Climate-Smart Rice Production in the Mekong River Delta, Vietnam

Vu Thi Hoai Thu[1] and Huynh Thi Mai Dung[2]

[1,2] Lecturer, Faculty of Urban and Environmental Economics and Management,
National Economics University, Hanoi, Vietnam
[1] E-mail: thuvh@neu.edu.vn, [2] E-mail: dunghm@neu.edu.vn

Abstract

Agricultural sector is key to climate change response, not only because of its high vulnerability to climate change impacts, but also because it is a main contributor to climate change problem. Developing climate-smart agriculture plays a vital role in achieving food security, adaptation to climate change and mitigation of climate change. Rice production plays a key role in ensuring food security, poverty reduction, and job creation in the Mekong River Delta in Vietnam. However, this sector is increasingly vulnerable to climate change impacts which can be a critical problem for the future rice production systems in the region since it is the most important crop in agricultural production and food security in Vietnam. The sustainability of rice production in the Mekong River Delta plays an important role in sustainable development of the region in response to global climate change. This paper provides an analysis of rice production in the Mekong River Delta of Vietnam in the context of climate change based on the framework of climate-smart agriculture. Several recommendations to develop climate-smart rice production in the Mekong River Delta of Vietnam in the coming time are also recommended.

Keywords: adaptation, climate change, climate-smart agriculture, mitigation, rice production

1. Introduction

Agriculture is an essential driver of economic growth and poverty reduction, particularly in rural areas and least developed countries. In agriculture-based countries, agriculture contributes an average of 29% to GDP and employs 65% of the labour force. In countries in the process of industrialization and urbanization, agriculture-related industries and services often contribute more than 30% to GDP. All over the world, there are 2.5 billion people living in households which their livelihoods are related to agriculture (FAO, 2012).

The world's population is expected to reach 9.73 billion in 2050, boosting agricultural demand by 50% as compared to 2013 (FAO, 2017). Satisfying increased demands on agriculture with existing farming practices is likely to lead to more intense competition for natural resources, increased greenhouse gas emissions, and further deforestation and land degradation. High-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil depletion, and high levels of greenhouse gas emissions, cannot deliver sustainable food and agricultural production. It is necessary to establish innovative systems that protect and enhance the natural resource base while increasing productivity (FAO, 2017).

Food security will be increasingly threatened as the world population continues to increase while agricultural production has been and will be severely affected by the impacts of climate change. Climate change affects disproportionately food-insecure regions, jeopardizing crop and livestock production, fish stocks, and fisheries (FAO, 2017). In addition, agriculture also contributes significantly to global greenhouse gas emissions (13.5% in 2004 (IPCC, 2007) and 11.8% in 2010 (IPCC, 2007) and is called for mitigation of climate change. Therefore, in the context of climate change, agriculture has to address simultaneously three intertwined challenges: ensuring food security through increased productivity and income, adapting to climate change and contributing to climate change mitigation. Addressing these challenges will require radical changes in food systems at all levels. Climate-smart agriculture plays an important role in achieving objectives of food security and effective response to climate change (FAO, 2012).

Vietnam has been identified as one of the countries mostly impacted by climate change. Storms, floods, and salinity intrusion have been occuring more frequently with higher severe level and unpredictability. In the Global Climate Risk Index 2018, Vietnam is ranked the 5th among the most affected countries by the impacts of weather-related loss events (storms, floods, heat waves etc.) in 2016 and Vietnam is ranked the 8th among the most affected countries by the extreme weather events in the period 1997–2016 with the total losses of 2,029 million US$ (PPP) (Germanwatch, 2018). In 2016, natural disasters caused the estimated loss of VND 39.7 trillion, equivalent to USD 1.7 million, accounted for 1% of the Vietnam's GDP (GSO, 2016). In 2017, natural disasters caused the estimated damage of VND 60 trillion, equivalent to USD 2,6 million, accounted for 1,2% GDP and 1,5 times higher than in 2016 (GSO, 2018).

Agriculture plays a crucial role in sustainable socio-economic development of Vietnam in terms of food security, poverty reduction, job creation, and economic growth since agriculture accounted for 40.2% of the labor force and contributed 15.34% to the country's GDP in 2017 (GSO, 2018). According to Vinanet, Vietnam rice export in 2017 reached 5.79 million tones with the turnover of USD 2.62 billion. According to World Attas, Vietnam ranked 5th in the list of top 10 largest rice producing countries in the world in 2017. However, Vietnam's agricultural growth has relied heavily on human and natural resources, and chemical factors, consequently causing serious

environmental degradation. In addition, agriculture development in Vietnam is threatened by global climate change impacts since agriculture in general and rice production in particular is a climate-sensitive sector.

The Mekong River Delta (MRD), which included 12 provinces and one central level city, including Long An, Tien Giang, Ben Tre, Tra Vinh, Vinh Long, Dong Thap, An Giang, Kien Giang. Giang, Can Tho, Hau Giang, Soc Trang, Bac Lieu and Ca Mau, is the largest rice production in Vietnam. The Delta occupied 54% of the country's rice cultivation area and produced 56% of the country's rice yield (GSO, 2018). Rice production plays a key role in ensuring food security, poverty reduction, and job creation in the MRD, but this sector is increasingly vulnerable to climate variability. At a global scale, the MRD is considered as one of the three most vulnerable deltas to the impact of sea level rise (IPCC, 2007). The future rice production systems of the MRD is expected to face many challenges, including climate change impacts in the forms of increased temperature, sea level rise, altered rainfall, and extreme climatic events; and changes in the upstream flow of the Mekong River as well.

In the context of climate change and unpredictably high frequencycy of natural disasters, the enhancement of climate resilience and risk mitigation for rice producers, especially smallholders in the MRD is a priority for Vietnam. Impacts of climate change on rice production in the MRD can be a critical problem since it is the most important crop in agricultural production and food security in Vietnam. The sustainability of rice production in the MRD plays an important role in sustainable development of the region in response to global climate change.

This study provides an analysis of rice production in the Mekong River Delta of Vietnam in the context of climate change based on the framework of climate-smart agriculture. Specific objectives are (i) to present an overview of climate change in the Mekong River Delta in Vietnam, (ii) to assess challenge of ensuring food security in the Mekong River Delta in Vietnam in the context of climate change, (iii) to analyze impacts of climate change on rice production and the need for climate change adaptation from rice cultivation in the Mekong River Delta, (iv) to indicate green house gas emissions from rice cultivation and the need for climate change mitigation from rice cultivation in the Mekong River Delta, and (v) to propose several recommendations to develop climate-smart rice production in the Mekong River Delta of Vietnam in the coming time.

2. Method

2.1. Theoretical framework and Literature review

The Climate Smart Agriculture (CSA) concept was firstly introduced by the Food and Agriculture Organization of the United Nations (FAO) in 2010 at the Hague Conference on Agriculture, Food Security and Climate Change to address food security and global climate change concerns (FAO, 2010). This concept continues to be consolidated in 2012 in the view of Rio+20 about green economy in the context of sustainable development. FAO (2012) in the report "Greening the Economy with Climate-Smart Agriculture" argued that agriculture is essential for a green economy and there can be no green economy without agriculture. In 2013, FAO published the book "Climate-Smart Agriculture Sourcebook" which aims to provide a number of theoretical and practical issues related to climate-smart agriculture. This book was subsequently revised and reprinted in 2017. In 2018, FAO published the book "Climate Smart Agriculture: Building Resilience to Climate Change" to continue call for countries to integrate climate change mitigation and adaptation concerns into their agricultural development strategies by providing best practices

and innovative approaches to CSR to support global food security in the context of climate change. Based on the CSR theoretical framework, FAO has also conducted a number of field studies in many countries around the world in many fields, including rice cultivation, livestock rasing, and aquaculture. Based on FAO's CSR framework, a number of academic studies have been developed worldwide. In general, CSA aims at sustainably increasing food security and incomes, adapting and building resilience to climate change while capturing potential mitigation co-benefits by adopting appropriate practices, developing enabling policies and institutions and mobilizing needed finances (FAO, 2018).

2.2. Data source and analysis

The study uses secondary data which were collected from a variety of sources, including statistical yearbooks, reports from General Statistics Office of Vietnam, Vietnam's Ministry of Agriculture and Rural Development, Vietnam's Ministry of Natural Resources and Environment, the Food and Agriculture Organization of the United Nations (FAO), Intergovernmental Panel on Climate Change (IPCC), books, journals, papers, and research reports of individuals and organizations related to the topic of research. Particularly, data related to rice cultivation was gathered from General Statistics Office of Vietnam; data on climate variables, climate change adaptation and mitigation of rice production in Vietnam and in the Mekong River Delta were collected from Vietnam's Ministry of Natural Resources and Environment, Vietnam's Ministry of Agriculture and Rural Development and research reports.

Desk study is used to review the literature to systematize theoretical framework and to summarize the practical experiences of climate-smart agriculture. Statistical, descriptive and comparative methods are used to analyze rice production in the Mekong River Delta of Vietnam in the context of climate change based on the framework of climate-smart agriculture.

3. Results

3.1. Overview of climate change in the Mekong River Delta in Vietnam

Most of the studies about climate change in the MRD indicated that the region are facing with potential impacts of sea level rise, salt water intrusion, floods, and droughts.

3.1.1. Sea level rise

The MRD is a flat and lowland area, which is accreted by alluvial soils of the Mekong River, with average elevation of 1m-2m above the sea level, even in some places with 20-30 cm above the sea level. At a global scale, the MRD is considered as one of the three most vulnerable deltas to the impact of sea level rise (IPCC, 2007). Over the past 30 years (1982-2011), sea levels in the East Sea and the West Sea and inland water levels along the MRD have increased by 5 cm per decade; equivalent to an increase of 15 cm over the past three decades (Southern Institute of Water Resources Planning, 2013). In general, main impacts of sea level rise in Vietnam are concentrated in the Red River Delta and Mekong River Delta since a large proportion of Vietnam's population and economic activities takes place in these two deltas (Dasgupta et al., 2007). Among possible impacts of global climate change on the MRD, sea level rise is the one that may create the most damages to the delta, because it may enhance saltwater intrusion and floods in terms of magnitude, duration, and intensity in the region.

3.1.2. Salt water intrusion

Salinity intrusion is a common phenomenon in lowland coastal areas which often causes salinization of cultivated land and water resource. Sea level rise is expected to exacerbate salinity intrusion in the coastal areas, thereby accelerating land degradation and creating harmful impacts on agricultural production in the coastal plains. Mekong River Delta and Red River Delta are regions mostly affected by salinity intrusion in Vietnam. Severe salt water intrusion in the MRD was recorded in 2016. According to MONRE, from November 2015 to May 2016, the rainy season ended earlier, the river flow from upstream of Mekong river to the MRD during the dry season reached the lowest level over the past 90 years; then salinity intrusion came almost 2 months earlier than previous years and intruded 10-25 km farther than annual intrusion. Salinity intrusion in the Mekong Delta provinces reached a highest record in nearly 90 years. Many provinces had to declare the emergency status of salt water intrusion in this period, namely Kien Giang, Long An, Ca Mau, Tien Giang, Vinh Long, Ben Tre, Soc Trang and Tra Vinh. In general, salt water intrusion trend in the MRD in recent yeas had changed significantly as compareded to previous period. It occurred earlier (1.5-2 months earlier), intruded farther (15-20 km farther than annual intrusion) and lasted longer (1-2 month longer).

3.1.3. Floods and droughts

The MRD has two water sources: water from the Mekong River and rainwater. Despite the abundance of water resources, seasonal imbalance of water availability is widespread in the Delta with surplus in the flood season and severe shortage in the dry season. Floods and droughts are therefore the most extreme climatic hazards in the MRD.

Being located at the end of the downstream of the Mekong River, flood flows from the upstream to the MRD go through the two tributaries of the Tien and Hau Rivers and go along inland bordered Cambodia and Vietnam. Flood season usually starts in July, then increases gradually from August to September, reaches the peak level in October and finally decreases gradually in November-December. In the rainy season, the highest flood flow is of 39,000 m^3/second, leading to a flood area of 1.2 to 1.9 million ha in the MRD (Le Quang Tri, 2016). Flood is a natural phenomenon that occurs regularly in the Mekong River basin, causing human and property damages, but at the same time serving as important ecological and environmental factors for improving soil quality in terms of increased fertility and decreased salinity.

In the dry season, from November to April, the Mekong River is the only source for water supply in the MRD. If the water flow is decreased, water availability in the area will be limited. During dry months, the Mekong River's water flow is very low, at 2,500 m^3/second. In recent years, the upstream countries of the Mekong River (including China, Thailand, Laos and Cambodia) have built hydropower dams that alter the flow, water volume and quality of the Mekong River, leading to less and less water flow from upstream to downstream. Serious shortages of water and long lasting drought days throughout the MRD took place as a result. High temperature and lack of water resulting from low flows in dry season led to severer salinily intrusion, mainly in coastal provinces such as Ca Mau, Bac Lieu, Soc Trang, Tra Vinh, Ben Tre, Tien Giang and Long An. In general, in the dry season, low rainfall and high evaporation due to rising temperatures have created a lot of pressures on water supply, especially at the end of the dry season, for local people in the MRD.

3.2. An analysis of Climate-Smart Rice Production in the Mekong River Delta, Vietnam

3.2.1. Ensuring food security

Most of communes in the MRD are located in flood plain areas. Due to its mostly flat terrain, the majority of the region's land can be used for agriculture and most of the agriculture land is used for rice cultivation.

The MRD has an agricultural land area of 2.622 million hectares, accounting for 64.3% of the region's natural land area and 22.8% of the country's agricultural land area (GSO, 2018). The MRD has a strong advantage in agricultural production, especially rice production. Rice cultivation area of the region accounts for 54% of the country's rice area. Rice is cultivated mostly in Kien Giang, An Giang, Long An, Dong Thap, and Soc Trang. Rice productivity in the MRD is higher than the national average and ranks the second (after the Red River Delta) among six economic regions in Vietnam. Provinces that produce high rice productivity are An Giang, Soc Trang, Tien Giang, Dong Thap, and Bac Lieu. In general, rice yield of the MRD accounts for 56% of the country's rice yield. Kien Giang, An Giang, Dong Thap, Long An, and Soc Trang are provinces that produce very high rice yields.

Table 1: Rice cultivation area, productivity, and yield in the MRD (2012-2017)

Criteria	2012	2013	2014	2015	2016	2017
1. Rice cultivation area (thousand ha)						
- Whole country	7,761	7,902	7,816	7,828	7,737	7,708
- MRD	4,184	4,340	4,249	4,301	4,241	4,188
2. Rice productivity (100 kg/ha)						
- Whole country	56.4	55.7	57.5	57.6	55.8	55.5
- MRD	58.1	57.6	59.4	59.5	56.2	56.4
3. Rice yield (thousand tons)						
- Whole country	43,737	44,039	44,974	45,091	43,165	42,763
- MRD	24,320	25,021	25,245	25,583	23,831	23,633

Source: GSO (2015), GSO (2018)

In Vietnam, rice is typically harvested twice a year with exceptions in the MRD where 3 crops are practiced in some regions. Rice is often rotated with other crops and in some coastal areas, rice is cultivated in the wet season, then rice fields are used for growing shrimp in the dry season. Rice can be grown up to 3 crops per year in the MRD since the local cropping systems have been optimized for the hydrological changes in terms of water from river flow, rainfall and tides. In some cases, diversification from rice to aquaculture and upland crops may be the most suitable strategy. However, the delta as a whole will undoubtedly rely on rice as the main agricultural production for any time in the future.

The MRD is popularly known as “rice bowl” of Vietnam. In 2017, the Mekong River Delta accounted for 55% of the Vietnam’s rice production while the Red River Delta occupied 14.2% (GSO, 2018). According to Vinanet, Vietnam rice export in 2017 reached 5.79 million tones with the turnover of USD 2.62 billion. According to World Attas, Vietnam ranked 5th in the list of top 10 largest rice producing countries in the world in 2017. Rice production plays a key role in ensuring food security, poverty reduction, job creation, and economic growth in the MRD. The delta has a population of 17.7 million people, of which 80% rely on rice cultivation for their livelihoods (GSO, 2018).

3.2.2. Impacts of climate change on rice production and the need for adaptation to climate change in the Mekong River Delta, Vietnam

Agricultural activities in the MRD, especially rice production, are mainly associated with the use of such essential natural resources as land and water which are very sensitive to climate change impacts. Therefore, rice production is the most vulnerable to the impacts of climate change.

Firstly, inundation caused by sea level rise creates loss of agricultural land. Inundation due to sea level rise will cause loss of cultivation land in the MRD due to its extremely flat topography (in average of about 1m elevation to the sea level). Around 80% of the Delta area is 2.5m under the sea level. The MRD is the most affected by inundation since the region has been annually suffering 4-5 months of floods. According to MONRE (2016), if the sea level rises by 1m by the end of 21th century, 38.9% of the MRD's land will be submerged. Subsequently, the MRD would lose 40.5% of its rice output. Carew-Reid (2008), using GIS technique to identify areas that will be inundated in Vietnam by 1m sea level rise by the end of the 21st century, indicated that 12 provinces in the MRD will seriously affected by 1m sea level rise. In terms of flooded areas, five provinces mostly affected are Long An (2,169 km^2), Kien Giang (1,757 km^2), Soc Trang (1,425 km^2), Ca Mau (1,183 km^2) and Ben Tre (1,131 km^2). In terms of proportion of flooded area to total area of the province, the most five inundated provinces are Ben Tre (50.14%), Long An (49.42%), Tra Vinh (45.72%), Soc Trang (43.71%), and Vinh Long (39.69%). Generally, if the sea level rises by 1m by the end of the 21st century, the total flooded area of the region is 12,376.7 km^2, accounting for 85.19% of the total flooded area of Vietnam and 31% of the entire MRD.

Secondly, salinity intrusion reduces the area of cultivated land. Saline intrusion due to sea level rise makes many land areas unable to be cultivated. Due to the impact of sea water, land in coastal areas is often saline, especially at the time seawater intrutes in stormy periods. In addition, fresh water for irrigation in these areas is also very limited. Sea level rise will worsen salinity intrusion in coastal areas, leading to reductions of cultivated land, e.g., land use coefficient can be reduced from 3-4 times per year to 1-1.5 times per year. Salinity will be particularly severe in the Mekong Delta. If the sea level rises by 1m, about 1.77 million ha of cultivated land will be salinated, accounting for 45% of the land area in the MRD and it is estimated that about 85% of people living in the MRD need support for agriculture production (ISPONRE, 2009). Provinces mostly affected by salinity intrusion are Bac Lieu and Ca Mau (Southern Institute for Water Resources Planning, 2013). In 2016, several provinces in the MRD have to change their crop seasons due to the effects of salt intrusion and droughts. Paddy outputs in some provinces in 2016 were reduced sharply as compared to 2015, for example, Kien Giang decreased by 175 thousand tons; Ben Tre reduced by 25.7 thousand tons; Soc Trang decreased by 19.7 thousand tons; and Long An reduced by 12 thousand tons (GSO, 2016). In general, coastal provinces are significantly affected by salinity incursion combined with high tides which heavily damage rice yield. Although increase in salinity may damage rice production, it can create favorable environment for shrimp farming which needs brackish water.

Thirdly, increased temperatures and droughts (and lack of irrigation water) will affect the distribution of crops, particularly reduction of rice productivity and yield. Changes in the climate also leads to changes in living conditions of species, leading to the disappearance of some species and appearance of some risky pests. In the last two years, brown planthopper, yellow dwarf, and leaf dwarf in the Mekong Delta have become increasingly complex and placed harmful impacts

on the capacity to intensify and increase crops and then reduce rice yields. In addition, climate change can affect crop seasons and change crop structure, irrigation, rice yield and productivity in the MRD (Le Quang Tri, 2016). In the high emission scenario for temperature and rainfall in Vietnam, by the end of the 21st century, the annual average temperature may increase from 2.5^{o}C to 3.7^{o}C while the annual rainfall may increase from 2% to 10%. Changes in temperature and rainfall can impact paddy production in terms of changes in evapotranspiration, growth stages or biomass production.

In general, the loss of agricultural land and decline in crop yields will poses challenges and threats to the lives of farmers, rice exports and national food security. Agriculture plays an important role in the Vietnam's economy since agriculture accounted for 40.2% of the labor force and contributed 15.34 % to the country's GDP in 2017 (GSO, 2018). It is forecasted that by 2100, if the sea level rises by 1m, the rice yield in the Mekong Delta and Ho Chi Minh City will be lost by about 7.6 million tons of rice per year, equivalent to 40.5% of the region's rice production. Thus, Vietnam will be at risk of severe food shortages by 2100 due to the loss of 21.39% of paddy production (Phan Sy Man and Ha Huy Ngoc, 2013).

Adaptation to climate change in agriculture is a long lasting and ongoing process in communities severely affected by climate risks. It is the process of regular adjustments in farming, livestock, fisheries and aquaculture practices based on needs and capacities of communities to adapt to weather and climate conditions. Farmers in the MRD are currently experiencing two hydrology-related risks: floods in the rainy season and droughts and salt intrusion in the dry season. In general, climate change places a great impact on the rice farming system in the MRD. Local residents in the region have found a variety of measures to adapt to rapid change in climate conditions, including both application of measures to reduce damages and exploitation of beneficial opportunities from climate change. Adaptation measures from rice cultivation to the climate change impacts are very diverse. Local residents cultivate rice only in rainy season in areas with high rainfall but limited water supply. Farmers grow only one summer-autumn crop in flooded areas while cultivating 2 crops (summer-autumn and autumn-winter crops) in non-flooded areas. Extensive shrimp farming combined with rice cultivation model have been applied in several areas in which shrimp are only cultured in the dry season when salinity intrusion occurs. Farmers also combine different crops and livelihoods, including rice, fruit trees and aquaculture. Living with floods is also an adaptation measure for local people in the MRD for many generations.

3.2.3. Green house gas emissions from rice cultivation and the need for climate change mitigation in the Mekong River Delta, Vietnam

During the period 1994-2013, the total green house gas (GHG) emissions (with land use, land use change, and forestry - LULUCF) in Vietnam, including CO_2, CH_4, N_2O, increased from 103.8 $MtCO_2e$ in 1994 to 259.0 $MtCO_2e$ in 2013 (Table 2). Emissions from energy sector went up the most rapidly, a six-fold increase, from 25.6 $MtCO_2e$ to 151.4 $MtCO_2e$, due to the rapid increase in energy demand. LULUCF sector in 2010 changed from an emission source to a removal and increased to 34.2 $MtCO_2e$ in 2013 as a result of recent effective reforestation and forest protection activities.

Table 2: GHG emissions inVietnam in the period 1994-2013

Unit: $MtCO_2e$

Sectors	**1994**	**2000**	**2010**	**2013**
Energy	25.6	52.8	141.1	151.4
Agriculture	52.4	65.1	88.3	89.4
Industrial processes	3.8	10.0	21.2	31.7
LULUCF	19.4	15.1	-19.2	-34.2
Waste	2.6	7.9	15.4	20.6
Total	**103.8**	**150.9**	**246.8**	**259.0**

Source: MONRE (*2014*), *MONRE* (*2017*)

The total GHG emission from agriculture sector in 2013 is 89.4 $MtCO_2e$ as presented in Table 3. Emissions from rice cultivation contributed the largest share (50.0%). The second largest share comes from agricultural soils (26.9%), followed by enteric fermentation (11.6%), manure management (8.8%), field burning of agricultural residues (2.7%), and a small amount from prescribed burning of savannas.

Table 3: GHG emissions in Agriculture in Vietnam in 2013

Categories	**CH_4 ($MtCO_2e$)**	**N_2O ($MtCO_2e$)**	**Total ($MtCO_2e$)**	**Share (%)**
1. Rice cultivation	44.74		44.74	50.0
2. Agricultural soils		24.04	24.04	26.9
3. Enteric fermentation	10.33		10.33	11.6
4. Manure management	2.08	5.81	7.81	8.8
5. Field burning of agricultural residues	1.97	0.415	2.38	2.7
6. Prescribed burning of savannas	0.1	0.001	0.1	0.001
Total	**59.13**	**30.27**	**89.4**	**100**

Source: MONRE, 2017

Rice production contributes a considerable amount of GHG emission. Therefore, efforts in reducing GHG emission from rice production in Vietnam will significantly contribute to the achievement of GHG reduction target of Vietnam's NDC. If having received international support, GHG reduction in rice production in Vietnam in general and in the MRD in particular would be successfully achived.

A wide range of field measurements conducted in different Asian countries provides a broad, though not exhaustive, data base on region-specific emission factors as well as crop management impacts on different rice ecosystems. However, there is not a single emission record published from Vietnam's rice fields. GHG emissions in the MRD can be expected to show distinct features as compared to other rice growing regions due to a range of peculiarities in edaphic, hydrological, and management settings.

Significant amount of GHG emissions from rice production in Vietnam in general and in MRD in particular places the need for implementation of climate change mitigation measures.

Several measures to mitigate climate change from rice cultivation include implementation of system of rice intensification (SRI), integrated crop management (ICM), wet and dry irrigation systems and improved rice cultivation system; replacement of urea with sulfate amon fertilizer; reuse of straw as an organic fertilizer; and re-use by-products of crop residues annually

4. Discussion and Conclusion

Climate change significantly impacts the MRD in general and rice production in particular. The impacts have resulted in high vulnerabilities and risks for 17.7 million people in the region (19% Vietnamese population) who are mainly smallholders and the poor. If these vulnerabilities and risks are not addressed and no effective response measures are implemented, such impacts will threaten lives, food security, poverty reduction, and economic development in the region and the nation as well.

The Vietnamese Government commited to use their own resources to reduce GHG by 8% compared to BAU – Business As Usual levels, equivalent to 474.1 million tonnes of CO_2-e by 2020 and 787.4 million tonnes of CO_2-e by 2030; reduce the per-GDP-unit emission magnitude by 20% as compared to 2010. With the international support, Vietnam can reduce GHG by 25% and per-GDP-unit emission magnitude by 30%. Vietnam has a great potential for GHG reduction from agriculture. Vietnam can reduce GHG only by 4.4% in energy sector and 5.8% in agricultural sector without an international assistance, but it can reduce GHG by 9.8% in energy sector and 41.8% in agricultural sector with the international assistance (MONRE, 2015). The Government issued Resolution No. 120/NQ-CP dated 17/11/2017 on sustainable development of the Mekong River Delta in response to climate change.

The sustainability of rice production in the Mekong River Delta can be damaged if effective measures have not been implemented to address food security and climate change concerns. It is vital to support the development of low emission, climate change resilient, sustainable rice value chain that can ensure food security, adaptation to climate change and implementation of the country's NDC's target of reducing up to 25% of GHG emission with international support.

To develop rice production in the MRD towards climate-smart rice production, it is necessary to transform ineffective rice land to cultivation of other effectivecrops (maize, soybean, vegetables, fruits, rice-aquaculture, organic agriculture). Low emission and adaptive rice production technologies will be scaled up and farmers should be trained on low carbon and climate smart rice production technologies, application of information technology to access information of material and agro-product marketing. The link between production and market should be established to promote agro-product consumption and increase income of farmers. It is also crucial to enhance the climate resilient capacity of agricultural systems through improved water security and resilient agricultural production; increase the capacity of small-holders and related organizations in using climate information for agricultural management. Policies and mechanisms should also be formulated to attract enterprises' investment, enhance linkage with farmers in resilient and low emission rice production.

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