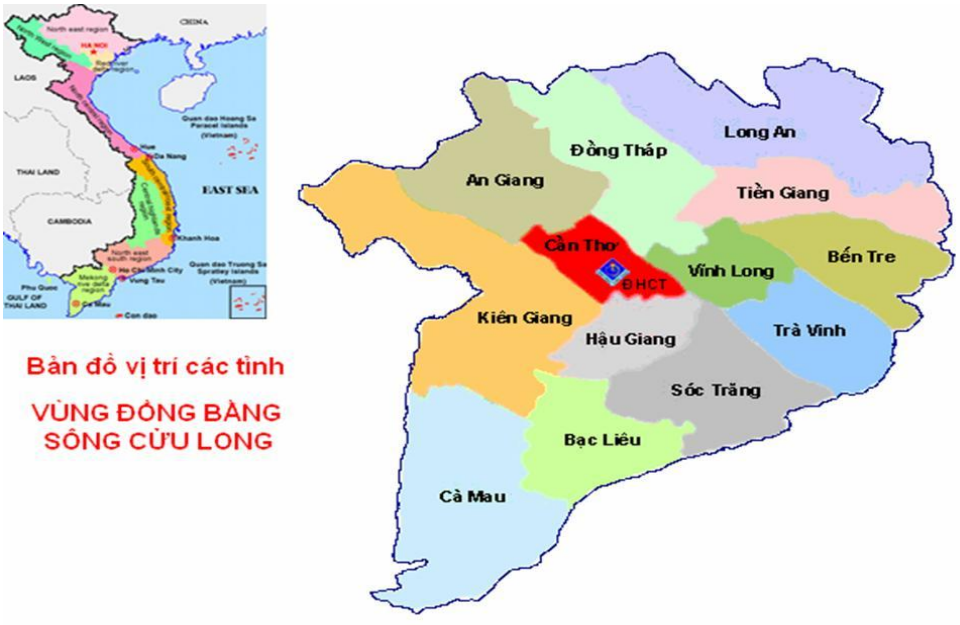

Figure 3: Location of provinces in the study

An Giang province

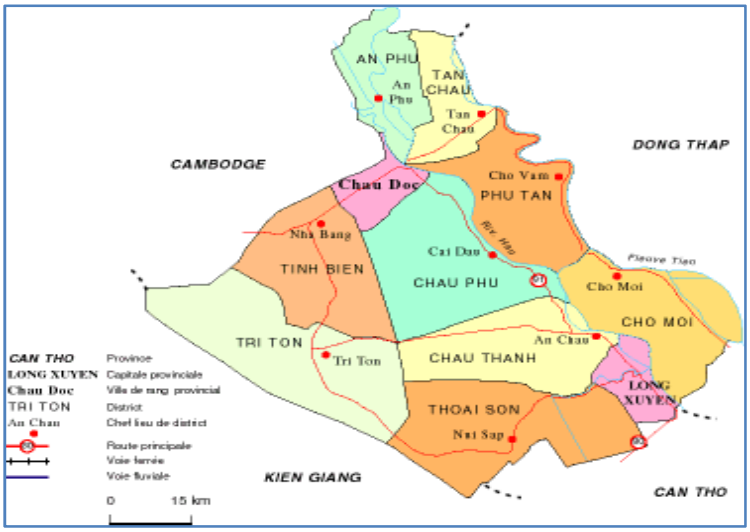

Figure 4: Map of An Giang province

An Giang province is located on the Long Xuyen Quadrangle with the total area of 3,500 square kilometers. Affecting by season flooding, almost half of the total area of the province is characterized as alluvial soil which is suitable for agricultural production especially rice. Taking advantage of soil condition and intensive cropping, An Giang is one of the two provinces having the largest rice area. In 2010, the annual rice area of An Giang was 590,000 hectares and total production was 3,692 metric tons which was the highest among the provinces in the Mekong Delta. In An Giang province, the two selected districts for the study are Thoai Son and Chau Thanh. With the improvement of canal network, rice production is the main agricultural activity of both districts although the area is affected by yearly flooding.

Hau Giang Province

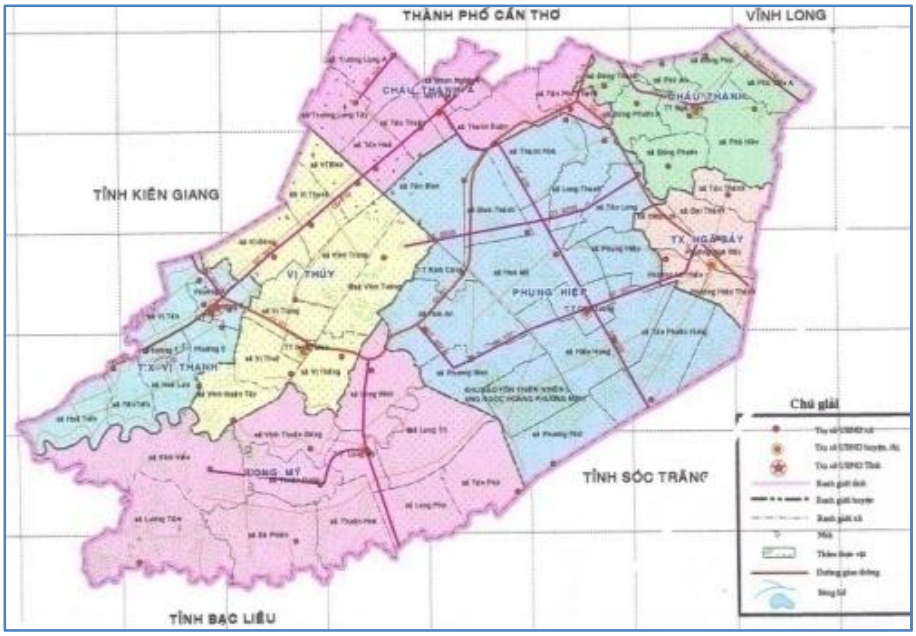

Figure 5: Map of Hau Giang province

Hau Giang province is belonged to the Trans-Bassac Depression agro-ecological zone and was separated from Can Tho province in 2004. The province covers an area of 1,602 square kilometer and has a complicated network of rivers and canals with the total length around 2,300 km. With a good irrigation system and weather, the provincial conditions are suitable for agricultural production. In the province, rice production is one of the most important agricultural activities with the annual rice areas of 210,000 hectares (GSO, 2010) and the annual total production around 100,000 metric tons. The two selected districts are Phung Hiep and Vi Thanh.

Tra Vinh Province

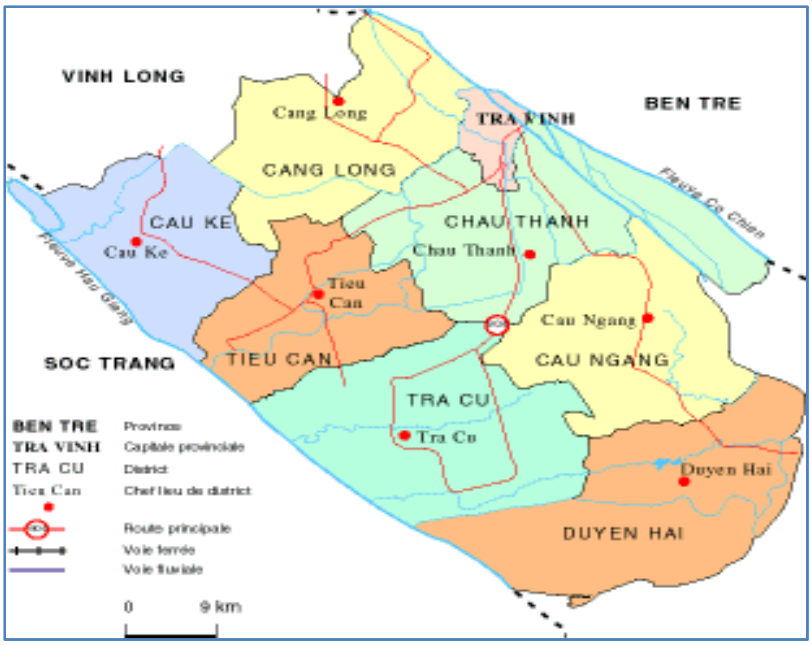

Figure 6: Map of Tra Vinh province

Tra Vinh province is located on the coastal zone of the Mekong Delta with the total area of 2,300 square kilometer. The main agricultural productions of the province are rice production and aquaculture. Although affected by saline intrusion, the rice area of the province is stable with the annual area of 230,000 hectares and total production of 1,156 metric tons (GSO, 2010). Among the seven districts, Tieu Can and Chau Thanh district were selected as the target area of the study. Sharing similar characteristics of local flooding in the wet season and saline intrusion in the dry season, rice production is still a main agricultural activity of both districts.

4.2 Data collection

Among the seven agro-ecological zones, three distinct zones are selected for the study namely floating area of An Giang province in the Long Xuyen Quadrangle, basin irrigation area of Hau Giang province in the Trans-Bassac Depression and rainfed-saline area of Tra Vinh province of coastal zone. At each province, two districts were randomly chosen. With the help of FARES (Strengthening Farmer – Agricultural Research and Extension System Partnership in Vietnam) project and district agricultural offices, 40 respondents were selected at each district. Due to individual works, there are 107 respondents participated in the study. In which, the highest number of respondent is in Hau Giang province with 40 participants, while the number of participants in An Giang and Tra Vinh province are 32 and 35 respectively.

Key informant panel (KIP) method was applied to collect primary data and responses from respondents through individual interview with semi-structured questionnaires during the period from June to August of the year 2013. In addition, secondary data is collect through scientific articles and reports, national and international statistical database such as General Statistical Office (GSO) and Food and Agriculture Organization (FAO).

4.3 Data analysis

The descriptive method of research was applied in this study. The data was coded and analyzed by Microsoft Office Excel 2007 software and SPSS program version 13.0. Profit/Cost ratio is calculated to compare the economic efficiency of rice production between the 3 agro-ecological zones.

One way analysis of variance (ANOVA) was used to find out the relationship between different variables and between 3 provinces. The variables which are used for analysis in the study are:

- Type of farming practice: number of crops that farmers plant in 1 year which generate the income for households.
- Seed rate: the amount of seed is used for sowing in 1 hectare of rice field, this is also 1 type of inputs and affect to cost and profit of production.
- Amount of fertilizer: this is one of the most costly inputs in rice production in the Mekong Delta affecting directly to the cost of production and profit of households.
- Times of pesticide application: contributing to production costs
- Method of water management: the methods of using water for production, this directly relate to the change of rainfall and water level during the last decade and forecasted scarcity in the future.
- Other variables such as cost of labor, cost of harvest activity are also taken into account for calculating production cost, net profit and profit/cost ratio.

Mean

$$\bar{x} = \frac{x1 + x2 + x3 + \ldots + xn}{n} = \frac{\sum x}{n}$$

$\bar{x}$ = mean of all value in the data set

x = value in the data set

n = total number of value in the data set

$\sum$ x = sum of each value in the data set

Percentage

$$P(\%) = \frac{n * 100}{N}$$

P = percentage (%)

n = particular number

N = total number

Standard Deviation (SD)

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}$$

σ = standard deviation

$\bar{x}$ = mean of all value in the data set

x = value in the data set

n = total number of value in the data set

$\sum$ x = sum of each value in the data set

Profit/Cost

$$\frac{P}{C}$$

$$C = \sum(s + f + l + c + p)$$

P = net profit

C = production cost

s = cost of seed

f = cost of fertilizer

l = cost of labor

c = cost of chemicals (pesticide, herbicide)

p = cost of harvest

5. RESULTS AND DISCUSSION

5.1 Demographic characteristic of respondent

5.1.1 Household size of the respondents

Based on the responses from 107 respondents, the data shows that the family size of participants ranged from 2 to 9 members. The weight mean is 4.43 (± 1.29) members. Among the study areas, Hau Giang province has the highest mean of family size of 4.6 (± 1.15), while there the difference between An Giang and Tra Vinh province is not significant with the size of 4.31 (± 1.44) and 4.37 (± 1.33) respectively (Table 3). For the statistical comparison of the weight mean, the result shows that the difference of household size of the three study areas is not significant ($p > 0.05$). However, the average household sizes at the three study areas are still higher than the average rural household size of 3.9 which was calculated in the population and housing census (GSO, 2009).

Table 3: Household size and age structure of respondents

Indicators	An Giang		Hau Giang		Tra Vinh		p-value
	Mean	SD	Mean	SD	Mean	SD	
Household size	4.31	1.44	4.60	1.15	4.37	1.33	0.606
Age	45.68	9.65	44.47	9.46	43.42	9.46	0.626

5.1.2 Age structure of the respondents

Data from the total 107 respondents show that the age distribution of participants ranged from 28 to 67 years. Table 3 shows the age structure of the study areas. Among the study areas, An Giang province has the highest mean of age which is 45.68 in comparison with 44.47 in Hau Giang province and 43.42 in Tra Vinh province. In total, the weight mean of age of

respondents is 44.49 (± 9.47). However, the result of statistical comparison of mean shows that age structure is not significantly different between the study areas ($p > 0.05$).

The figure 6 shows the age distribution of respondents at the three study areas. With the percentage of age 60 and above less than 10% in all study areas, the data shows that the respondents belong to the young and productive age. Among the the three areas, Tra Vinh province has the highest percentage of respondents in the age group from 20 to 40 with 45%, while An Giang province has the lowest number of respondents in this age group with 37.5%. For the age group of 41 to 60, An Giang province has the highest percentage and Tra Vinh province has the lowest percentage of 53.13% and 45.71% respectively.

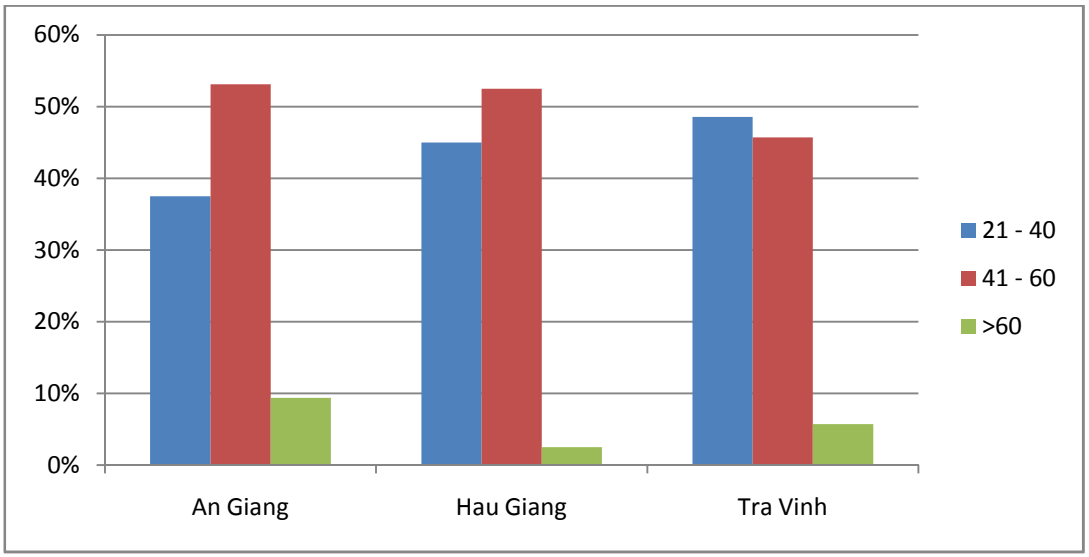

Figure 7: Age distribution of respondents by study areas

5.1.3 Education attainment

The result from the survey showed a positive situation of education of respondents that all participants are literate. The figure below shows the education attainment of the respondents in all study areas. The literacy rate of respondents is quite better than the rural literacy rate of the Mekong Delta which is 90.9% (GSO, 2009). The result shows that secondary attainment is the

majority among the respondents and there is not any respondent attending college or higher degree. Among the study areas, Hau Giang province has the highest percentage of secondary school attainment (65%) which is significantly higher comparing to An Giang province (43.75%). For elementary school attainment, there is significant different between An Giang and Hau Giang province with the percentage of 28.13% and 10% respectively. Lastly, there is not much different between the study areas in high school attainment. The reason for not attainting higher education degree of the respondents could be the poverty or household economic situation in the past. Because most of respondents belong to the age group of 40 and above, they grew up during and after the war time and they would rather work to help their family than continue studying. Data from the General Statistic Office of Vietnam (2009) shows the improvement of literacy rate of the country in during the last two decades, in which rural literacy rate increases from 85.4% in 1989 to 92% in 2009.

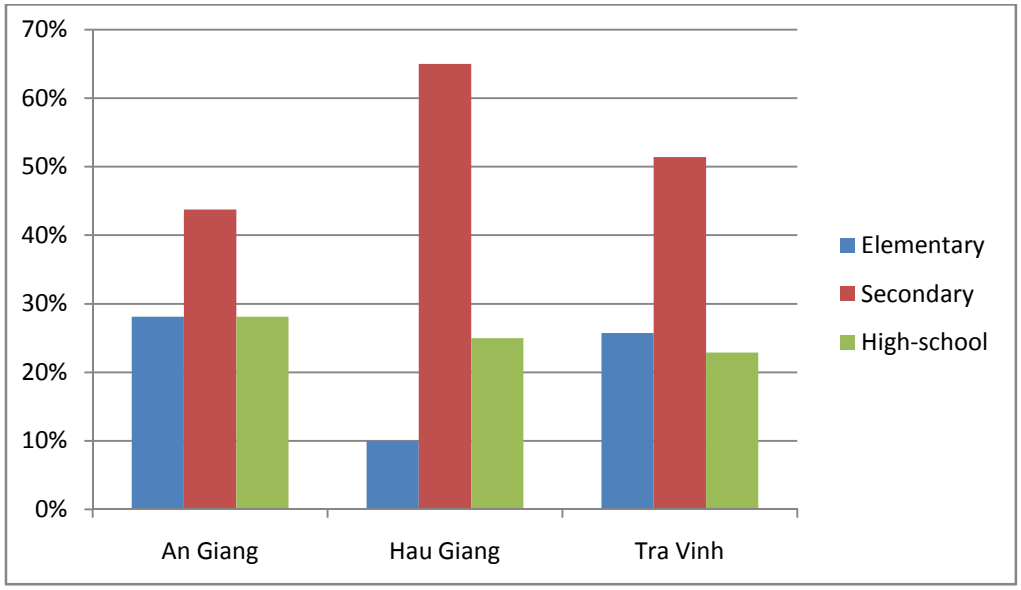

Figure 8: Education attainment of respondents by study areas

5.1.4 Ethnicity

In the Mekong Delta, the main ethnic groups are Kinh, Khmer and Hoa, in which the Kinh ethnic is the majority. The Hoa ethnic is considered as the thrid majority and they are really

good in business and service. The Khmer ethnic, in the other hand, is considered the second largest ethnic group and poorer than the other 2 groups. In the Mekong Delta, the Khmer population is distributed mostly in Soc Trang, Tra Vinh and Kien Giang province (UNFPA, 2009). Table 4 shows the ethnicity distribution among the study areas. Data indicates the dominant of Kinh ethnic which occupies 92.5% of the total respondent. There is significant difference among the study areas; while there is not any Khmer respondent in Hau Giang province, Tra Vinh province has the highest percentage of Khmer respondent (17.1%) and the next is An Giang province with 6.2%.

Table 4: Ethnicity distribution among the respondents by study areas

	An Giang		Hau Giang		Tra Vinh		Total	
	Freq	Percent	Freq	Percent	Freq	Percent	Freq	%
Kinh	30	93.8	40	100	29	82.9	99	92.5
Khmer	2	6.2	0	0	6	17.1	8	7.5
Total	32	100	40	100	35	100	107	100

5.2 Rice production system

5.2.1 Landholding and farming experience of respondents

In the Mekong Delta, agriculture is characterized as small-scale rice-based farming with the average landholding of 1.1 ha (De, 2006). Based on the information from the respondents, the study found that the weight mean of landholding is 1.73 (± 1.34) hectares and the range is from 0.2 to 7 hectares. Statistical comparison of weight means shows that the landholding of respondents between the study areas is significantly difference (Table 5). Among the study areas, respondents from An Giang province have the highest mean of 2.96 (± 1.67) hectares. In addition, the highest landholding of respondents is found in An Giang province with the area of 7 hectares, while the lowest is found in Tra Vinh province with only 0.2 hectare. Based

on the report of General Statistic Office of Vietnam (2011), An Giang province has the largest total area and agricultural land among the three study areas, it is 279,300 hectares comparing to 148,600 and 134,100 hectare in Tra Vinh and Hau Giang province, respectively.

Table 5: Landholding and farming experience of the respondents by the study areas

	Land (ha)		Experience (years)	
	Mean	SD	Mean	SD
An Giang	2.96 a	1.67	16.65 a	8.10
Hau Giang	1.12 b	0.58	19.15 a	7.96
Tra Vinh	1.31 b	0.88	18.77 a	9.38

Within column, means followed by the same letter are not significantly different (Duncan's test, p = 0.05)

Studying on the farming experience, the data shows a wide range in experience of respondents. The range varies from 6 to 40 years of experience, in which highest experience was reported from Tra Vinh province. However, statistical comparison of weight means revealed that the farming experience is not significantly different between the study areas (Table 5). Besides from self-experience, respondents improved their knowledge through trainings in their provinces. Almost all of respondents (85%) replied that they have already attended at least 1 training about techniques of rice production. These trainings are usually organized by local agricultural agencies (extension center, seed center or crop department) or agricultural projects (both international and national). Figure 8 shows the topics of training that respondents have attended. The data indicates that IPM is the most interested topic which is attended by more than 50% of respondents, while there are only 15% of respondents participating in the topic of seed production.

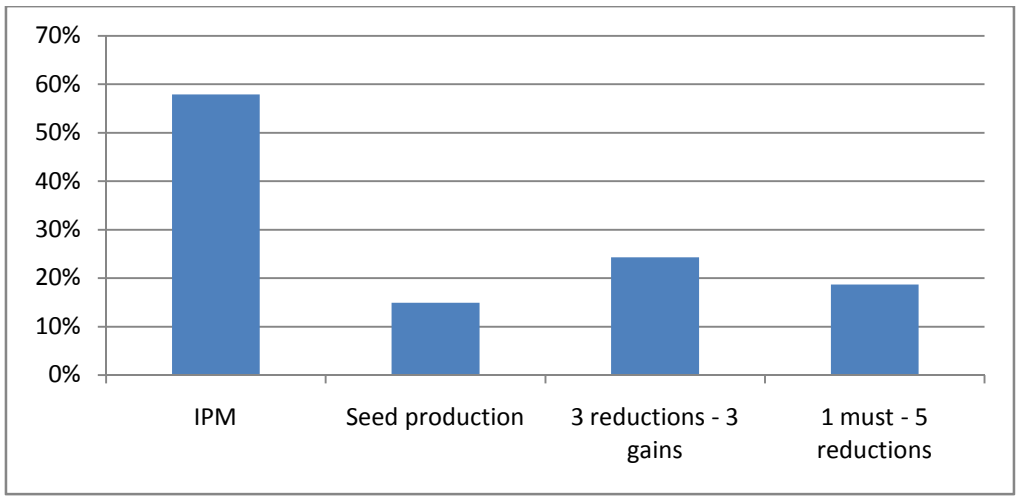

Figure 9: Training topics attended by respondents

5.2.2 Production orientation

Figure 9 shows the orientation in rice production of the respondents in the study areas. The graph indicates that market orientation is the main trend of all respondents at the study areas. In An Giang province, the respondents sell 90% of their total production which makes the province having the highest proportion for selling among the three areas. In the other hand, the proportion of total production using for processing is very low in all areas which is less than 5%. The figure also shows that the farm saved seed system is not strong in all study areas with the percentage of production using as seed is less than 10% which is slightly lesser than the proportion for household consumption. The reason for this could be the lack of knowledge and techniques in seed production of the respondents as in the figure 8 shows the less percentage of respondents attending in seed production training.

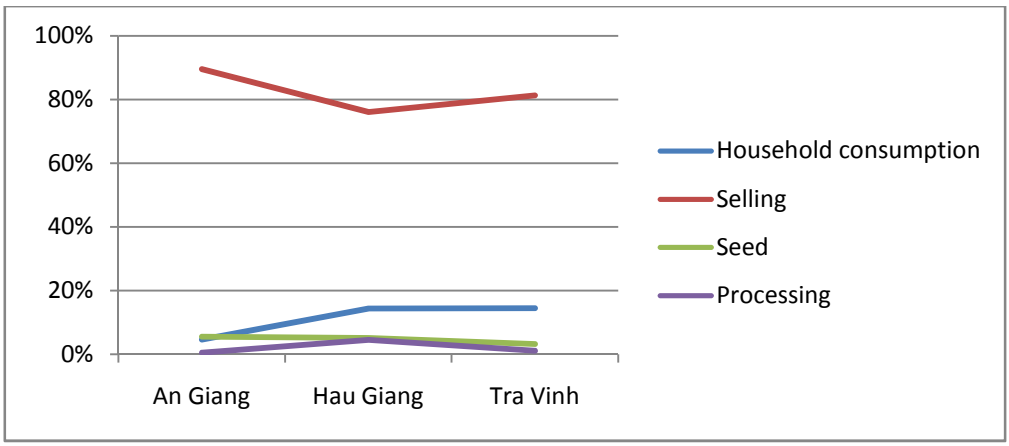

Figure 10: Rice production orientation of respondents by the study areas

5.2.3 Farming system

5.2.3.1 Farming practices

The table 6 shows the changes in farming practice of the respondents in the three study areas throughout the last 10 years. The data proves diversity in farming practice of respondents in different agro-ecological areas in the Mekong Delta. In the past, respondents in all study areas practiced many farming systems. In which, two rice crops per year is practiced by slightly more respondents (30.84%) than other system namely one rice crop (22.43%), one rice crop following by one traditional rice crop (21.50%) and three rice crops (23.36%). The data clearly shows the difference in farming system between the study areas. It was also the common practice in the Mekong Delta during that time with about two-thirds land area locating in the irrigated or partly irrigated areas (De, 2006). Having a good irrigation system, farmers from Hau Giang province could practice triple rice cropping with 40% of respondents in the area. On the other hand, because of seasonal flooding, farmers from An Giang province could only practice double rice cropping using short duration rice varieties with 56.25% of respondents. At the same time, although the area was affected by saline intrusion, there was not any dominant farming system in Tra Vinh province.

In the current situation, diversified farming systems are kept practicing in the study areas. However, the trend is shifted from single and double cropping toward triple cropping in which dry (December to March) and wet (April to July) season is the main production cropping generating most of the income for households. Thanks to the improvement of irrigation system in the region, most of the areas now can practice double and triple cropping. The data shows that triple cropping is the dominant system now at the study areas which is practiced by 64.49% of total respondents and following by double cropping with 21.50%. From the table 6, it is clearly to realize that all respondents (100%) from Tra Vinh province practice the triple cropping, while half of respondents (50%) from An Giang province are practicing double rice cropping. Interestingly, respondents from Hau Giang province practice more diversified systems than those from other two provinces. With the advantage of irrigation system, 10% of respondents from Hau Giang province also practice the system of double cropping with aquaculture (fresh water fish). On the contrary, rice cropping following by upland cropping (maize, bean, potato, etc) is not a common practice in all study areas.

Table 6: Changes in farming system of respondents by the study areas during the last 10 years

	An Giang (n=32)		Hau Giang (n=40)		Tra Vinh (n=35)		Total (n=107)	%
	Freq	%	Freq	%	Freq	%		
1 rice crop								
Current	0	0	0	0	0	0	0	0
10 years ago	8	25.00	8	20.00	8	22.86	24	22.43
1 rice crop + 1 traditional rice crop	5	15.63	0	0	0	0	5	4.67
Current	6	18.75	10	25.00	7	21.50	23	21.50
10 years ago								
2 rice crops								
Current	16	50.00	7	17.50	0	0	23	21.50
10 years ago	18	56.25	6	15.00	9	25.71	33	30.84
3 rice crops								
Current	11	34.38	23	57.50	35	100	69	64.49
10 years ago	0	0	16	40.00	9	25.71	25	23.36
Rice + upland crop								
Current	0	0	0	0	0	0	0	0
10 years ago	0	0	0	0	1	2.86	1	0.93
2 rice crops + upland crop								

	Current	0	0	1	2.50	0	0	1	0.93
	10 years ago	0	0	0	0	1	2.86	1	0.93
2 rice crops + aquaculture		0	0	4	10.00	0	0	4	3.74
	Current	0	0	0	0	0	0	0	0
	10 years ago								
Other									
	Current	0	0	5	12.50	0	0	5	4.67
	10 years ago	0	0	0	0	0	0	0	0

5.2.3.2 Water management

World Bank (2012) estimated that in the Mekong Delta it will be drier in the dry season and wetter in raining/wet season and rainfall concentration will also be changed. Tuong and Bouman (2003) also estimated that there will be a large area of South and Southeast Asia facing the economic water scarcity by 2050. This problem will strongly affect rice production which is sensitive to water requirement. In the efforts to adapt with the situation, some water management methods are introduced. Alternative wetting and drying (AWD) method which was introduced by the International Rice Research Institute (IRRI) as a water-saving method is commonly used in many countries such as China (Cabangon et al., 2004), the Philippines (Belder et al., 2004) and Japan (Chapagain and Yamaji, 2010). In practice, the method could help farmers saving from 10% to 30% of the water requirement while ensures the rice yield in comparison to the traditional method.

Table 7 demonstrates the change in water management of respondents during the last decade. The data clearly shows the change in practice among the study areas. In the past (10 years ago), continuous flooded method was the most common one (46.73%) following by AWD (42.99%). Among the study areas, Tra Vinh province has the highest percentage (62.86%) of respondents practicing continuous flooded method. It is due to the less improved irrigation system in Tra Vinh province in comparison to the rest. Thus, the production is highly relied on seasonal rainfall.

In current situation, the practice of all respondents has changed toward to the AWD method. However, the AWD technique that farmers in the Mekong Delta applied is not really the right AWD. The right technique is that farmers have to adjust the water level of the rice field at particular time period during the season. Though, water is just drained out about 5 – 7 days at the end of the tillering stage. Although there are some differences in practice, the AWD applied by farmers and respondents is still a good adaptation in rice production for saving water to face with the changes in rainfall. With the effort to diffuse the knowledge, many trainings about the techniques have been organized with the support of international and national organizations and governmental agricultural agencies. In addition, the improvement of irrigation system in the whole region also contributes greatly to the change of farmers and respondents. Consequently, AWD is the most common water management method applied by farmers with the responses of 80.37% of total respondents. Interestingly, AWD is the dominant method which is practiced by 100% of respondents in Hau Giang province, while more than half of respondents in the other provinces also practice this method with 78.13% and 60% of respondents in An Giang and Tra Vinh province, respectively.

Table 7: Changes in water management of respondents by the study areas

	An Giang (n=32)		Hau Giang (n=40)		Tra Vinh (n=35)		Total (n=107)	%
	Freq	%	Freq	%	Freq	%		
Continuous flooded								
Current	1	3.13	0	0.00	8	17.14	9	8.41
5 years ago	3	9.38	7	17.50	11	31.43	21	19.63
10 years ago	12	37.50	16	40.00	22	62.86	50	46.73
Water saving								
Current	6	18.75	0	0.00	6	17.14	12	11.21
5 years ago	5	15.63	1	2.50	4	11.43	10	9.35
10 years ago	5	15.63	3	7.50	2	5.71	10	9.35
Alternative wetting and drying								
Current	25	78.13	40	100.00	21	60.00	86	80.37
5 years ago	22	68.75	32	80.00	20	57.14	74	69.16

	10 years ago	14	43.75	21	52.50	11	31.43	46	42.99
Other									
	Current	0	0.00	0	0.00	0	0.00	0	0.00
	5 years ago	2	6.25	0	0.00	0	0.00	2	1.87
	10 years ago	1	3.13	0	0.00	0	0.00	1	0.93

5.2.3.3 Seed rate

Table 8 shows the farming practice of respondents in seed rate and fertilizer application in the three study areas. The data shows a decreasing trend of seed rate in all study areas in both dry and wet season during the last decade. Statistical comparison means of seed rate confirms a significant difference in seed rate between current and past situation in all study areas. The results also indicate that the seed rates in wet season are higher than in dry season across the study areas. In wet season, the growth of rice is affected negatively by the weather such as lower growth capacity, high rate of lodging, highly affected by golden snails, etc. Thus, farmer use higher seed rate to ensure the productivity from the rice field. Among the provinces, An Giang province has a highest seed rate in both seasons (around 200 kg/ha) and this difference is significant as shown in the table 8. There are reasons for the reduction in seed rate not only in study areas but also in the Mekong Delta. In the past, the common sowing method was direct - seeding (sowing by scattering seed) because this method required less labor and easier to practice than transplanting method. However, the drawback of this method is that it requires high seed rate. Fortunately, the problem has been solved with the introduction of drum seeder. Since then, direct seeding using drum seeder has been applied widely in the Mekong Delta. The advantages of the new technique are that it requires less labor, lesser seed rate and ensuring productivity. Thus, this method is recommended to rice production farmers and during the last 6 years, the Ministry of Agriculture and Rural Development of Vietnam (MARD) has promoted the program “3 reductions – 3 gains”. The program explains the need to decrease the seed rate, pesticide and nitrogen fertilizer (3 reductions) so that the farmers can improve rice yield, rice quality and income (3 gains). Information and instruction of the

program has widely diffused to community through broadcast media, local agricultural agents, leaflets, etc. Until now, the program has influenced and been widely practiced by farmers in the Mekong Delta.

Table 8: Change in seed rate by the study areas during the last 10 years

	Current (kg/ha)		5 years (kg/ha)		10 years (kg/ha)	
	DS	WS	DS	WS	DS	WS
An Giang						
Mean	183.00 a	190.71 a	217.28 a	229.03 a	249.37 a	265.18 a
SD	35.20	39.70	44.20	44.28	55.49	55.89
Hau Giang						
Mean	149.37 b	172.60 b	161.50 b	190.75 b	164.62 c	180.32 c
SD	21.78	38.63	34.25	43.22	58.19	65.41
Tra Vinh						
Mean	113.05 c	115.62 c	179.42 b	186.39 b	197.46 b	201.76 b
SD	55.49	55.89	58.19	65.41	53.44	53.79

Within column, means followed by the same letter are not significantly different (Duncan's test, p = 0.05)
Note: DS = Dry Season; WS = Wet Season

5.2.3.4 Fertilizer application

On the contrary with seed rate, fertilizer application in the study areas has experienced an increasing trend during the last 10 years (Table 9). The significant increase in amount of fertilizer used is experienced in An Giang province with more than 200 kg/ha during the last 10 years and is also the highest increasing among the study areas. On the other hand, the lowest amount of fertilizer used by respondents is recorded in Hau Giang province.

Table 9: Change in fertilizer application in the study areas during the last decade

	Current (kg/ha)		5 years (kg/ha)		10 years (kg/ha)	
	DS	WS	DS	WS	DS	WS
An Giang						
Mean	245.28	246.28	239.37	251.18	215.59	223.70
SD	47.01	65.81	79.84	76.94	88.73	84.97

Hau Giang						
Mean	162.15	177.57	160.37	179.52	123.51	135.72
SD	69.34	68.75	69.30	69.59	95.00	95.34
Tra Vinh						
Mean	204.00	197.76	190.00	181.75	169.90	169.00
SD	60.00	60.11	63.45	64.32	90.58	80.27

Within column, means followed by the same letter are not significantly different (Duncan's test, p = 0.05)
Note: DS = Dry Season; WS = Wet Season

In the current situation, statistical comparison means of fertilizer application shows that there is a significant difference in fertilizer used between the study areas in both seasons. Table 10 shows that respondents in Hau Giang province use the least amount of fertilizer (162.15 kg in dry season and 177.57 kg in wet season) among the 3 study areas. Besides, pesticide application is also significant different between the three provinces in which respondents in Tra Vinh province applied the least (average of 5.42 times in dry season and 5.97 times in dry season), those in the Hau Giang province used the highest and there is not significant different between Hau Giang and An Giang province.

In the Mekong Delta, farmers are used to applied high seed rates, high fertilizer rates and more pesticide than necessary. These practices might be derived from the perception that higher input would generate higher yields (Huan et al., 2005). However, the use of high seed rates and fertilizer could cause higher pest and disease infestation thus increasing the production cost and reducing profit (Huan et al., 2005 and Lang et al., 2006).

Realizing the situation, the "3 reductions - 3 gains" promoted by MARD encouraged and instructed the reduction in fertilizer to farmers. In the recent years, a new program known as "1 must – 5 reductions" has been introduced to farmers. This program as an upgrade for the "3 reductions – 3 gains" introduces new technique in water saving, reducing pesticide use and decreasing losses in post-harvest activities. However, the data shows that the later techniques are not applied well yet in the study areas.

Table 10: Comparison of seed rate, fertilizer and pesticide application in current situation between the study areas

	Seed rate (kg/ha)		Fertilizer application (kg/ha)		Pesticide application (times)	
	DS	WS	DS	WS	DS	WS
An Giang	183.00 a	190.71 a	245.28 a	246.28 a	6.56 a	7.15 a
Hau Giang	149.37 b	172.60 b	162.15 b	177.57 b	7.12 a	7.90 a
Tra Vinh	113.05 c	115.62 c	204.00 c	197.76 b	5.42 b	5.97 b

Within column, means followed by the same letter are not significantly different (Duncan's test, p = 0.05)
Note: DS = Dry Season; WS = Wet Season

5.2.3.5 Rice yield

Table 11 shows the change in rice yield in the study areas. In general, the rice yield in all study areas increases significantly during the last 10 years from around 5 tons/ha to 7 tons/ha in dry season and about 4 tons/ha to around 6 tons/ha in wet season. Among the provinces, respondents in An Giang province have the highest rice yield of 7.65 (± 0.48) tons/ha, although they almost applied the same techniques in production. In all study areas, the rice yield in dry season is significant higher than in the wet season. Weather condition is the major reason for the difference of rice yield between the two seasons. Usually, during the dry season, the rice plant can product higher productivity due to longer shining time, low rainfall and low rate of lodging and easier for harvesting. Statistical comparison means of rice yield shows that there is a significant difference between the study areas in which respondents from An Giang province enjoy the highest yield in both seasons. Higher rice yield in An Giang province could be attributed by yearly flooding and siltation during rainy season which replenishes soil fertility in the area (Chiem, 1993).

The data also shows the increase trend of rice yield in all study areas. There are several reasons for the increasing of rice yield in the study areas. The most important reason is the improvement and maintenance of dikes and irrigation system in the areas. Thanks to this achievement, intensive rice production (triple cropping) can now be practiced in most of areas

of the Mekong Delta as well in the study areas. Other important reason is the introduction of new techniques in production, especially the reduction of seed rates which also decreases the competition between rice plants and busting the growth for higher productivity. The introduction of new high yielding rice varieties with short growth duration are also a remarkable reason contributing to the increase of rice yield.

Table 11: Comparison of the change in rice yield by the study areas during the last 10 years (tons/ha)

	Current		5 years ago		10 years ago	
	DS	WS	DS	WS	DS	WS
An Giang						
Mean	7.65 a	6.09a	6.27 a	4.78 ab	5.23 a	4.11 a
SD	0.48	0.60	1.03	1.21	1.37	1.16
Hau Giang						
Mean	7.14 b	5.44 b	6.52 a	5.05 b	5.10 a	3.92 a
SD	0.62	0.66	0.78	0.75	1.15	1.03
Tra Vinh						
Mean	6.89 b	5.95 a	5.32 b	4.53 a	4.29 b	3.88 a
SD	0.99	1.05	0.77	0.76	0.69	0.61

Within column, means followed by the same letter are not significantly different (Duncan's test, p = 0.05)
Note: DS = Dry Season; WS = Wet Season

5.3 Economic efficiency

Table 11 shows the weight means of annual production cost, net profit and profit-cost ratio per hectare between the study areas. Analyzing the production cost, the results show that the cost is significantly different between Tra Vinh and Hau Giang province in which the later has the higher mean with 1560.40 (±187.88) USD/ha. Across the study areas, there is no significant difference in the price of seed (around 15,000 VND or 0.72 USD per 1 kilogram of certified seed), pesticide application (around 1,200,000 VND or 57.58 USD per 1 hectare for 1 time of spraying) and harvesting activity (around 3,000,000 VND or 143.95 USD per 1 hectare for hiring combine harvester). Thus, the reasons of the difference in production cost are the seed

rate and pesticide application. As shown in the table 9, respondents in Tra Vinh province use lesser seed rate and lesser time of pesticide application comparing to the rest. Regarding the net profit, there is a significant difference between the provinces in which respondents in Hau Giang province earn the least profit than those in other provinces with 1319.83 (±503.46) USD/ha. The reasons of the difference are that respondents in An Giang province applied less pesticide and had a higher rice yield, while those in Tra Vinh province used low seed rate and less pesticide application. Other important reason is that the price of paddy in Hau Giang province which is 0.24 USD/kg is significantly lower than those in An Giang province (0.25 USD/kg) and Tra Vinh province (0.27 USD/kg). Therefore, Tra Vinh province has the highest profit-cost ratio with 1.62 and Hau Giang province has the lowest ratio of 0.86.

Table 11: Annual production cost, net profit and profit-cost ration across study areas in the current situation

	Production cost (USD/ha)		Net profit (USD/ha)		Profit/Cost	
	Mean	SD	Mean	SD	Mean	SD
An Giang	1560.40 ab	187.88	1937.28 a	591.29	1.27 a	0.47
Hau Giang	1631.13 a	301.88	1319.83 b	503.46	0.86 b	0.38
Tra Vinh	1430.33 b	315.53	2100.54 a	906.49	1.62 c	0.92

Within column, means followed by the same letter are not significantly different (Duncan's test, p = 0.05)
Note: 1 USD = 20,840 VND

5.4 Respondents' perspective toward climate change in rice production

5.4.1 Impacts of climate change in rice production

In all study areas, almost all respondents are aware of the term climate change with 99 responses which account for 88. 80%. When asking about the impacts of climate change toward rice production, many ideas and information were provided and those could be grouped into 4 categories namely increasing in saline intrusion, flood, drought frequency and appearance of pest and diseases. In general, increasing in flood frequency has the highest response with 50.47% following by pest and diseases with 45.79% and drought with 42.06%.

In Tra Vinh province, increasing of drought frequency (62.86%) causes the increasing the saline intrusion (51.43%) which might affect greatly not only rice production but also other kind of crops. High frequency of appearance of pest and diseases (51.43%) is also a problem in Tra Vinh province. While high frequency of flood is a remarkable impact in Hau Giang and An Giang province with 70% and 56.25% respectively. Besides, more than 60% of responses about drought problem are also recorded in An Giang province.

Table 12: Perspective of respondents across the study areas toward the impacts of climate change

	An Giang		Hau Giang		Tra Vinh		Total	%
	Freq	%	Freq	%	Freq	%		
Salinity	6	18.75	5	12.5	18	51.43	29	27.10
Flood	18	56.25	28	70	8	22.86	54	50.47
Drought	20	62.5	3	7.5	22	62.86	45	42.06
Pest diseases	24	75	7	17.5	18	51.43	49	45.79

5.4.2 Adaptations toward the issue

Regarding to the methods for adapting to climate change in rice production, respondents proposed and confirmed many methods. Those were grouped into 4 main categories which are improvement of irrigation system, protecting forest, using improved rice varieties and applying new practices (changing cropping calendar, balancing nitrogen fertilizer, saving water, etc.). In general, many respondents prefer the option of applying new practices in rice production with 42.06% of responses. The second preferred option is using improved rice varieties (36.45%) and the interested rice varietal traits are short growth duration, resistance to

pest/disease, strong stem, and resistance to saline/acid sulphate condition. In particular, respondents in Hau Giang province prefer to use improve rice varieties with 60% of responses, while applying new practice shares a high interest among the study areas with more than 40% responses in each province.

Table 13: Proposed and applied adaptations by respondents across the study areas

	An Giang		Hau Giang		Tra Vinh		Total	%
	Freq	%	Freq	%	Freq	%		
Improvement of irrigation	9	28.13	7	17.5	14	40.0	30	28.04
Applying new practices	14	43.75	16	40	15	42.86	45	42.06
Protecting forest	2	6.25	20	50	2	5.71	24	22.43
Using improved varieties	7	21.88	24	60	8	22.86	39	36.45

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The Mekong Delta which is divided into seven agro-ecological zones is the main rice production region of the whole country. Since the reunification of the country, the region has experienced many changes and improvement in all sectors in which agricultural production is the most important sector, especially rice production.

The region is characterized as small-scale rice-based farming with the average landholding of 1.1 hectare per household and diversified farming practices. Sharing the same situation, during the last decade, An Giang, Hau Giang and Tra Vinh province with different agro-ecological conditions have experienced in changes of farming practice.

Farmers in the three provinces have certain knowledge and experience in rice production and almost all of them have attended at least 1 training in different topics such as integrated pest management (IPM), seed production, 3 reductions – 3 gains, etc. With a well-equipped knowledge in rice production, farmers direct their production toward commercial orientation with more than 80% of total production selling to local and regional market.

Regarding to farming practice, farmers in the three study areas share many similarities. There is a fast shift from single rice cropping toward double and triple rice cropping thanks to the improvement of irrigation system in the region. New techniques in rice production have been introduced and transferred to farmers not only in the study areas but also in the whole Mekong Delta; in which, 1 must – 5 reductions – an upgrade method from 3 reductions – 3 gains is the dominant applying model in which water-saving technology by applying alternative wetting and drying (AWD) method is common used and seed rate, fertilizer and pesticide are gradually decreased in the three provinces.

On economic aspect, rice yield significantly increased about 2 tons/ha in comparing to the last decade at the three provinces. Although farmers in Tra Vinh province have lower rice yield in comparing to the other two study areas, the highest profit in rice production (2100 USD/ha) is recorded in this province, while farmers in Hau Giang province have lowest profit. The better economic performance in Tra Vinh province is due to the low production cost by decreasing the amount of seed rate and pesticide application along with a higher price of paddy.

Although the region achieved many improvements, the area is facing a global issue known as climate change affecting many sectors. The impacts of climate change vary in different areas. High frequency of drought and saline intrusion is reported from Tra Vinh province, while An Giang and Hau Giang province face the effects from high frequency of flood. In addition, high frequency of pest and disease infestation could be taken into account for finding solution to respond with the responses in An Giang province (75%) and Tra Vinh province (51.43%).

Adapting to climate change, many solutions and options are proposed and applied by farmers across the three provinces by applying improved practices such as adjusting cropping calendar, water management, reducing fertilizer, etc. In which, water-saving method (AWD) is successfully applied by almost the farmers in the study areas, this method allows farmers full control of water level in the rice field during the season which can help them adapting with the forecasted changes in rainfall and water scarcity. In addition, the most preferred expectation from respondents is the use of the improved rice varieties which can adapt to the local conditions.

6.2 RECOMMENDATIONS

Based on the results of the study and perspectives of respondents, following recommendations are made in order to improve the livelihood of farmers and adapt to climate change issue:

- Although there is a decreasing in production inputs, farmers should keep reducing more the inputs as there is no correlation between rice yield and high input of fertilizer. Recommended seed rate for direct seeding using drum seeder should be 120 kg/ha, which reduces inputs cost about 9.45 USD/ha (likely reducing 80 kg of seed/ha and fertilizer, etc.) and increases profit (Huan et al., 2005). Furthermore, decreasing nitrogen fertilizer could reduce the emission of nitrous oxide (N_2O) which directly affects the climate change issue.

- Local agricultural agencies should provide extension programs to update information about market price, pest disease situation, water source forecast to farmers. This can lead establishing suitable cropping calendar for rice production.

- Cooperation between local agricultural agencies / research institutions and farmers should be strengthened in participatory technology development (PTD) and participatory plant breeding (PPB) for rice crop. From this, farmers can enhance their knowledge and capacity in adapting to climate change and lead sustainable agricultural for the Mekong Delta, Vietnam.

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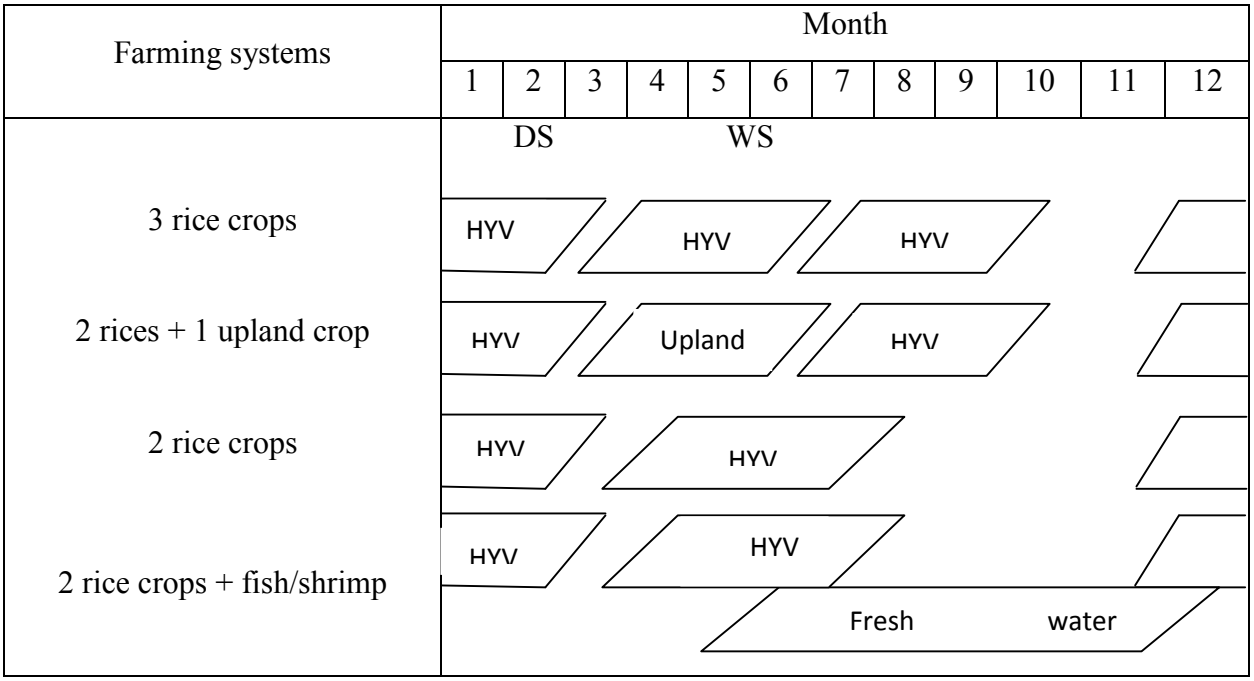
ANNEX

ANNEX 1: Table

Table 1: Season calendar of farming systems in the Mekong Delta, Vietnam



Source: De 2006, modified by author

Note: DS = dry season; WS = wet season; HYV = high yielding variety

ANNEX 2: Questionnaire

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

FARES Project

Dear Sir/Madam;

I, the undersigned am a master student from Czech University of Life Sciences Prague (CZU). I'm now working for my master thesis entitled "Rice production systems in the Mekong Delta, Vietnam: situation and adaptation of farms to climate change".

I would like to seek your help by answering the attached questions which would greatly contribute to the accomplishment of my master thesis. Your cooperation is highly appreciated and your information is assured to be treated with utmost confidential.

Thank you very much

Sincerely yours,

Huynh Nguyen Vu Lam

1. General information

1.1 Full name: _____

1.2 Age: _____ Gender: _____

1.3 Ethnicity: _____

1.4 Education attainment: _____

1.5 Province: _____ District: _____ Commune: _____

1.6 Source of income: _____

1.7 Farming experience: _____ years

1.8 Training attended:

a) ☐ IPM

b) ☐ Seed production

c) ☐ 3 reductions – 3 gains

d) ☐ 1 must – 5 reductions

1.7 Rice production orientation

☐ Household consumption (……..%) ☐ Selling (…….%)

☐ Farm saved seed (…….%) ☐ Processing (…….%)

2. Rice production

2.1 Land use

	Areas (ha)	**Type of soil**	**Water source**	**Ownership**
Total areas				
Rice production				
Aquaculture				
Vegetable/upland crop				
Perennial crops				
Others…….				

2.2 Farming system

	Current	**5 years ago**	**10 years ago**
1 rice crop (traditional rice)			
2 rice crops			
3 rice crops			
1 rice crop + upland crop			
2 rice crops + upland crop			
2 rice crops + fish/shrimp			
Rice + ……			

2.3 Farming techniques

Techniques	**Current**	**5 years ago**	**>10 years ago**
Sowing method	☐ wet-direct seeding ☐ using drum seeder ☐ dry-direct seeding ☐ sowing without tillage ☐ transplanting	☐ wet-direct seeding ☐ using drum seeder ☐ dry-direct seeding ☐ sowing without tillage ☐ transplanting	☐ wet-direct seeding ☐ using drum seeder ☐ dry-direct seeding ☐ sowing without tillage ☐ transplanting
Seed rate	DS: ……… kg WS: ……… kg	DS: ……… kg WS: ……… kg	DS: ……… kg WS: ……… kg
Fertilizer application	DS: Urea: ……….kg DAP: ……….kg NPK: ……….kg KCl: ………..kg ……………… WS Urea: ……….kg DAP: ……….kg NPK: ……….kg KCl: ………..kg ………………	DS: Urea: ……….kg DAP: ……….kg NPK: ……….kg KCl: ………..kg ……………… WS Urea: ……….kg DAP: ……….kg NPK: ……….kg KCl: ………..kg ………………	DS: Urea: ……….kg DAP: ……….kg NPK: ……….kg KCl: ………..kg ……………… WS Urea: ……….kg DAP: ……….kg NPK: ……….kg KCl: ………..kg ………………
Pesticide application	DS: …………. times WS: …………. times	DS: …………. times WS: …………. times	DS: …………. times WS: …………. times
Water management	☐ continuous flooding ☐ water-saving ☐ alternative wetting and drying ☐ …………………	☐ continuous flooding ☐ water-saving ☐ alternative wetting and drying ☐ …………………	☐continuous flooding ☐ water-saving ☐ alternative wetting and drying ☐ …………………
Rice yield	DS: …………. tons/ha WS: ………….tond/ha	DS: …………. tons/ha WS: ………….tond/ha	DS: …………. tons/ha WS: ...……….tons/ha

3. Economic performance

	Dry season	Wet season
Cost of Seed		
Cost of fertilizers		
Cost of pesticide		
Cost of labour		
Cost of harvesting		
Price of paddy		

3.1 Which source that you sell your product?

☐ Local traders

☐ Others …….

4. Climate change

4.1. Do you know about climate change?

☐ Yes ☐ No

From which source?_____

4.2. According to you, what is climate change?

_____

_____

4.3 Which impacts of climate change have you encountered in you rice production?

☐ Saline intrusion

☐ Increasing rainfall

☐ Drought

☐ Increasing pests and diseases

☐ Other

…….

4.4 How have you adapted to the situation and what would your recommendations be?

_____

_____

_____

_____

4.5 Do you think that participatory plant breeding is a good way for farmers adapting to climate change?

☐ Yes Why? ……

☐ No Why? ……