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Promotion of Climate Resilience in Rice and Maize

Vietnam National Study

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ASSOCIATION OF SOUTHEAST ASIAN NATIONS (ASEAN) and the GERMAN-ASEAN PROGRAMME ON RESPONSE TO CLIMATE CHANGE (GAP-CC), DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GMBH. IN PARTNERSHIP WITH THE SOUTHEAST ASIAN REGIONAL CENTER FOR GRADUATE STUDY AND RESEARCH IN AGRICULTURE (SEARCA)

List of Acronyms

AMS	ASEAN Member States
ASEAN	Association of Southeast Asian Nations
AWD	Alternate Wetting and Drying
CCA	Climate Change Adaptation
DAS	Days After Sowing
IRRI	International Rice Research Institute
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
MRD	Mekong River Delta
NGO	Non-government Organization
NMMA	Northern Midlands and Mountainous Areas
RRD	Red River Delta

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Foreword

Vietnam is one of the countries that is dramatically affected by climate change. Key climate risks are sea level rise, extreme weather events, rising temperature and changes in precipitation, which could severely affect the agriculture production. Therefore, it is highly necessary for Vietnam to have proper climate change adaptation measures to mitigate the impacts and ensure food security, agricultural production and development in the long term.

In this context, the regional study through the ASEAN Technical Working Group on Agricultural Research and Development (ATWGARD) with the generous support of GIZ through the German-ASEAN Programme on Response to Climate Change (GAPCC), which seeks to promote resiliency of rice and other crops is highlight appreciated. Vietnam has knowledge on climate adaptive practices in the region, and through this project, we are happy to be given the opportunity to share and also learn from our neighbors at ASEAN.

Under this project, five good case studies are highly recommended which include three for rice, namely: Alternate Wetting and Drying (AWD) technique, rice-shrimp farming, and adjustment of rice crop cultivation timing and use of short growing duration rice varieties; and two for maize production, namely: an appropriate planting density with adequate row spacing and plant spacing within rows in flat areas, and improving cultivation practices in sloping areas for maize.

This body of work is not only beneficial to our work in Vietnam, but to other relevant entities in the ASEAN region, which work with farmers and climate change. Therefore, the highlighted practices need to be encouraged and replicated in similar areas, through regional collaboration of joint measures such as research and information exchange.

Dr. Nguyen Thi Thanh Thuy
Director General
Department of Science, Technology & Environment
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Executive Summary

The Intergovernmental Panel on Climate Change (2007) considers Vietnam as one of the countries that are most vulnerable to climate change. Key climate change risks in the country are sea level rise, extreme weather events, rising temperature, and changes in precipitation. Climate change has caused great human and property losses, substantially influenced socio-economic and cultural infrastructure, and imposed negative effects on the environment nationwide. Agriculture is expected to be the most vulnerable sector as agricultural production depends more heavily on climate than on other factors. Therefore, it is imperative for Vietnam to devise proper climate change adaptation (CCA) and mitigation measures to ensure long-term food security, agricultural production, and development.

This report reviews climate change impacts on rice and maize, the two main food crops in Vietnam. It also presents good examples of CCA measures for these crops. Practices are considered good examples if they are effective in limiting the negative effects of climate change and have the potential for regional replication.

The following good practices in CCA options for rice and maize are highly recommended: for rice, (1) alternate wetting and drying (AWD) technique, (2) rice-shrimp farming, and (3) adjusting rice crop timing and using short-duration rice varieties; and for maize, (1) applying appropriate planting density with adequate row spacing and plant spacing within rows in flat areas, and (2) improving cultivation practices in sloping areas. These procedures, which have been applied across the country, have shown promise in reducing the harsh consequences of climate change and being replicated in other geographic regions experiencing the same impacts. They can also be disseminated to other countries in Southeast Asia through technical and financial collaboration.

I. INTRODUCTION

1.1 Context

Climate change is one of the biggest challenges of today. It has become increasingly serious and is mainly manifested by global warming and sea level rise. This phenomenon attracts significant global interest, and countries worldwide are striving to identify measures for CCA and mitigation.

The annual average temperature in Vietnam has increased by 0.5ºC–0.7ºC and continues to intensify. The rate of sea level rise was about 3 millimeters (mm) per year from 1993 to 2008, which coincides with the global tendency. Precipitation has been inconsistent, but it decreased by about 2 percent in the 50 years following 1958. Extreme weather events, such as typhoons, floods, and droughts, have been increasing in number and density (MONRE 2009).

Climate change has caused great human and property losses, substantially influenced socio-economic and cultural infrastructure, and imposed negative effects on the environment nationwide. Since 2001, natural disasters, such as floods, flash floods, landslides, droughts, soil and water salinity, and other calamities, have resulted in 9,500 deaths and unrecovered people as well as damaged about 1.5 percent of annual gross domestic product.

As stated in Decision No. 2139/QD-TTg (2011), food security and agricultural development are the most threatened among the sectors that have been strongly affected by climate change. Agricultural lands have decreased, especially a significant area of low-lying coastal lands, and the Red River Delta (RRD) and the Mekong River Delta (MRD) are flooded with saltwater because of sea level rise. As a result, crop growth, productivity, and cultivation schedules have changed; pestilent insects now pose greater risks; the adaptability period of tropical and subtropical plants has expanded and diminished, respectively; and the reproduction and growth of domestic animals, including their resistance to epidemics, have been negatively influenced (Decision No. 2139/QD-TTg 2011).

It is predicted that Vietnam is one of several countries that will be most adversely affected by climate change. It has been dubbed a "natural disaster hotspot," ranking 7th on economic risk, 9th on the percentage of land area and population exposed, and 22nd on mortality from multiple climate hazards (e.g., sea level rise, floods, and typhoons) (IFAD 2011, 1; IPCC 2007). Vietnam is also considered a "hotspot of key future climate impacts and vulnerabilities in Asia" and an "extreme risk" country, ranking 13th among 170 countries in terms of vulnerability to climate change impacts over the next 30 years (IFAD 2011, 1; IPCC 2007).

Recognizing potentially remarkable outcomes, the government of Vietnam has made a strong commitment to confront climate change. It has carried out a series of actions to combat, adapt to, and mitigate the effects of climate change. In agriculture, CCA measures include (1) increased spending on research, development, and extension to raise average crop yields by 13.5 percent by 2050 relative to the baseline; and (2) extending irrigated land area by about 688,000 ha by 2050 (World Bank 2011, p.76). The total costs of adaptation measures are substantial and were estimated at USD 8.8 billion in 2009; however, despite the prices (without discounting) estimated for 2010–2050, which covers agricultural research and extension (USD 4.05 billion) as well as irrigation expansion (USD 4.76 billion), the benefits of adaptation outweigh its costs (IFPRI 2009).

Adaptation measures will improve both crop yield and areas compared with no-adaptation scenarios, improving all economic indicators.

Compared with no-adaptation scenarios, adaptation measures will improve not only overall welfare but also income equality between different types of households, which are classified as urban or rural and expenditure quintile. Poorer households will gain more from adaptation than richer households. Adaptation measures will also make climate change impacts more evenly distributed across Vietnam's eight agro-ecological regions (CoPS/MONASH 2012).

The rice sector is a key player in ensuring national food security in Vietnam. Rice is the staple food of the majority in the country, and rice production is the main livelihood of about 50 percent of the country's total population. The rice sector also contributes to production value and export turnover, but rice production is forecasted to be severely disrupted by sea level rise and temperature increase. Rice yield in the MRD, the main rice bowl in Vietnam, will decrease by 6.3 percent to 12 percent under different scenarios because of higher temperature. Paddy land will be exposed to extensive inundation and saltwater intrusion because of sea level rise, which will also lead to a decline in rice area and production. It is estimated that a sea level rise of 30 centimeters (cm) by 2050 will result in rice area losses of 193,000 hectares (ha) and 294,000 ha because of inundation and saltwater intrusion, respectively. Consequently, rice production in MRD will decline by about 13 percent (IFPRI 2010).

Maize is the second most important food crop in Vietnam. It is used commonly as a substitute staple in periods of rice shortage and extensively for human consumption in some rural areas and mountainous regions. Maize is considered the primary source of feed for livestock production and thus an important source of income for many farmers. As with rice, climate change is likely to reduce maize productivity and production by 18.71 percent, which is higher than that of rice.

The potential impacts of climate change on rice and maize are presented in Table 1.

Table 1. Potential impacts of climate change on rice and maize under the MONRE medium emissions scenario, 2030

Crop	Quantity (1,000 t)	Rate (%)
Rice	-2,031.87	-8.37
Impacts of natural disaster	-65.27	-0.18
Impacts of change in potential yield	-1,966.60	-8.10
Maize	-500.40	-18.71

Source: Nguyen Van Viet (2011)
Note: Negative values indicate negative impacts, which denote a reduction in quantity and rate.

This study was conducted to identify good practices in CCA options for rice and maize in Vietnam, and to determine areas for regional cooperation to improve and spread CCA measures across the region of the Association of Southeast Asian Nations (ASEAN).

The methodology sought to cover the following objectives:

1. To identify climate change-related vulnerabilities in rice and maize that could lead to food insecurity

2. To identify where vulnerabilities exist or are likely to exist in the supply of rice and maize, focusing primarily on production and related inputs and secondly on post-production activities, specifically drawing out where regional collaboration could be most valuable

3. To use the lessons learned from the abovementioned points to stimulate and spread meaningful action across the region.

1.2 Approaches and Methodologies

This study made full use of existing information and data from official sources in Vietnam, such as government agencies that are responsible for or related to climate change policy formulation, implementation, and assessment; research institutions; and local and international non-government organizations (NGOs) that focus on climate change issues as well as CCA and mitigation measures. The research team also conducted in-depth interviews with experts on rice and maize production as well as discussions with specialists on climate change to gather more detailed information and develop a deeper understanding of the subject matter.

The study used the value chain analysis as a visualization tool to highlight phases that are vulnerable to climate change and likely to have good mitigation activities. Among many phases along the value chain, production and inputs supply are the main concerns, followed by post-production activities.

II. VALUE CHAIN MAPPING

2.1 Value Chain Selection

Rice is cultivated throughout Vietnam, mainly in RRD and MRD. Among six different agro-ecological zones, MRD accounts for the largest proportion of the total paddy rice planted area and is the biggest contributor to the total paddy production in the country (GSO 2013) (Table 2).

Table 2. Paddy planted area and production, 2012

Particulars	Paddy planted area		Paddy production	
	1,000 ha	%	1,000 t	%
Red River Delta	1,139.1	14.7	6,872.5	15.7
Northern midlands and mountainous areas	674	8.7	3,264.4	7.5
North central and central coastal area	1,235.9	15.9	6713	15.4
Central highlands	228.1	2.9	1,129.4	2.6
Southeast	294.8	3.8	1,389.5	3.2
Mekong River Delta	4,181.3	53.9	24,293.0	55.6

Source: GSO (2013)

Among rice production systems in the country, the irrigated lowland system is the most dominant, covering more than 80 percent of the national production volume (Table 3). It is vital to national consumption because it sustains both domestic demand and export supply. However, without proper and timely intervention, irrigated lowlands will deteriorate because of climate change impacts such as floods and salinity. The rice value chain in irrigated lowlands, specifically in MRD, was selected for analysis in this report.

Table 3. Rice production systems in Vietnam

Production system type	National production volume (1,000 t)	National production value (USD)	Assessment of impact on national/regional consumption	Indication/ estimate of relative vulnerability to climate change
Irrigated lowland	20,171.9	N/A	3	2
Rainfed lowland	2,420.0	N/A	1	2
Upland production	2,600.8	N/A	2	2

Source: GSO (2013)
Note: In the assessment of impact on national/regional consumption, the production system is estimated to represent the following values of domestic rice consumption for national food security: 1 – Low (less than 30 percent), 2 – Medium (from 30 percent to 55 percent), and 3 – High (greater than 55 percent).

Unlike rice, maize production is concentrated in upland areas. Upland maize production contributes nearly 60 percent of the total production and meets about 45 percent of domestic demand for maize as a food source (Table 4). Similar to rice production in MRD, upland maize production faces several climate change impacts that should be addressed immediately.

Table 4. Maize production systems in Vietnam

Production system type	National production volume (t)	National production value (USD)	Assessment of impact on national/ regional consumption	Indication/ estimate of relative vulnerability to climate change
Irrigated lowland	1,317.4	N/A	1	2
Rainfed lowland	597.7	N/A	1	2
Upland production	2,691.7	N/A	3	2

Source: GSO (2013)

Among agro-ecological regions, the northern midlands and mountainous areas (NMMA) is the main production area, where maize planted area and production comprise about 42 percent and 35 percent of the total, respectively (Table 5). NMMA is followed by the central highlands. The maize value chain in NMMA was selected for analysis because of the significance of maize production in the area.

Table 5. Maize planted area and production, 2012

Particulars	Maize planted area		Maize production	
	1,000 ha	%	1,000 t	%
Red River Delta	86.6	7.7	404.3	8.4
Northern midlands and mountainous areas	466.8	41.7	1,696.2	35.3
North central and central coastal area	202.3	18.1	826	17.2
Central highlands	243.9	21.8	1,214.3	25.3
Southeast	79.3	7.1	445.3	9.3
Mekong River Delta	39.4	3.5	217.5	4.5

Source: GSO (2013)

2.2 Value Chain Mapping

2.2.1 Rice Value Chain in the Mekong River Delta

There have been several studies on the rice value chain in MRD. The first and seemingly most detailed rice value chain was done by Agrifood Consulting International in 2002, which mentions five key actors along the chain: input providers, farmers, collectors, millers/polishers, and traders and retailers/ end-users. Below is the most updated rice value chain (Figure 1).

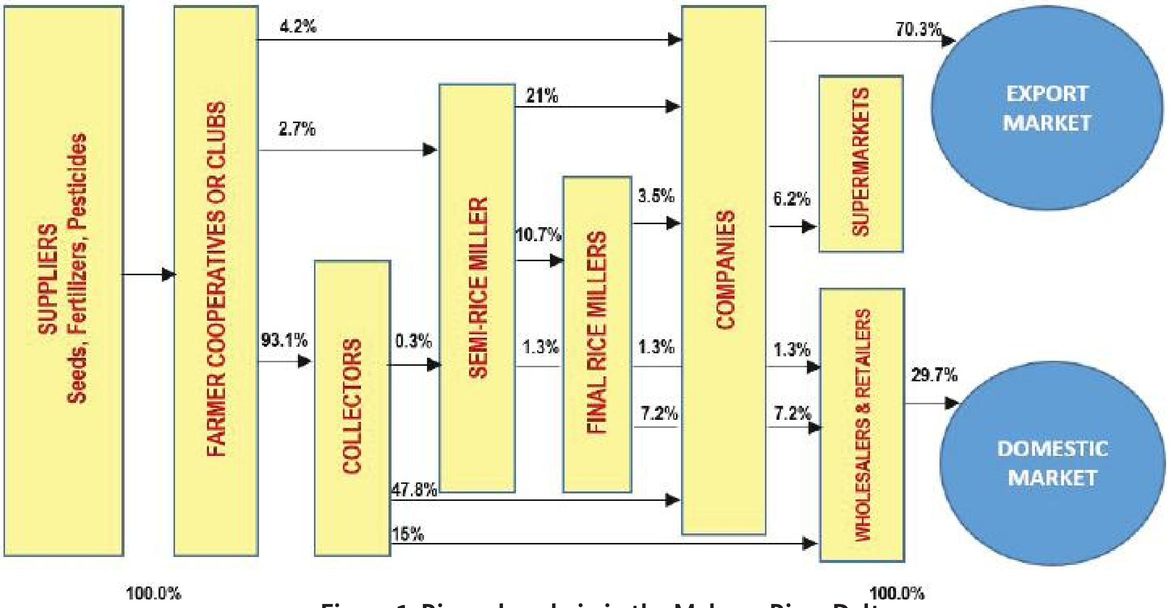

Figure 1. Rice value chain in the Mekong River Delta

Compared with the value chain in 2001, the number of actors along the rice value chain has more or less remained the same over time. In the export value chain, the key actors are still input suppliers, which include seed, fertilizer, and pesticide suppliers; farmers; collectors; millers; and exporters. In the domestic value chain, wholesalers and retailers replace exporters. One outstanding feature of the chain is that while various actors carry out post-production activities, farmers (as individuals or as members of cooperatives or clubs) and input providers are solely responsible for production and input.

2.2.2 Maize Value Chain in the Northern Midlands and Mountainous Areas

Maize is the staple food of people in the NMMA. This crop has become increasingly important to national food security because it is also important to the feed industry. More than 80 percent of maize production is used for animal and aqua feed industries.

The maize value chain shown in Figure 2 was drawn from a study in 2002. In the current maize value chain, which is similar to the traditional value chain, many actors participate in post-production activities. Such participation is also visible in the rice value chain. Only farmers are involved in production, and the lack of cooperatives is striking. Another noticeable feature of the value chain is the lack of input providers. Input providers are available, but they are not mentioned because of their very limited role in the whole value chain. Farmers mainly use their own seeds and hardly use other inputs such as fertilizers and insecticides. This will be reviewed in more detail in the case studies.

Unlike the rice value chain in MRD, where all stages are almost done in the zone, only some actors (e.g., farmers, assemblers, and local wholesalers) in the maize value chain operate in NMMA, which is vulnerable to climate change impacts. Other actors in the maize value chain operate in RRD.

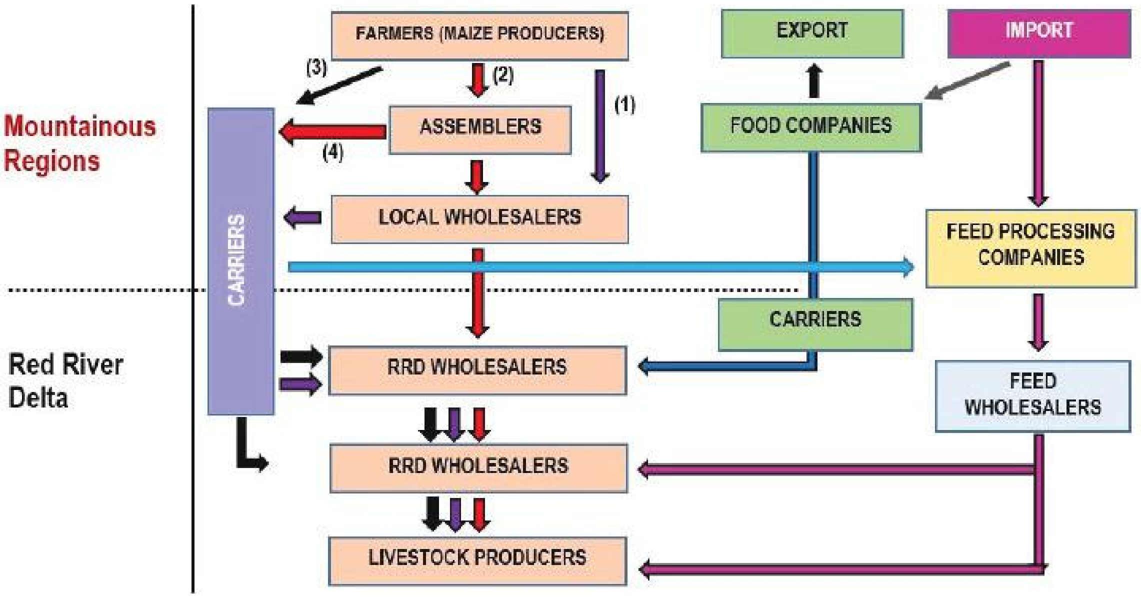

Figure 2 . Maize value chain in the northern midlands and mountainous areas in Vietnam
Source: CIRAD (2014)

III. CLIMATE CHANGE IMPACTS AND VULNERABILITIES

3.1 Review of Climate Change Variables

Vietnam is considered one of the countries that are most vulnerable to climate change. The following climate change variables considerably influence agriculture in general and selected crops and regions in particular:

- Based on historical data from 1958 to 2008, temperature increased nationwide (MONRE 2009). This rising trend will continue and the northern part of the country will experience a faster increase rate, especially during winter.

- Typhoons, which barely affected the southern part of the country in the past, have recently moved southward. Typhoons of extremely high density and abnormal movement have caused substantial damages and losses.

- Sea level rise is considered the most serious climate change risk in the country. It has already negatively affected the largest areas of agricultural production and dense population. Sea level rise is associated with inundation and saltwater intrusion, which have reduced production area as well as weakened the productivity and quality of agricultural products, especially rice.

- Historical data on production show a decrease in precipitation and the number of rainy days per year. It is anticipated that rainfall will increase but highly fluctuate between the rainy and dry seasons. There will be a higher rate of increase in the northern region than in the southern region.

These trends are presented in Table 6.

Table 6. Historical and projected trends in climate variables in Vietnam

Variable	Specific climate risk/opportunity	Historical trend	Projections	Confidence	References
Mean temperature	Increase	Increased by 0.5ºC–0.7 ºC from 1958 to 2007	Increase of about 0.5 ºC by 2020 but faster in winter and northern areas than summer and southern areas	High	MONRE (2009)
Rainfall	Increase High fluctuation between dry and rainy seasons	Decreased by 2 percent from 1958 to 2007	Decrease and increase in rainfall during the dry and rainy seasons, respectively By 2020, rainfall will increase by about 1.5 percent in the north and 0.5 percent in the south	High	MONRE (2008, 2009)
Cold fronts	Decrease	Reduced dramatically but anomalous events seem more frequent and extreme	Decrease in frequency and intensity	High	MONRE (2008, 2009)
Typhoons	Increase	More frequent and moved southward with higher density and abnormal movement	Increase in frequency and intensity in the north and no changes in the south Increase in southward movement between September and November	High	MONRE (2003, 2009)
Number of rainy days	Decrease	Decreased gradually	Gradual decrease	High	MONRE (2009)
Sea level	Increase	Increased by about 3 mm/year	Increase of 11 cm by 2020	High	MONRE (2009)

Climate change variables vary among climate zones, resulting in diverse consequences. In NMMA, the average temperature will increase, leading to higher evaporation and lower relative humidity. Rainfall will also increase, primarily during the peak rainy season, while the number of rainy days per year will decrease. The NMMA will be more prone to droughts during the dry season and floods during the rainy season. In addition to higher temperature and precipitation, MRD will face sea level rise and tropical cyclones. Cyclones of higher frequency and density during September and November may cause severe floods, resulting in substantial losses and damages in both agricultural production and infrastructure. Sea level rise, which will severely affect this region, will be manifested by the inundation and saltwater intrusion of vast areas.

These trends are presented in Table 7.

3.2 Impacts on Selected Crops and Vulnerabilities

3.2.1 Impacts on the Rice Sector

In Vietnam, rice production in RRD and MRD constitutes about 70 percent of the total paddy planted area and production. Among the three rice production systems in the country, irrigated lowland is the most common and also the most vulnerable to climate change impacts in terms of exposure and sensitivity.

Seedling or sowing in RRD and MRD seems to be severely influenced by the drop in precipitation during the dry season. This results in water shortage or even drought, especially during the dry season. As a coping mechanism, farmers have to either delay the current crop to wait for supplemental water supply, thus delaying the subsequent crops; or find ways to supply adequate water on time, thus increasing rice production cost. Another negative impact is lower rice yield due to insufficient water supply during sowing, resulting in lower production and smaller income earned by farmers from selling rice.

Flowering is also highly dependent on water supply. Increase in temperature and a decrease in rainfall during the dry season will trigger a decline in available water. Consequently, rice productivity will decrease and farmers' income will drop due to lower production.

Agriculture in Vietnam has used water extensively and wastefully. Up to 85 percent of annual freshwater withdrawals is from agriculture compared to 40 percent in other countries (Table 8). Moreover, the rate of evaporation is considerably high and continues to increase. As such, water shortage caused by evaporation under high temperature and rainfall fluctuation between seasons will hamper the development of agriculture, especially the rice sector, in the near future.

Table 7. Historical and projected trends in climate variables by climate zones in Vietnam

Climate zone	Year	Change in		Narrative
		Temp (°C)	Rainfall (%)	
Sea level rise in coastal Vietnam: 11–12 cm in 2020 and 28–33 cm in 2050				
Northwest	2020	0.5	1.4–1.7	**Cold fronts:** Lower frequency, with the northwest region more affected; increased variability of occurrence; mid-winter peaks diminish **Temperature:** Increased occurrence of hot spells in mid and lower elevations; longer hot season and shorter cold season at lower elevation; higher evaporation and lower relative humidity **Rainfall:** Increased variability during the dry season; increased incidence of severe droughts, especially in the final months of the dry season; increased incidence of extreme rainfall events (e.g., intensity, scale, duration, and rainy periods); decrease in "drizzly" rainfall between the dry and rainy seasons in northeast mountains; increased variability of the onset and/or end of the dry and rainy seasons; increased rainfall concentration in peak months
Northeast	2050	1.2–1.3	3.6–3.8	
Red River Delta and Quang Ninh (a coastal province in the northeastern region)	2020	0.5	1.6	**Tropical cyclones:** May increase frequency and intensity; inter- and intra-annual variability increase; typhoon season starts earlier and/or ends later **Cold front:** Lower frequency and intensity; inter- and intra-annual variability increase **Temperature:** Higher normal and maximum values; increased occurrence, intensity, and duration of hot spells; warmer and shorter cold season; longer and more severe warm season; higher evaporation **Rainfall:** Long-term increase in rainfall during the rainy season; increased rainfall variability during the dry season; increased variability of the onset and/or end of the dry and rainy seasons; increased incidence of extreme rainfall events (e.g., intensity, scale, duration, and rainy periods); increased incidence of droughts; decrease in "drizzly" rain **Sea level:** Increased rate of rise (5–6 mm/year)
	2050	1.2–1.3	3.9–4.1	
North central coast	2020	0.5–0.6	1.5–1.8	**Tropical cyclones:** May increase frequency and intensity; inter- and intra-annual variability increase; typhoon season starts earlier, ends later, and becomes shorter **Cold front:** Decreased incidence; shorter seasons and longer intervals between fronts **Temperature:** Higher normal values; the windy season (dry, hot, and westerly winds) arrives earlier and/or ends later; increased number and duration of hot spells; shorter cold season in the north; southern boundary of the cold season will move to higher latitudes; ceased occurrence of hoarfrost in the north (now rare); higher evaporation **Rainfall:** Long-term increase in rainfall during the rainy season; rainfall will increasingly be concentrated in months with higher precipitation; minimal changes in the south during the dry season, but the north may be permanently dry and hot like in the south in May and June; decrease in "drizzly" rain in the north; increased daily/monthly/annual maximum values in the central coastal strip; increased incidence and severity of droughts **Sea level:** Increased rate of rise (5–6 mm/year)
	2050	1.4–1.5	3.8–4.0	
South central coast	2020	0.3	0.7	
	2050	0.9–1.0	1.6–1.7	
Central highlands	2020	0.4	0.3	**Cold front:** Decreased incidence (rate is already increasing) **Tropical cyclones:** May penetrate deeper inland **Temperature:** Higher normal and maximum values, especially in lower elevations and mid or lower reaches of major rivers; increased occurrence of hot spells in lower elevations, hollows, and river valleys; longer hot season in mid or lower elevations and shorter cold season in mid or high elevations; higher evaporation contributing to severe droughts in early months of the year **Rainfall:** Long-term increase in rainfall during the rainy season; strong increase in variability during the dry season; overall increase in variability with increased maximum daily/monthly/annual rainfall; increased incidence and severity of droughts in the latter half of winter; increased variability of the onset and/or end of the dry and rainy seasons
	2050	0.8	0.7	
South (Southeast and Mekong River Delta)	2020	0.4	0.3	**Tropical cyclones:** May remain unchanged but will increase in southward movement between September and November **Temperature:** Higher normal and maximum values; increased incidence and severity of hot spells in the early months of the year; higher evaporation with increased dryness, especially in April and May **Rainfall:** Long-term increase in rainfall during the rainy season; increased rainfall variability during the dry season; distribution across southern areas will change significantly; inter-annual and intra-seasonal variability in rainy seasons; increased rainfall intensity and maximum daily/weekly/monthly amounts (equal or nearly equal to south central) **Sea level:** Increased rate of rise (5–6 mm/year)
	2050	1.0	0.7–0.8	

Source: ISPONRE (2009), MONRE (2010)

Table 8. Annual freshwater withdrawals from agriculture (% of total)

Country	Year	Annual freshwater withdrawals from agriculture (% of total freshwater withdrawal)
Cambodia	2011	94.0
China	1987	86.3
	1997	77.6
	2011	64.6
Indonesia	1997	93.1
	2011	81.9
Laos	2011	93.0
Malaysia	1997	60.2
	2011	34.2
Myanmar	1987	98.6
	1997	98.6
	2011	89.0
Thailand	2011	90.4
Vietnam	1987	89.8
	2002	89.8
	2007	94.8
	2011	94.8

Source: World Bank (2014).
Note: Annual freshwater withdrawals refer to total water withdrawals, excluding evaporation losses from storage basins. Withdrawals also include water from desalination plants in countries where they are a significant source. Withdrawals can exceed 100 percent of total renewable resources where extraction from non-renewable aquifers or desalination plants is considerable or where there is significant water reuse. Withdrawals for agriculture are total withdrawals for irrigation and livestock production.

In contrast to sowing and flowering, harvesting activities are exposed to high risks, especially floods, due to higher rainfall during the rainy season. Farmers in RRD and MRD have experienced higher post-harvest losses during the rainy season, or partial or full damages or losses because of floods. They manage the risks by using submergence-tolerant or short-duration rice varieties, or adjusting the cropping calendar to ensure that the crops are harvested before the rainy season begins.

Typhoons tend to be more frequent and abnormal, and they cause similar problems in harvesting activities. Typhoons or floods also affect post-harvest activities (e.g., processing or drying) because storage capacity and processing facilities at the household level are limited.

Sea level rise is the biggest challenge for MRD because of its adverse effects. Inundation and saltwater intrusion caused by sea level rise will reduce rice production in MRD from 5.2 percent to 8 percent by 2050 (Table 9). Production losses may increase if productivity decrease is incorporated in this calculation.

Table 9. Effects of sea level rise on rice production and area in the Mekong River Delta, 2050

Particulars	Rainy season (Inundation)	Dry season (Saltwater intrusion)
Affected area (1,000 ha)	276.00	420.00
Affected rice area (1,000 ha)	193.00	294.00
Production loss (million t)	0.89	1.77
Production loss (%)	5.20	8.00

Source: IFPRI (2010)

For RRD, more frequent and extreme anomalous cold fronts are likely to have adverse effects on winter-spring crops, reducing productivity.

A decrease in the number of rainy days will also cause water shortage, leading to lower productivity and higher production cost because of higher water supply cost. However, it will be easier for rice farmers to manage a decline in rainy days than other climate change impacts.

To locate points in the value chain that are vulnerable to climate change impacts, vulnerability was estimated by considering various aspects, including exposure, sensitivity, and ability to adapt. For rice in MRD, production activities, especially seedling, flowering, and harvesting, have medium vulnerability. For sea level rise, both exposure and sensitivity are high because of the current substantial impacts on rice production and the increasing number of potential impacts. Ability to respond is at the medium level, which means that to some extent, rice production can respond to climate change. However, its ability to respond should be strengthened to improve its capacity to cope. Responses can be done in different ways, but a more manual approach is required for some activities or stages that have a low level of mechanization. Plowing, watering, and transportation have a higher level of mechanization than drying and sowing in rice production nationwide and in MRD. The level of mechanization in harvesting is only 30 percent compared to 90 percent or more in other activities. The mechanization in rice production for the whole country and MRD is presented in Table 10.

Table 10. Mechanization in rice production

Stage	Degree of mechanization
Whole country	
Plowing	75%
Sowing	20%
Watering	85%
Drying	39%
Transporting	70%
Mekong River Delta	
Harvesting	30%
Threshing	90%
Husking	95%

Source: MARD (2010)

The level of mechanization is diverse among different types of production organizations. Enterprises have the highest level of mechanization, followed by cooperatives and households. Approximately 14.8 percent of enterprises own tractors and ploughs, 74 times higher than the average of the whole agricultural sector (0.2%). The number of engines and generators is 9–38 times higher than the average of the agricultural sector. The number of water pumps and pesticide sprayers is 6–17 times higher and the level of mechanization of cooperatives is also higher than the average of the agricultural sector. Given the large number of small households, the level of mechanization in agricultural production in Vietnam remains low (GSO 2012).

Women are active in harvesting activities and some post-harvest activities such as drying. As such, using machines during these activities will reduce the work load of women. Climate change impacts on and vulnerability rating for rice production are synthesized in Table 11.

3.2.2 Impacts on the Maize Sector

As the main production system for maize is rainfed upland, maize production is extremely sensitive to water availability. Rainfall decrease or droughts during the dry season will lead to a shortage of water for maize production. The absence of rain at sowing time will push farmers to delay cropping, which will most likely delay the planting of maize or other crops. Similarly, rain is the primary prerequisite during flowering for maize to grow and mature. Otherwise, productivity will be drastically reduced or farmers may suffer from absolute losses.

Water shortage makes all production activities before harvesting more difficult, but an increase in rainfall at harvesting time is the main cause for higher post-harvest losses in maize production. Harvesting activities are mainly done manually and highly vulnerable to bad weather conditions. Storage as well as processing facilities and technologies (e.g., drying after harvesting) are not available in NMMA.

Applying the same vulnerability rating method, sowing, flowering, harvesting, and post-harvest activities have medium vulnerability. These processes have medium ability to respond, but they have high exposure and sensitivity to climate change because maize production in NMMA is naturally rainfed. It is completely dependent on rain and the application of CCA measures has been very limited.

Unlike rice production in MRD, maize production is mainly done manually in all stages of production. Challenging geographic conditions (i.e., small farm size with different slopes in NMMA), as well as limited technical and financial capacity of farmers in NMMA, make it difficult to use machines. Almost all maize farmers are ethnic minorities from low income quintiles and with low educational levels. Therefore, with the intensive participation of women in sowing and harvesting activities, it is likely that improvements in maize production will increase income-generating opportunities for women and girls. Climate change impacts on and vulnerability rating for maize production are synthesized in Table 12.

Table 11. Climate change impact assessment and vulnerability rating for rice production in Vietnam

System of interest	Geographic location	Climate change trend	Biophysical impact	Socio-economic impact	References	Exposure	Sensitivity	Ability to respond	Vulnerability rating
Irrigated lowland rice flowering	MRD	Increasing mean temperature	Water shortage caused by high evaporation	Lower productivity Higher production cost for water supply	Experts on climate change and rice	M	M	M	M
	RRD					M	M	M	M
Irrigated lowland rice seedling/ sowing	MRD	Increasing rainfall, highly fluctuating between the dry and rainy seasons	Water shortage in dry season Droughts	Lower productivity Higher production cost for water supply Delayed cultivation of current and subsequent crops		M	M	M	M
	RRD					M	M	M	M
Irrigated lowland rice flowering	MRD	Increasing rainfall, highly fluctuating between the dry and rainy seasons	Water shortage in dry season Droughts	Lower productivity Higher production cost for water supply		M	M	M	M
	RRD					M	M	M	M
Irrigated lowland rice harvesting	MRD	More frequent and abnormal typhoons	Damage crop Higher post-harvest losses	Lower rice productivity and quality Partial or total losses		M	M	M	M
	RRD					L	L	M	L
Irrigated lowland rice post-harvest activities (e.g., storage and processing)	MRD	More frequent and abnormal typhoons	Damaged crops Higher post-harvest losses	Lower rice quality Partial or total losses		M	M	M	M
	RRD					L	L	M	L
Irrigated lowland rice production	MRD	Sea level rise	Soil quality affected by saltwater intrusion and inundation Paddy land diminishes	Lower rice productivity and quality Decrease in farmers' income		H	H	M	M
Irrigated lowland rice flowering	RRD	More frequent and extremely anomalous cold fronts	Damaged crops	Lower rice productivity and quality or total losses		M	M	M	M
Irrigated lowland rice production	RRD	Decreasing number of rainy days	Water shortage	Lower productivity Higher production cost for water supply		L	L	M	L
	MRD					L	L	M	L

Sources: ISPONRE (2009), MONRE (2010), and author's synthesis of results from meetings with various experts on rice and climate change

Table 12. Climate change impact assessment and vulnerability rating for maize production in Vietnam

System of interest	Geographic location	Climate change trend	Biophysical impact	Socio-economic impact	References	Exposure	Sensitivity	Ability to respond	Vulnerability rating
Rainfed upland maize seedling/ sowing	NMMA	Decreasing rainfall during the dry season Increasing incidence of severe droughts	Water shortage	Lower maize productivity Delayed cultivation of current and subsequent crops Bigger workload for farmers	Experts from NMRI	H	H	M	M
	Central highlands					H	M	M	M
Rainfed upland maize flowering	NMMA	Increasing mean temperature Decreasing rainfall during the dry season	Water shortage	Lower maize productivity and quality		H	H	M	M
	Central highlands					L	L	M	L
Rainfed upland maize harvesting	NMMA	Increasing rainfall	Damaged crops or higher post-harvest losses	Lower rice productivity and quality Total losses Bigger work load for farmers		H	H	M	M
	Central highlands					L	L	M	L
Rainfed upland maize production	Central highlands	More frequent and abnormal typhoons	Damaged crops	Lower rice productivity and quality		L	L	M	L
Rainfed upland maize harvesting	Central highlands		Damaged crops or higher post-harvest losses	Lower rice productivity and quality Total losses		L	L	M	L

Sources: Author's synthesis of results from meetings with various experts on maize and climate change

IV. AREAS OF REGIONAL COLLABORATION

Regional cooperation can be done through either technical assistance or financial support, or a combination of both. It is difficult to determine which is more important, but technical support will be more useful than financial support because it will generate more sustainable results and opportunities to expand and multiply good practices.

Technical assistance should focus heavily on issues or activities that require high expertise. Vietnam has minimal experience in research and development of new varieties, technology transfer, and capacity building. Technical support and technology transfer for post-harvest activities such as drying and processing; sharing experiences on storage and processing to reduce post-harvest losses and augment value added for rice and maize; and technology transfer for storage and processing that have been successfully applied in other countries will be very useful in rice and maize production in Vietnam.

Financial support is necessary to develop and improve infrastructure for production, but it may have several unwanted side effects. One of the disadvantages of financial support is self-dependency, where recipients usually become reliant on the support, lose their influence, and sometimes make unnecessary decisions. Financial support for irrigation systems or dike systems should be limited. After it has been carried out, community participation should be monitored to ensure the appropriateness, effectiveness, and sustainability of the investment.

The combination of technical and financial support seems more appropriate as it will provide technical assistance as well as pilot and promote application. For example, designing an intercropping model between rice or maize and other crops is the initial step. This could be backed up by piloting in specific locations to transfer technologies to farmers, which will give farmers opportunities to test and further understand the model, thus proving the benefits of the model.

Regional collaboration should also focus on improving climate change awareness at different levels, especially at the household level. Rural households should be properly informed about climate change and its impacts. In addition, efforts to mainstream climate change issues in plans and activities of different stakeholders at different levels should also be generated. This requires both technical and financial support.

From Vietnam's perspective, the issue of agro-insurance should be raised. Vietnam has just finished its pilot program for agro-insurance, and many concerns and problems should be answered. The most important issue is the significance of agro-insurance in terms of managing the risks related to agricultural production. To successfully implement agro-insurance, technical and financial support from multilateral donors and other ASEAN Member States (AMS) are essential. Regional collaboration should also focus on disseminating advanced technology to risk monitoring and management (e.g., affordable remote sensing technology).

4.1 Stakeholder Analysis

After assessing climate change impacts, vulnerabilities, and adaptation and mitigation measures that require regional collaboration, this section analyzes the main stakeholders that are involved in different stages along the selected value chains, which can be seen below (Figure 3).

[1] Read more about community participation from http://www.ilo.org/public/english/employment/recon/eiip/download/irap_laos4.pdf

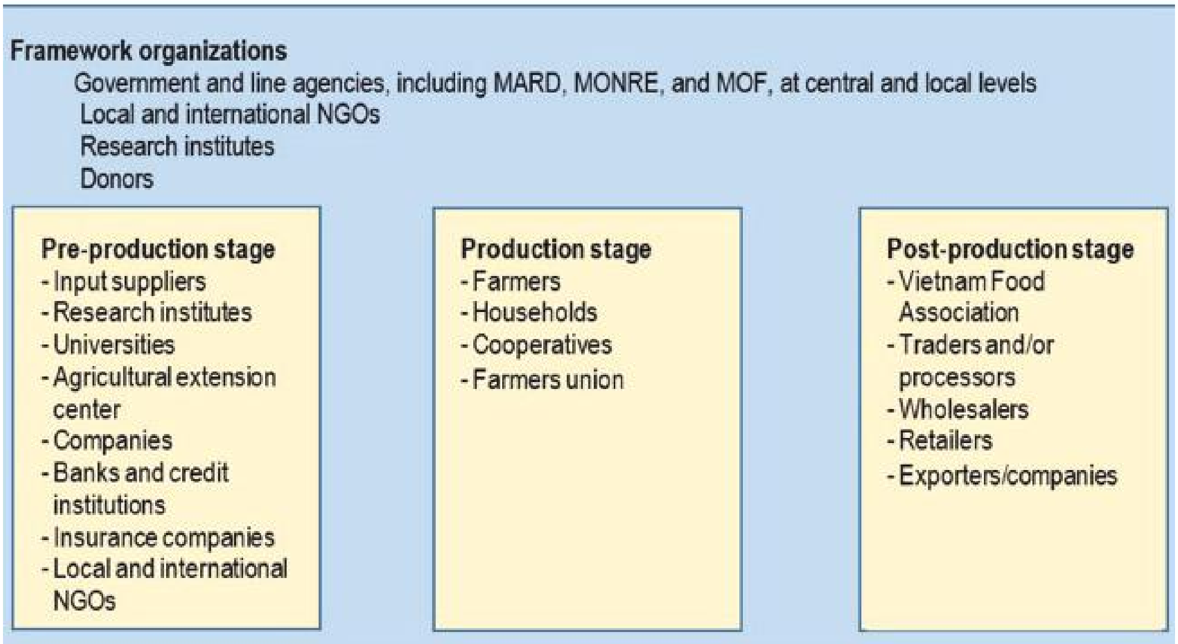

Figure 3. Stakeholder mapping

Input suppliers include individuals or companies that are very active in promoting the use of seeds, fertilizers, and chemicals for agricultural production. They have extensive networks as well as direct and long-standing contacts with farmers. However, as they work for profit, it is impossible to ensure that they will promote inputs that are good in terms of CCA or mitigation but offer them limited margins. Therefore, the activities of input suppliers should be controlled to harmonize their own benefit and the sustainability of agricultural production.

Research institutions, universities, local and international NGOs, and agricultural extension centers primarily work on researching new varieties, improving production techniques, and designing and piloting models. However, as they are non-profit agencies, they can only carry out a few pilot models. The widespread application of CCA-related practices is particularly difficult because proving their effectiveness takes time. Such application may also require farmers to make large financial investments.

In principle, banks, credit institutions, and insurance companies should be important stakeholders. Their limited contribution, which has gradually improved, is due to several reasons. Firstly, Vietnam has a limited state budget for rural credit and insurance activities. Of the total investment from various sources, investment from the state budget accounts for 39 percent and is spent mainly on infrastructure (more than 30 percent), whereas only 6 percent is for the agricultural sector and remains unchanged over time (GSO 2012).

Secondly, the improper implementation of policies on agriculture and rural development limits the efficiencies. Taking the credit policies in Vietnam as an example, Decree No. 41/2010/ND-CP is the most important legal document issued on the credit policy for agricultural and rural development, in which the most prominent provision is about providing loans without collateral at the following levels:

(i) Up to VND 50 million for individuals and households engaged in agricultural sub-sector, forestry, fishery, or salt production

(ii) Up to VND 200 million for households carrying out business or production activities or providing services for agriculture and rural areas

(iii) Up to VND 500 million for cooperatives and farm owners

The efficiency of policy implementation became debatable when the agricultural and rural dwellers were required to submit their land-use rights certificates, or the confirmation about non-dispute plot from the People's Committee, to approach credit sources. Such requirements pose more obstacles to finding funds for agricultural production.

Farmers and households are main stakeholders responsible for production, and they normally suffer bigger losses from climate change impacts than other stakeholders. Farmers can boost their capacity to apply CCA measures by joining cooperatives and forming clubs. Such groups will give farmers more power and a stronger voice in dealing with other stakeholders, thus reducing climate change risks and vulnerabilities.

Stakeholders in post-production stages are those who have hardly been affected by climate change impacts. Therefore, their importance in promoting and applying CCA measures is limited.

In addition to the stakeholders that are directly involved in various stages, there are others that facilitate the development of the value chains and thus enhance climate change mitigation measures. Government and other line agencies, such as Ministry of Finance, Ministry of Agriculture and Rural Development, and Ministry of Industry and Trade, are responsible for formulating policy and supervising policy implementation. Multi-level local authorities that are in charge of policy implementation mainly receive policy responses and propose amendments or new policies.

Research institutions, donors, and NGOs are very helpful in providing valuable inputs such as primary data from surveys, data analysis, and worldwide experiences. Recently, they have worked actively in policy advocacy, which contributes to policy formulation, and more importantly policy mainstreaming at different levels. Policy mainstreaming is vital especially for CCA, which is a relatively new concept in Vietnam.

V. CASE STUDIES ON GOOD PRACTICES

5.1 Selection of Case Studies

Vulnerability rating is the first criteria for selection. From the list of impacts on rice and maize, only those that are rated medium or high vulnerabilities are selected for next step. As discussed at the beginning, this report mainly focused on rice in MRD and maize in NMMA because of their importance to food security. Crop production systems were assessed to determine good case studies. (Table 13).

To ensure that the highlighted case studies have the potential to be replicated and scaled up within the region, the following criteria were used for the second round of selection:

(1) Whether adaptation measures will be carried out through both technical and financial support

(2) Whether adaptation measures will be carried out without the need for a big investment, since developing better infrastructure for production will significantly dent the state budget

(3) Whether adaptation measures will require limited technical understanding and thus be easily applicable for farmers, and can be replicated with minor adjustments in other areas for rice and maize production

(4) Whether the benefits of adaptation measures will be easily noticed and visually measured in terms of increases in productivity and income for farmers. This is a very important feature that makes them attractive to farmers. Moreover, they can have spillover effects, such as reduction in greenhouse gas emissions, because of lower water consumption for rice crops or better environment because of lower fertilizer or chemical application for crop production.

Selected CCA measures with areas for regional collaboration are presented in Table 14; while good practices as CCA measures in Vietnam are presented in Table 15.

In addition to the abovementioned measures, setting up a risk management scheme appears to be the most integrated solution in dealing with climate change impacts. Increasing climate change awareness and mainstreaming CCA into action plans at different levels, especially at the commune level, will also increase farmers' understanding of climate change and its consequences. It will also encourage their participation in planning local action on CCA and mitigation.

In Vietnam, mainstreaming CCA is very important because it is the prerequisite to mobilizing efforts from all related stakeholders and funds from sources at different levels. Some pilot programs gained initial success, but efforts to ensure that they will bring sustainable results and be made applicable to other geographic areas should be furthered.

Farmers have also benefitted from the pilot agro-insurance program in the country because of the active participation of three stakeholders (i.e., government, farmers, and enterprises) that formed a rationale for scaling up agro-insurance programs in the future. However, running an agro-insurance program smoothly and applying it nationwide with or without limited subsidy call for more time and effort. Agriculture in the country offers low income and high risks, which is why enterprises are not interested in agro-insurance without government subsidy. Income diversification has been considered a good scheme for farmers to reduce their high vulnerabilities; however, given the farmers' low levels of education and professional training, there is no example of successful income diversification for farmers in Vietnam.

Table 13. Crop production systems and their vulnerabilities

System of interest	Geographic location	Climate change trend	Biophysical impact	Socio-economic impact	References	Exposure	Sensitivity	Ability to respond	Vulnerability rating
Irrigated lowland rice flowering	MRD	Increasing mean temperature	Water shortage caused by high evaporation	Lower productivity Higher production cost for water supply	Experts on climate change and rice	M	M	M	M
Irrigated lowland rice seedling/sowing	MRD	Increasing rainfall, highly fluctuating between the dry and rainy seasons	Water shortage during the dry season or drought conditions	Lower productivity Higher production cost for water supply Delayed cultivation of current and subsequent crops		M	M	M	M
Irrigated lowland rice flowering	MRD	Increasing rainfall, highly fluctuating between the dry and rainy seasons	Water shortage during the dry season or drought conditions	Lower productivity Higher production cost for water supply		M	M	M	M
Irrigated lowland rice harvesting	MRD	More frequent and abnormal typhoons	Damaged crops Higher post-harvest losses	Lower rice productivity and quality Partial or total losses		M	M	M	M
Irrigated lowland rice post-harvest activities (e.g., storage and processing)	MRD	More frequent and abnormal typhoons	Damaged crops Higher post-harvest losses	Lower rice quality Partial or total losses		M	M	M	M
Irrigated lowland rice production	MRD	Sea level rise	Soil quality affected by saltwater intrusion and inundation Paddy land diminishes	Lower rice productivity and quality Decrease in farmers' income		H	H	M	M
Rainfed upland maize seedling/ sowing	NMMA	Decreasing rainfall during the dry season Increasing incidence of severe droughts	Water shortage	Lower maize productivity Delayed cultivation of current and subsequent crops Bigger workload for farmers	Experts from NMRI	H	H	M	M
Rainfed upland maize flowering	NMMA	Increasing mean temperature Decreasing rainfall during the dry season	Water shortage	Lower maize productivity and quality		H	H	M	M
Rainfed upland maize harvesting	NMMA	Increasing rainfall	Damaged crops Higher post-harvest losses	Lower rice productivity and quality Total losses Bigger workload for farmers		H	H	M	M
Rainfed upland maize post-harvest activities	NMMA	Increasing rainfall	Damaged crops Higher post-harvest losses	Partial or total losses in farmers' income Bigger work load for post-harvest activities		H	H	M	M

Table 14. Highlighted areas for regional collaboration

Adaptation measures	Good practices	Areas for regional collaboration	Support needed
Improved irrigation techniques	AWD for rice production	Research on the techniques to fit local conditions	Technical + Financial
		Design detailed technical guidelines	
Adjustments in cropping pattern	Rice-shrimp farming in MRD	Develop rice varieties of better quality for this farming system	Technical + Financial
		Research on measures/technical options to ensure the sustainable development of this system such as specific types of fertilizers/ chemicals for rice and safe medicines/ chemicals for shrimp	
Better adaptive varieties and crop timing	Adjustment of rice crop timing and use of short-duration rice varieties	Weather forecast activities and climatic data collection/analysis/sharing	Financial + Technical
		Develop rice varieties of short duration and better quality	
Better cultivation practices	Application of appropriate planting density with adequate row spacing and plant spacing within rows in flat areas for maize	Modifying rice crop timing and using short-duration varieties are very useful in avoiding possible floods and unusual weather events.	Technical + Financial
	Use of quality varieties and fertilizers, optimal rotation of crops or cropping systems, and adjustment of crop timing for maize production etc.	Develop maize varieties of high tolerance and better quality for this farming system Research on measures/technical options to ensure the sustainable development of this system such as specific types of fertilizers/ chemicals for maize	Technical + Financial

5.2 Detailed Description of Case Studies

5.2.1 Alternate Wetting and Drying Technology

AWD is a water-saving farming technique developed by the International Rice Research Institute (IRRI) to help rice farmers maintain yield despite water shortage. According to IRRI guidelines, AWD application in Bac Lieu was adjusted and implemented with the following steps (GIZ 2013):

1. **Wetting period**

a. From 10 to 30 days after sowing (DAS): In this period, the field requires adequate water. The water level is maintained at a height of 3–5 cm for the first and second time of manure.

b. From 40 to 55 DAS: In this period, the water level is maintained at a height of 3–5 cm for the third time of manure.

c. From 65 to 75 DAS: Before and after flowering, rice plants need water. The water level is maintained at a height of 3–5 cm for the fourth time of manure (if any).

Table 15. Good practices as CCA measures in Vietnam

Adaptation measures	Good practices	Regional relevance	Impacts on women	References
Improved irrigation techniques	AWD for rice production	IRRI developed the AWD technique to help rice farmers maintain rice yield despite water shortage.	Neutral	GIZ (2013)
Adjustments in cropping patterns	Rice-shrimp farming in MRD	In the last 30–40 years, many rice farmers in salt-affected areas have adapted to natural conditions by growing rice during the rainy season, subsequently using the rice fields for shrimp farming during the dry season.	Neutral	FAO (2001)
More adaptive varieties and better crop timing	Adjustment of rice crop timing and use of short-duration rice varieties	Modifying rice crop timing and using short-duration varieties are very useful in avoiding possible floods and unusual weather events.	Reduce workload for women	Experts on climate change and rice
Better cultivation practices	Application of appropriate planting density with adequate row spacing and plant spacing within rows in flat areas	Following the correct planting density in maize production can maximize productivity and improve adaptation to drought conditions in flat areas.	Increase workload for women	Phan (2011)
	Use of quality varieties and fertilizers, optimal rotation of crops or cropping systems, and adjustment of crop timing	Following these procedures in maize production can maximize productivity and improve adaptation to drought conditions in sloping areas.	Increase workload for women	Experts on climate change and maize

2. Water-saving or drying period

a. From 1 to 10 DAS: In this period, the field can be kept dry for pesticide and molluscicide application.

b. From 30 to 40 DAS: In this period, rice is growing. The field can be kept dry to help rice get more nutrition and be robust.

c. From 55 to 65 DAS: In this period, the paddy rice grows. The field can be kept dry.

d. From 85 to 100 DAS: In this period, the field can be kept dry for easy harvesting.

The differences between AWD recommended by IRRI and its application in Bac Lieu province are as follows:

1. AWD recommended by IRRI

a. Safe AWD: Irrigate when water is 15 cm below the surface.

b. Keep the field continuously flooded (3–5cm) 20 days after sowing and during flowering.

2. AWD application in Bac Lieu

a. Safe AWD: Irrigate when water is 10 cm below the surface.

b. Four water-saving stages: seedling, panicle initiation, panicle formation, and ripening.

According to farmers, AWD is a suitable technique that can be easily applied to farming. Farmers said that applying AWD and the "One Must Five Reductions"[2] (2012) technique helped them gain more benefits. In particular, they were able to obtain a higher income because of lower costs for water pumping and agriculture material. The amount of savings increased yearly. Compared with the traditional method, AWD application helped strengthen the rice stem and increase plant resistance to pest and diseases. Most of the farmers believed that AWD was an appropriate measure for coping with the abnormal weather. Some of the farmers mentioned that there were still a few disadvantages in using the technique.

Observing field water level using field tubes is time-consuming, and this may discourage farmers from practicing AWD. They may also be constrained by insufficient irrigation systems, especially inner field watering systems. In reality, without a suitable irrigation system, it will be difficult for farmers to apply AWD. The results revealed that AWD was increasingly applied during the winter-spring seasons. After one year, the proportion of AWD farmers who continuously applied AWD during winter-spring seasons increased from 51 percent in 2011–2012 to 93 percent in 2012–2013. In addition, AWD was applied not only to winter-spring crops but also to summer-autumn crops. However, it is difficult and not efficient to apply AWD during the summer-autumn seasons because heavy, high-frequency rainfall inhibits the monitoring of water level. As such, AWD during this season is not recommended.

There was a difference between what farmers learned from the training workshop on AWD funded by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and what they practiced. A large proportion of AWD farmers did not use a tube to observe the water level in the field. Instead, they hollowed out a hole in the field for observation.

Most of the farmers were satisfied with their training on AWD, but their assessment of its suitability to different conditions was different. They indicated that AWD application suited the natural, financial, and workplace conditions in their location, but not the existing infrastructure, particularly irrigation systems, and social conditions in some areas. The results of the survey also revealed that there was a difference in the suitability of the technique to different agro-areas during practical application. AWD is more suitable for soil with light acid concentration than soil with high acid concentration. It is also more suitable for elevated areas than inundated areas.

Almost half of non-AWD farmers said that they learned about the technique through

[2] **1 must:** forcing farmer to plan originated seeds, qualified by the authority. The planting seeds must be in local authority's list of recommendation.

5 reductions:

-Reduction in the quantity of sowing seeds: sowing with appropriate density: 80 – 120 kg/ha
-Reduction in the amount of nitrogen fertilizer: balanced and rational fertilizer. Using the colour chart to control the nitrogen excess.
-Reduction in plant protection drug: Applying IPM, ICM. Only use chemical drugs in plant protection when highly necessary and must comply with 04 RIGHT rules.
-Reduction in water irrigation: Rice plants do not always need to be flooded. Farmer can apply the method of "flooding, alternat ing dry" to save water, help the rice root growth, and prevent lodging, increase productivity and decrease pumping /irrigation cost.
-Reduction in post-harvest losses:
-Harvesting: Standard degree (85-90% of the seeds turn yellow straw) should use combine harvester-thresher…)
-Drying: Not drying in the field, not drying on traffic axis
-Heat drying: For seeds, heat drying temperature is not over 40°C; for commercial rice, it is not over 45°C
-Storage: For seeds, it is stored in anaerobic bags with moisture of no more than 13%; for commercial rice, it is / not over 14%.

media such as television, newspaper, and brochures issued by the plant protection sub-department, as well as AWD farmers, friends, and agricultural technicians. The majority of the respondents said that they were willing to join any training program or workshop on new farming techniques if they were invited. This showed that there is great potential for designing new training programs in Bac Lieu. Farmers wanted to learn many new techniques, which they could learn in training programs or workshops, such as cultivation of new rice varieties; use of fertilizer and insecticides; and application of new techniques in farming, water control, and irrigation, Three Reductions Three Increases[3] (NCAE 2014), One Must Five Reductions, and Integrated Pest Management.

The following are recommendations to facilitate the transfer of the AWD technique in Bac Lieu:

(1) AWD, as part of the farmers' water-saving measures, should be integrated in training programs or workshops for farmers. For example, AWD should be integrated into training programs like "One Must Five Reductions" and "Three Reductions Three Increases." AWD application should be considered an example of a rural vocational training activity. Given the success of the GIZ training program, AWD should be officially included in extension programs at the local level.

(2) Irrigation systems, including inner field watering systems, should be suitably prepared. In addition, the paddy fields should be flattened before AWD application. A good irrigation systems and a flat field will help farmers apply the technique more efficiently as they can monitor the water level.

(3) AWD is recommended for winter-spring season, which gains the highest efficiencies among all seasons. The technique can be used in areas with water shortage, but not in areas with severe saltwater intrusion.

(4) AWD should be promoted to sustain its application. Media involvement should be enhanced to support the dissemination of information on AWD. This GIZ-sponsored water-saving technique can be extended through outreach programs covering agro-areas in all administrative units in Bac Lieu. To scale up the technique in the province, more dissemination and training activities are recommended. The establishment of demonstration sites should be implemented at a larger scale. To do this, active participation of local government, department of agriculture and rural development, plant protection department and mass organizations is highly important.

5.2.2 Rice-shrimp Farming

The description of rice-shrimp farming in coastal areas of Vietnam below is drawn from the study by FAO (2001). It is a way to utilize paddy fields during the dry season which were often left fallow, thus helping increase farmers' income.

Tidal flats in coastal areas are periodically flooded during high tides. Salinity is usually higher than 5 parts per thousand (ppt) during the dry season, which is why most paddy fields are left fallow. Salinity declines during the rainy season, making rice cultivation possible. The living standards of farmers in the coastal areas of southern Vietnam are lower than those of their counterparts in freshwater regions. Integrating freshwater prawn culture with rice during the rainy

3 reductions:
o decline volume of seed
To decrease the amount of pesticide
To decrease the amount of fertilizer
3 increases
To rise crop productivity
To rise quality of product
To rise economical effectiveness

season, as well as marine shrimp mono-culture during the dry season, is one way of increasing their incomes. Integrating freshwater prawn culture with rice during the rainy season is described as below.

Site selection

-The field should be close to a river or channel
-Choose a low and flat place so it is easy to get water during high tide
-Avoid high acid sulphate soils

Dike and trench construction

-Surface area of field: 1 000-3 000 m²
-Trench is 2-3 m wide and 0.8- 1.0 m deep with trench-to-rice field rate of 10-20 percent.
-Peripheral dikes should be at least 20 cm higher than the annual flooded level.
-Install 2-3 inlet and outlet pipes (at least 20 cm diameter) made of coco nut trunk or wood. The inlet pipe should be installed so as to let water into the paddy field at high tide; the outlet pipe should allow water to drain from the trench when opened.
-Inlet and outlet pipes should be screened to prevent the intrusion of predators.
-Cover the trench surface with tree branches or plant water hyacinths, etc., along the trench to discourage poaching.

Stocking

-Stock juveniles of giant freshwater prawn (Macrobrachium rosenbergii) at a density of 1.2/m² (at least 4-5 g each).
-Stock 10-15 days after transplanting.
-Criteria for juveniles: vigorous, strong and uniform in size
Note: If stocking density is higher than 1/m², supplementary feeding should be done and trench-to-rice field rate should be higher than 10 percent. If water exchange is poor, do not stock higher than 1/m².

Feeding

-Prawn can subsist on natural food in the paddy field, especially if it is load ed with manure.
-The following supplementary feed can be given: rice bran, rice grain, copra, oil cake, cassava root, bro ken maize, fiddler crab (Uca spp.), shrimp or prawn head wastes and trash fish.
-Feeds can be given daily at 5 percent of the prawn's body weight (if no manure loading) or 2-3 percent (with manure loading). Mix ingredients thoroughly, form them into balls and put them in feeding trays. The use of feed ing trays controls consumption of feeds and prevents wastage.
-Feed twice a day: one-third of the quantity in the morning and the rest in the afternoon.
-Check feed consumption daily to ad just the feeding regime as necessary.
Below is a recommended formula for prawn in rice paddies
50 percent - rice bran, broken rice or rice grain
20-30 percent - cassava root or broken maize
20-30 percent - trash fish, shrimp or prawn head wastes or oil cake

Predator prevention

Predators include sea bass, tilapia, snakehead and other wild fish that compete with the prawn for feeds. Predation can result in very low prawn yields. Before stocking prawn, use any of the following measures:

-Drain rice fields and apply lime at the rate of 10 kg/100 m² (15-20 kg for acid sulphate soils).
-Apply Derris root (Derris elliptica), 1-1.5 kg soaked in 10 liters water/1 000 m².
-Release ducks into the rice fields for

several days.

Within the culture time, put gill nets in the trenches to catch the predators going to the rice fields.

■ **Care and maintenance**

-Water exchange is essential to supply oxygen to the prawn and to remove detrimental substances in the water. This should be done at least twice a month. The more fre quent the water is changed, the more suitable it is for the prawn's growth and development.

-Water exchange also improves the pH value in the fields especially in sulphate acid soils.
-Dikes should be repaired yearly.
-Cover crab holes along the dikes to prevent leakage.
-Check daily the screen mesh on the outlet and inlet pipes.

■ **Harvesting**

-Harvest prawn 5-6 months after rice harvest.
-Open the outlet pipe at low tide and drain the field and trench.
-Hand-collect prawn in the rice field and use a net to harvest in the trench.
-Harvest only the big (more than 15 g) prawn. The small ones are reserved for the next culture season.

Note: Transfer small prawn immediately to a hapa (net cage) to keep them alive for the next culture. Bring harvested prawn as soon as possible to the dealer or keep them in ice so that they stay fresh.

■ **Land preparation and transplanting for rice**

-Local varieties are recommended.
-Transplanting should be done when the salinity is lower than 5 ppt.
-Plough and harrow thoroughly be fore transplanting.
-Transplant 3-40 days after seeding.

■ **Fertilizing**

-Apply 50 kg diammonium phosphate and 5 t manure/ha before ploughing.
-Use 50 kg urea/ha for top-dressing.

■ **Pest control**

-No pesticide or herbicide is applied in integrated prawn-rice culture.
-Use brown planthopper-resistant varieties of rice.
-Release one-month old ducks into rice field to feed on insects, especially hoppers.

Note: In case the above measures cannot control pests, pesticide application can be an alternative. Before applying the pesticide, drain water in the field to let prawn take refuge in the trench for 3-5 days.

5.2.3 Adjustment of rice crop cultivation timing and use of short duration rice varieties

As different rice production areas suffer from different impacts of CC, they adjust their rice crop cultivation timing in different ways to reduce risks. Here below is an example of changes in rice planting calendar that uses some specific short duration rice varieties in Quang Nam province (Ngo et al, 2014) to avoid adverse effects from abnormal climatic events such as floods and storms.

■ **Rice planting calendar**

Before the period of 2001-2005, Quang Nam farmers planted three rice crops (winter-spring, spring-summer, autumn-winter) per year. For winter-spring crop season, farmers have to sow early so that the ear appearance and flowering stage of winter-spring rice coincides with the coldest period of the year (January-February) with very low temperature (18-20oC), low humidity (<55 percent) and drizzling rain. Accordingly, rice yield earnings could reduce by 30 to 50 percent because of empty or half-filled ears. For summer-autumn, prolonged drought occurred (from May to July)

and high temperatures of over 37°C during the reproductive stages reduced rice production, especially when the rice plant flowered, causing low seed setting and yield losses (rice plants are most sensitive at the flowering and ripening stages and both of yield and grain quality are adversely affected by high temperatures.

Extremely high temperatures during the vegetative growth reduce tiller number, and plant height and negatively affect panicle and pollen development, thereby decreasing rice yield potential. High temperature is of particular importance during flowering, which typically occurs at mid-morning. Exposure to high temperatures (>35°C) can greatly reduce pollen viability and cause irreversible yield loss because of spikelet sterility. Last crop season (autumn-winter) coincided with the rainy season which typically starts in September and lasts until November. Due to the effects of tropical depression and seasonal storms from the late September to December, the last crop season of the year had low yield and productivity or was even lost completely from flooding. Thus, from the practical rice production in recent years, Quang Nam province has a large transition area from three rice crops to two crops per year in order to avoid climate disadvantages and negative impacts of climate change. Under the guidance of the province's authorities, from 2001, farmers began to remove the spring-summer rice season and change its cropping calendar to winter-spring (from December-April instead of November-March) and summer-autumn (from May-September instead of May-August) to be more suitable to any abnormal changes in climate. Farmers have been encouraged to grow short-term rice varieties in summer-autumn crop season in less than 105 days so they can harvest the summer-autumn rice before September 15 to avoid the flooding season.

Rice varieties

Survey statistics showed that rice varieties Xi23, Xiec13.2 (long growth duration varieties), QN1, VL20, NhiUu 838, TBR1 (medium growth duration varieties), and HT1, Q5, GL102, IR325 (short growth duration varieties), etc., were popular at the study sites. Today, most farmers in Quang Nam have realized the importance of paddy seed for good results in cultivation. They shifted to growing high-yielding rice varieties, usually nitrogen-responsive varieties. Most of these have medium or short growth duration, ranging from 85 to 110 days. However, long-duration rice still makes up (45 percent) the rice varieties mostly used by farmers, especially in hilly midland areas

Thanks to the re-arrangement of the cultivation calendar, new rice varieties and appropriate crop structure, production of two rice crops has been higher than three rice crops, although the cultivated area reduced nearly one third. As a result, the cost of investment reduced by 30 percent and economic efficiency increased by 30 to 50 percent. Cultivation calendar was completely changed to avoid rain and storms in rainy season. In general, the impact of climate change on Quang Nam's agricultural production activities clearly changed the structure of crops.

5.2.4 Optimal Row Spacing and Density

Row spacing and plant density are the most important cultural practices to determine maize yield. High populations heighten interplant competition for light, water and nutrients. Therefore, optimal row spacing and density are easy ways to improve productivity especially in the context of water shortage (Phan, 2014). According to Phan, the planting density should be 65,000–75,000 seeds/ha with 1 seed/hole. Planting less than 65,000 plants/ha should be avoided because a 10 percent loss of plants is not uncommon under rainfed field conditions. The planting density at harvest should be at least 60,000 plants/ha to achieve high yield. A more uniform crop stand is reached with 1 seed/hole (and narrower plant spacing within rows) than 2 seeds/hole (and wider plant spacing within rows). Densities of more than 75,000 seeds/ha will not increase the yield unless the growing conditions are very favorable, with a yield potential of over 13 t/ha. In drought-prone environments, a planting density of more than 75,000 seeds/ha should be avoided.

Row spacing that works well with othermanagement practices should be selected. For optimal row spacing, rows should be 50–75 cm apart (the narrower the better). The required plant spacing within rows should be determined to achieve the desired planting density. For optimal plant spacing within rows, plants should be 20–30 cm apart (the wider the better) (Figure 4).

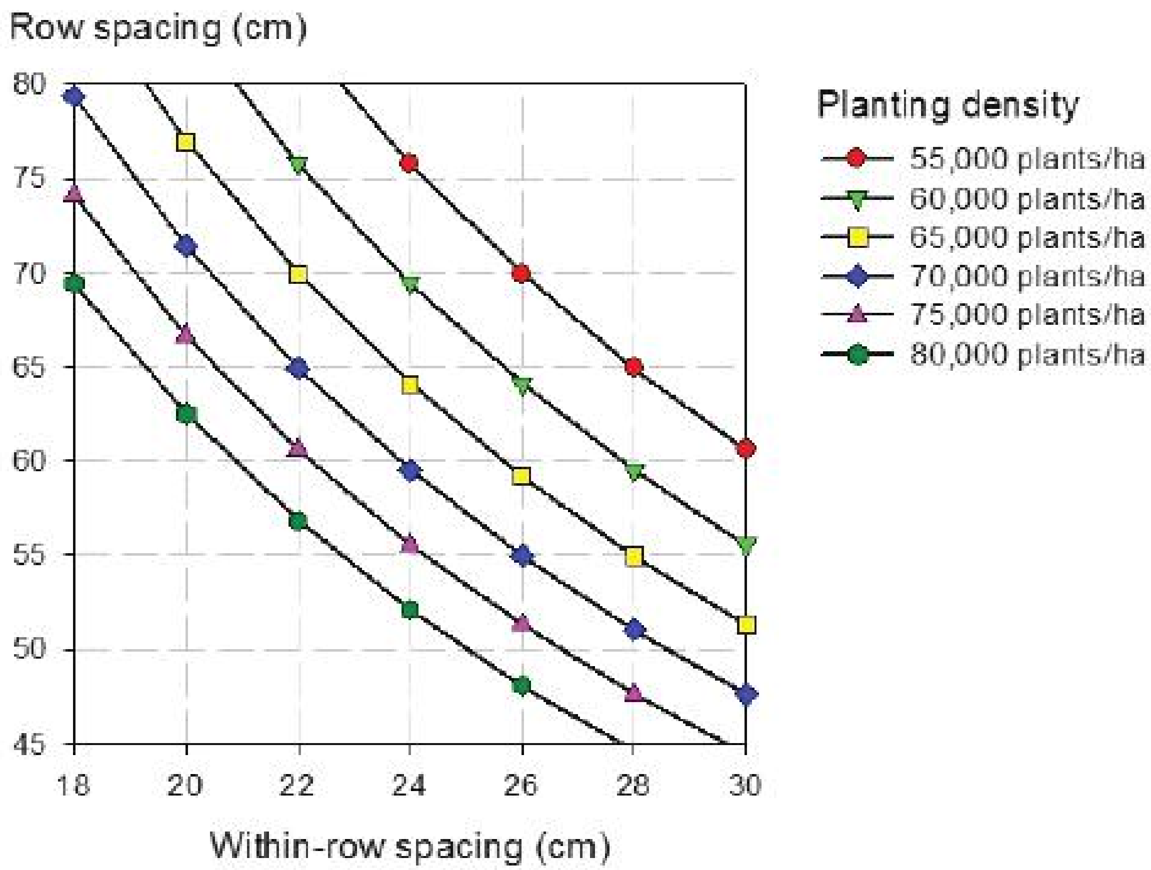

Figure 4. Row spacing and within-row spacing for different planting density
Source: Phan (2014)

Uneven row spacing should be considered to ensure that plants within rows are not planted too close to each other to avoid stress.

Appropriate planting density (e.g., 75,000 seeds/ha) and optimal row spacing (e.g., 70 cm and 50 cm rows alternating) should be selected. The average row spacing should then be calculated ([70+50]/2 = 60 cm). After determining the average row spacing, the required spacing within rows should be identified (e.g., about 22 cm) (Figure 5).

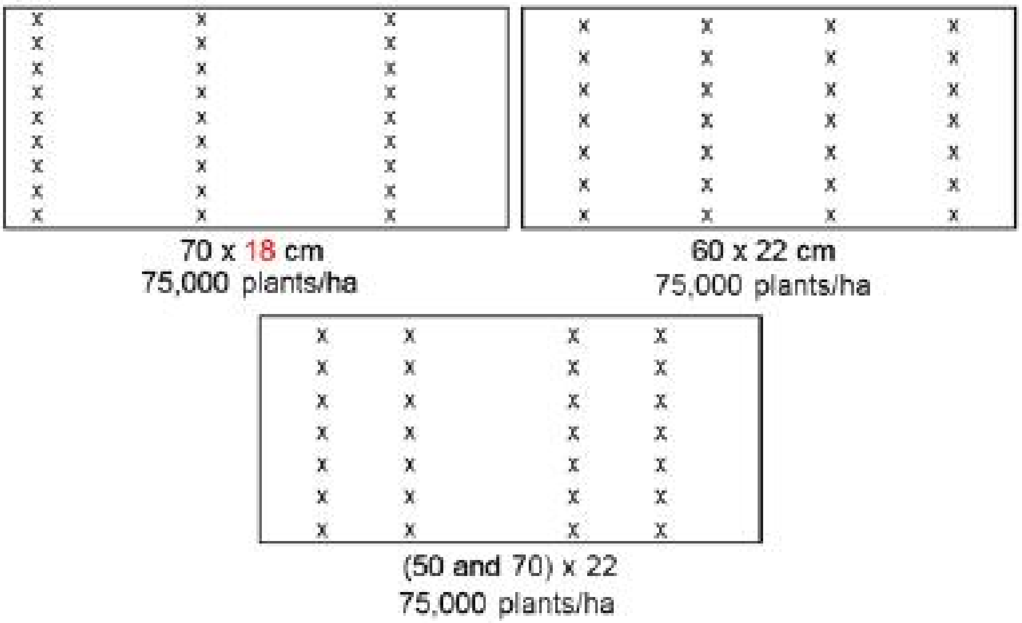

Figure 5. Uneven row spacing for planting density of 75,000 plants/ha
Source: Phan (2014)

5.2.5 Improvements of cultivation practices in sloping areas for maize

As mentioned, drought is the main problem in maize production in NMMA. Intercropping maize with legume crops (soybean, groundnut, and mung bean) proves to be a good measure to reduce evaporation from the soil surface, increase profit, and improve soil conditions and water holding capacity. Vietnamese farmers have practiced intercropping for a long time but their success has been limited when unsuitable combinations of species are planted together or when they planted at inappropriate intercropping ratios. (Ngo, 1996). A recent study by the Agriculture and Forestry Research and Development Center for Northern Mountainous Region of Thai Nguyen University of Agriculture and Forestry (Rural Economy, 2014) concluded that intercropping maize with mungbean instead of maize and mung bean mono-culture is a model that adapts well to climate change because the system works well in severe drought, improving soil fertility, sustaining and increasing farmers' income.

Adoption of stress tolerant and short/ medium duration varieties is another way to reduce adverse effects. of climate change. Early-maturing maize varieties are widely used to curve drought impacts during critical development stages of maize. Early-maturing OPVs such as 'TSB-2', 'MSB-49', 'MSB-49B' (a yellow version of MSB-49), and 'Q-2' are favored by farmers even in unfavorable growing conditions as their yields were as high as some hybrids' (Ngo, 1996). The National Maize Research Institute (NMRI) under MARD has been paying high attention on developing new hybrids which are early-maturing, have high yield potential and improved resistance to diseases. LVN25 and SB099 are some examples of such new hybrids (NMRI, 2011).

VI. CONCLUSION

This report highlighted five case studies on CCA measures that can be scaled up regionally to provide solutions for ensuring food security, sustainable agricultural production, and higher income for farmers. Although they are good practices, several issues should be taken into consideration and confronted through regional cooperation. These matters call for further sharing of knowledge and experiences among AMS.

Firstly, the framework conditions for the massive application of good practices should be examined. At national and regional levels, there are sufficient legal documents and strong institutional frameworks to enhance climate change awareness and mainstream climate change issues in annual national and regional action plans. Raising awareness on climate change and promoting CCA measures at the grassroots level should be strengthened to increase national and regional understanding of climate change impacts, adaptation, and mitigation.

Secondly, regional collaboration should be carried out through both technical and financial support instead of either technical assistance or financial support to safeguard the success and sustainability of results.

Thirdly, large-scale adjustments and pilot models should be done. Technical issues require more careful examination to prevent adverse side effects, especially on the environment.

Fourthly, the institutional framework for the application of CCA measures should be improved. The role of actors who are participating in post-production activities remains very limited, although they capture a large portion of profit along the value chain with low risks while farmers suffer from high risks with small profit.

Therefore, it is necessary to develop solutions to encourage these actors to participate more actively in this field.

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