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Promotion of Climate Resilience in Rice and Cassava

Cambodia National Study

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Promotion of Climate Resilience in Rice and Cassava

Cambodia National Study

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

ABK	Aphivat Bandanh Kasekar
AMS	ASEAN Member States
AQIP	Agricultural Quality Improvement Project
ASEAN	Association of Southeast Asian Nations
CARDI	Cambodian Agricultural Research and Development Institute
CCA	Climate Change Adaptation
CelAgrid	Centre for Livestock and Agriculture Development
CIAT	International Center for Tropical Agriculture
DNT	Domnak Teuk Group Company
FAO	Food and Agriculture Organization
GDA	General Directorate of Agriculture
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
MOE	Ministry of Environment
NGO	Non-government Organization
NIS	National Institute of Statistics
PDA	Provincial Department of Agriculture
RUA	Royal University of Agriculture
UNDP	United Nations Development Programme
WB	World Bank
WFP	World Food Programme

Table of Contents

List of Tables

List of Figures

Foreword

The Cambodian Agricultural Research and Development Institute (CARDI) is proud to endorse this national study of climate adaptive practice to ensure resiliency of rice and cassava in Cambodia, and in the region. Climate change has brought about so many threats to our country's agricultural production, with rice and cassava as particularly vulnerable. These threats include numerous climate risks such as flood, drought, sea water intrusion, pests and diseases, extremely hot days, land degradation, nutrient depletion. However, despite the significant degree of risk and uncertainty that climate change has brought, there are practices that can be adapted with no regrets. Within the course of this study, five good adaptation practices have been identified. Among them, three are identified as practical intervention for rice value chain, namely: model farming, and use of submergence tolerant as well as drought tolerant varieties; while the two remaining are recommended for cassava value chain, namely: use of healthy planting materials and contour intercropping.

We believe that these practices need to be encouraged and replicated in similar areas, through regional collaboration of joint measures such as research and information exchange. This body of work is not only useful to our work in Cambodia, but as well to other relevant entities which work with farmers and climate change. We are happy to be able to contribute to this exercise through the ASEAN Technical Working Group on Agricultural Research and Development (ATWGARD) with the support of the ASEAN-German Programme on Response to Climate Change (GAPCC). We look forward to witnessing similar practices be promoted in a larger scale that will benefit the people of Cambodia.

Signed:

Dr. Ouk Makara
Director

Executive Summary

Cambodia is one of the countries in the Association of Southeast Asian Nations (ASEAN) that are most vulnerable to the impacts of climate change. The country's high vulnerability is connected to various socio-economic factors (e.g., high dependency on agriculture and natural resources, income inequality, poverty, and low education) and poor adaptive capacity (e.g., low public awareness, lack of early warning systems, poor access to irrigation water, and weak national research systems).

Agriculture is the core driver of economic development in Cambodia, where rice is the major crop and the main source of food, nutrition, and income, followed by cassava and maize. The country's climate is governed by a tropical monsoon with distinct wet and dry seasons. Rainfed lowland rice has the biggest share of wet season rice and plays a significant role in the national economy.

Cassava, on the other hand, is mainly produced in the rainfed uplands. These crops and their ecosystems are highly vulnerable to climate change. As such, they were selected for this study, which aims to promote climate resilience of crops for the sustainable development of the country.

In Cambodia, climate-related hazards have caused substantial damages. These hazards negatively affect people's livelihoods, particularly the rural population whose main income depends heavily on agriculture. Studies suggest a rising trend in all climatic factors such as temperature, rainfall, sea level, and wind storm. Increases in average temperature, rainfall intensity, and saltwater intrusion in coastal rice production areas will most likely influence the productivity of rice and cassava, and thus affect the farmers' livelihoods.

The Cambodian agricultural production system is characterized by smallholder farming. Cambodian farmers, who are generally economically resource poor, are among the people that are most vulnerable to climate change. Climatic threats to agricultural production, particularly the production of rice and cassava, include floods, droughts, pest and disease outbreaks, saltwater intrusion, extremely hot days, land degradation, and nutrient depletion, among others. To effectively respond to these threats, appropriate adaptation practices must be developed and implemented.

The following case studies on good practices in climate change adaptation (CCA) options for rice and cassava were prioritized: for rice, (1) model farming (integrated farming system), (2) use of submergence-tolerant varieties, and (3) use of drought-tolerant varieties; and for cassava, (1) use of healthy planting materials and (2) contour intercropping. The five suggested good practices are applicable to situations in Cambodia, but they can also be adopted by other countries in the region.

Climate change is a global phenomenon. Factors such as population growth, economy, and politics are specific to each country, but climate-related problems are similar across the ASEAN region. Good practices in CCA options that are effective in one country have the potential to be successful in other countries. Therefore, instead of working in isolation, ASEAN Member States (AMS) should collaborate to respond to climate change. Several platforms for regional collaboration, such as exchange of experts between countries, establishment of a regional ministry or council for climate change science, and/or creation of a regional research center on climate change, can help strengthen regional partnerships and enhance regional adaptive capacity.

I. INTRODUCTION

The Kingdom of Cambodia is located in the southwestern corner of Indochina in Southeast Asia between latitudes 10°N and 15°N and longitudes 102°E and 108°E. Cambodia, which covers an area of 181,035 square kilometres (km2), shares borders with Lao PDR and Thailand to the north, Thailand and the Gulf of Thailand to the west, and Vietnam to the east and south (Figure 1).

Geographically, Cambodia is characterized by a low-lying central plain dominated by the Great Lake (Tonle Sap). The plateau region is dominated by the Mekong valley in the east; Dangrek Mountain in the north; and Kravahn (Cardamom) Mountains and Damrei (Elephant) Mountains in the southwest, which separate the coastal region from the rest of the country.

Figure 1. Countries bordering Cambodia
Source: www.maps.com

The country's climate is governed by a tropical monsoon with distinct dry and wet seasons. The dry season is from November to April, while the wet season is from May to October. The annual rainfall, which ranges from 1,250 millimeters (mm) to 4,000 mm, is low in the central plain and increases towards the Gulf of Thailand. The mean temperature ranges from 21ºC to 35ºC, with April as the hottest month and December as the coolest month.

In Cambodia, a low-income country with an estimated gross domestic product (GDP) per capita of USD 1,007 in 2013, more than 20.5 percent of the population live below the national poverty line of USD 1 per day and 40 percent of the children are chronically malnourished (World Bank 2013, 2014).

Approximately 80 percent of the estimated total population of 14.7 million live in rural areas, where poverty incidence is found to be higher and people are more likely to be less educated and solely dependent on farming for their livelihoods (RGC 2010). Among all sectors of the national economy, which include services and industry, agriculture contributes about one third to the GDP, where half of this contribution comes from rice (MAFF 2013).

This report provides insights to rice and cassava production systems in Cambodia, assesses the climate change vulnerability of these two production systems using value chain analysis, and identifies good agricultural adaptation practices that can be nationally and regionally adopted.

II. VALUE CHAIN MAPPING

Cambodia relies heavily on agricultural production. Crops are the biggest contributor to the national GDP, accounting for 50-60 percent of the contribution from the agricultural sector. The country has a total land area of about 18.1 million hectares (ha). At present, about 3.9 million ha (21%) of the total land area is cropped. Rice occupies more than 3 million ha (76.4%) of the total cropped area, followed by cassava (10.5%) and maize (6%) (Table 1).

Table 1. Crop production (%) in agricultural land in Cambodia, 2010–2013

Rank	Crop	2010		2011		2012		2013	
		ha	%	ha	%	ha	%	ha	%
1	Rice	2,795,892	79.51	2,968,529	77.60	3,007,545	76.71	3,052,420	76.44
2	Maize	205,070	5.83	174,257	4.56	216,330	5.52	239,748	6.00
3	Cassava	190,525	5.42	391,714	10.24	361,854	9.23	421,375	10.55
4	Soybean	101,904	2.90	70,584	1.85	71,337	1.82	80,688	2.02
5	Mungbean	66,265	1.88	68,111	1.78	66,850	1.71	54,312	1.36
6	Vegetables	49,873	1.42	53,757	1.41	76,495	1.95	52,449	1.31
7	Others	106,690	3.03	98,354	2.57	120,017	3.06	92,456	2.32
Total production area		3,516,219	100.00	3,825,306	100.00	3,920,428	100.00	3,993,448	100.00

Source: Annual Reports, MAFF (2011–2014)
Note: Other crops include peanut, sugar cane, sweet potato, sesame, jute, and tobacco.

Rice production in the country dominates the crop sector in terms of planted area, food security, and employment. Rice provides up to 75 percent of the population's total calorie intake and employs more than 70 percent of the labor force, of which 52 percent are women (MOE and UNDP 2011).

Rice is cultivated in both wet and dry seasons, accounting for 83.5 percent and 16.5 percent of the rice cultivated area, respectively (MAFF 2013). Wet season rice depends heavily on rainfall between May and October, whereas dry season rice is cultivated under either full or supplementary irrigation or in receding floodwaters between November and April. Rainfed lowland rice, deepwater rice, and rainfed upland rice account for about 93 percent, 5 percent, and 2 percent of the total production area of wet season rice, respectively (Figure 2).

Figure 2. Rice agro-ecosystem in Cambodia, wet season
Source: Sarom (2013)

Rainfed lowland rice can be found in all provinces, but its production is concentrated in the central plain around the Great Lake (Tonle Sap) and in the lower streams of the Mekong River and Bassac River. It is also produced in the coastal areas to the west and southwest as well as in the highlands of the north and northeast of the country (Figure 3). The average annual rainfall in the central plain is from 1,200 mm to 2,000 mm.

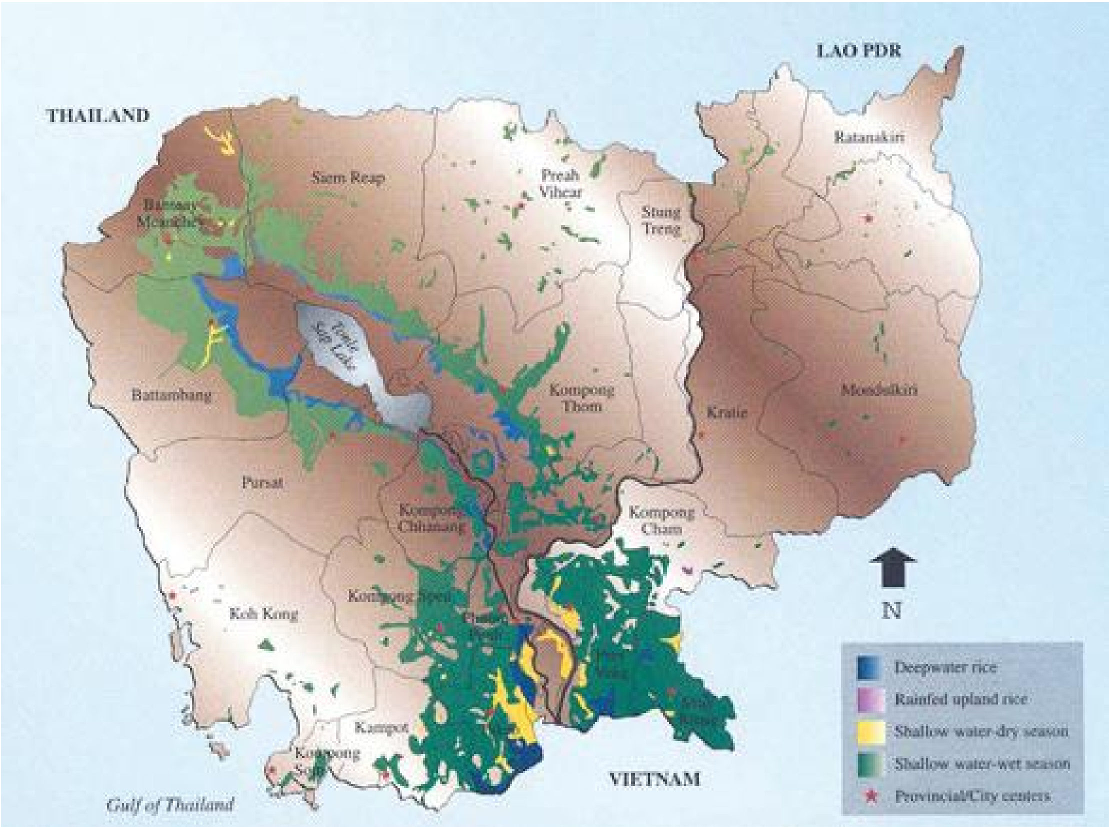

Figure 3. Major rice areas in Cambodia
Source: Nesbitt (1997)

Deepwater rice is also cultivated in the same areas as rainfed lowland rice, but it is concentrated along the edges of lakes where water is deeper than in higher fields. Rainfed upland rice is grown in small pockets, mainly in hilly regions in northern and northeastern Cambodia where the annual rainfall is higher than in the central plain.

The rice production environment in Cambodia is generally harsher than the fertile lowlands in other AMS. Soils are generally poor, often becoming waterlogged during the wet season, and commonly prone to floods and droughts, which can negatively affect production. Poor production consequently affects the national economy and the livelihoods of poor farmers. From its own side, wet season rice production produces a significant amount of greenhouse gases, mainly methane, which contribute to a certain degree of global warming.

Cassava is the next most important crop in Cambodia after rice. It is grown mainly by smallholder farmers for food to supplement the rice diet, animal feed, and extraction of starch from its roots. In recent years, there has been a major interest in the use of cassava as a raw material for ethanol production. Cassava production areas in Cambodia expanded exponentially from less than 20,000 ha in 2010 to more than 400,000 ha in 2013 (Table 1). Cassava is cultivated in almost all provinces in the country, but it is mainly produced in Kampong Cham, Battambang, Pailin, Kratie, and Kampong Thom. Cassava production areas range from 20,000 ha in Pailin to almost 70,000 ha in Kampong Cham (MAFF 2013).

Cassava is believed to cause serious soil degradation due to excessive uptake of nutrients, leading to soil nutrient depletion, or serious soil erosion when grown on slopes. On the contrary, however, research has shown that cassava extracts fewer nutrients from the soil than other food crops (Howeler 1991). Nevertheless, when the crop is grown continuously on the same land without inputs of manure or fertilizers, soil nutrients will eventually be depleted and productivity will decline, as is true for all crops.

In some areas the problem is alleviated by bush-fallow rotations, but where such rotations are not possible, farmers need to apply animal or green manure, or chemical fertilizers to maintain yields. Soils are mainly susceptible to erosion during the initial stage of the crop before the canopy closes; therefore, rain at the early growth stage can significantly affect soil quality (Putthacharoen et al. 1998).

Cassava processing produces large amounts of wastes, including solids and liquids, which are high in organic matter and cyanide. Solid wastes mainly derived from cassava chip processing, if properly managed, can be utilized in many ways. Liquid (water) waste, on the other hand, has the potential to pollute groundwater or lakes, rivers, or streams into which it flows. Cassava processing can also produce unpleasant odors and unattractive surroundings. Given these problems, cassava processing has always been regarded as a major environmental pollutant.

Both rice and cassava are very important to the daily diet of the Cambodian people and the national economy (Tables 2 and 3). However, these crops and their ecosystems are highly vulnerable to climate change. As such, they were selected for this study, which aims to promote climate resilience of crops for the sustainable development of the country. This report focuses on production activities, including the inputs to production (e.g., seed supplies). Rainfed lowland rice, which occupies more than 80 percent of the country's rice production, and rainfed upland cassava, the only production system available for the crop, were selected.

Table 2. Types and volume of rice production systems in Cambodia, 2013

Production system type	National production volume (t)	National production value (million USD)	Assessment of impact on national/regional consumption (1–3)	Indication/estimate of relative vulnerability to climate change (1–3)
Irrigated Lowland (Dry season)	2,118,710	423	1	2
Rainfed Lowland (Wet season)	7,271,251	1,818	3	3

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%), 2 – Medium (30%–55%), and 3 – High (greater than 55%). In the relative vulnerability to climate change, the following descriptions apply: 1 – Low (any impact upon the production system is likely to be manageable), 2 – Medium (without intervention, the production system is likely to suffer problems in the future), and 3 – High (the production system is already experiencing significant problems with extreme weather events and these are very likely to become more severe in the future).

Table 3. Types and volume of cassava production systems in Cambodia, 2013

Production system type	National production volume (t)	National production value (million USD)	Assessment of impact on national/regional consumption (1–3)	Indication/estimate of relative vulnerability to climate change (1–3)
Rainfed upland (Wet season)	7,632,997	534	3	3
Rainfed upland (Dry season)	300,384	22	1	2

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%), 2 – Medium (30%–55%), and 3 – High (greater than 55%). In the relative vulnerability to climate change, the following descriptions apply: 1 – Low (any impact upon the production system is likely to be manageable), 2 – Medium (without intervention, the production system is likely to suffer problems in the future), and 3 – High (the production system is already experiencing significant problems with extreme weather events and these are very likely to become more severe in the future).

A value chain, which has two sequential functions (i.e., seed or planting material supply and production), consists of a functional map combined with a map of actors depicting the following diagrammatically (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, 2007):

(1) The sequence of related business activities (functions) from the provision of specific inputs for growing and harvesting a specific crop through primary production, distribution, marketing, trading, and retailing of the final product to consumers (the functional view of a value chain)

(2) The set of enterprises (operators), which are linked by a series of business transactions in which the product is passed on from primary producers (growers) to end consumers, performing these functions (i.e., producers, processors, traders, and distributors of a particular product)

Based on the value chain analysis, many rice seed producers and distributors were listed, while only a few cassava seed suppliers were identified. The rice value chain has a number of seed suppliers, which include the following:

■ **General Directorate of Agriculture (GDA)** – GDA, which is under the Ministry of Agriculture, Forestry, and Fisheries (MAFF), primarily provides technical support on crop production to farmers in the country. They also participate in rice production as seed regulatory and rice seed distributor.

■ **Cambodian Agricultural Research and Development Institute (CARDI)** – CARDI, a public semi-autonomous institution, is the prime agricultural research institute in the country. It primarily develops agricultural technologies for sustainable agricultural production and transfers newly developed technologies to farmers. CARDI is the main producer and supplier of rice seeds, mainly breeder and foundation seeds, of all varieties that it has released. In 2012, it produced 6,112 kilograms (kg) of foundation seeds; 11,910 kg of registered seeds; and 27,706 kg of graded seeds and supplied them to seed production companies (CARDI 2013).

■ Private seed distributors

a. **Agricultural Quality Improvement Project (AQIP) Seed Production Company** – AQIP, a public-private seed production company, works with its provincial or district branches to supply large quantities of rice seeds to its growing market. In 2014, the company supplied 3,600 tons (t) of rice seeds to farmers and some development agencies and projects (Sak Choeun, personal communication).

b. **Aphivat Bandanh Kasekar (ABK)/ HCLP Co. Ltd – ABK/HCLP,** an affiliate of a non-government organization, produces quality premium aromatic rice and guarantees accessibility to the market. It works entirely on aromatic rice varieties, particularly Phka Rumdoul.

c. **Domnak Teuk Group Co. Ltd (DNT)** – DNT, an operational hand of the Centre for Livestock and Agriculture Development (CelAgrid), provides market access support to farmers through their contract business on quality rice production. In 2012, DNT supplied about 23 t of commercial seeds to its farmers' cooperators (Khieu Borin, personal communication).

■ **Farmer seed associations** – Given the limited capacity of the formal seed sector, local seed production associations that vary in size and structure also produce and distribute seeds. Many farmer seed associations can be found in Siem Reap, Battambang, Kampong Cham, and Kampong Thom.

A general mapping of the stakeholders in the rice and cassava production chains is presented in Figures 4 and 5.

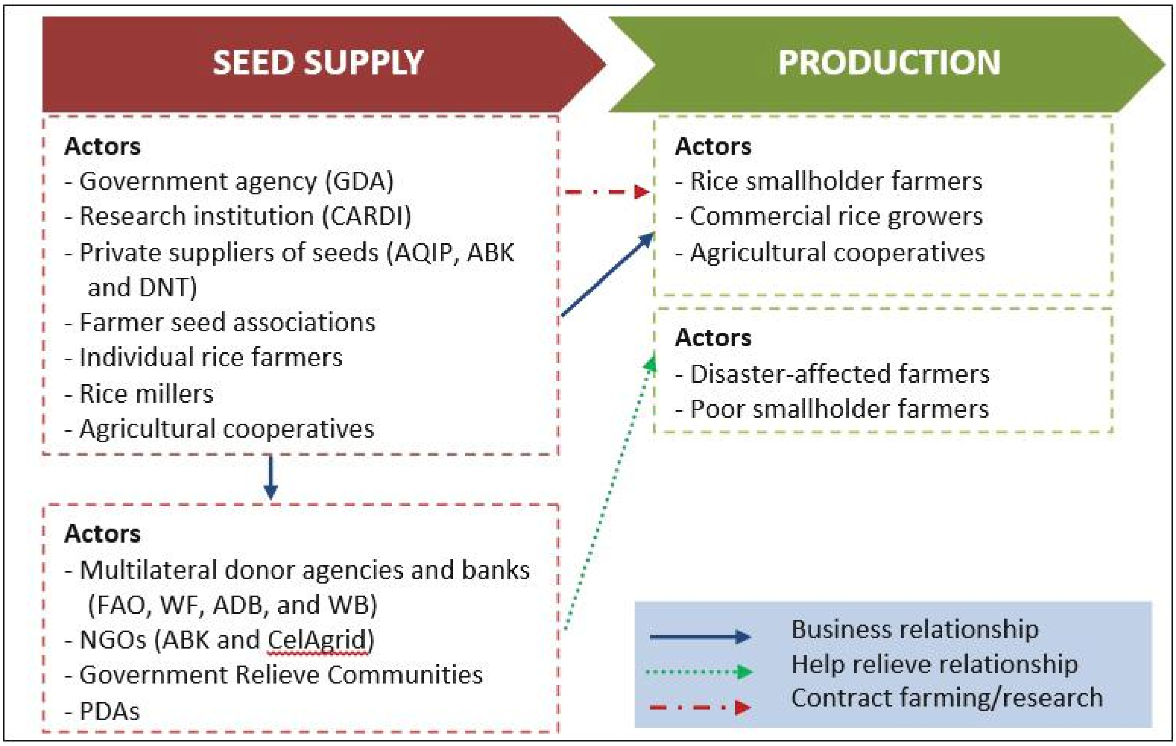

Figure 4. Rice value chain in Cambodia

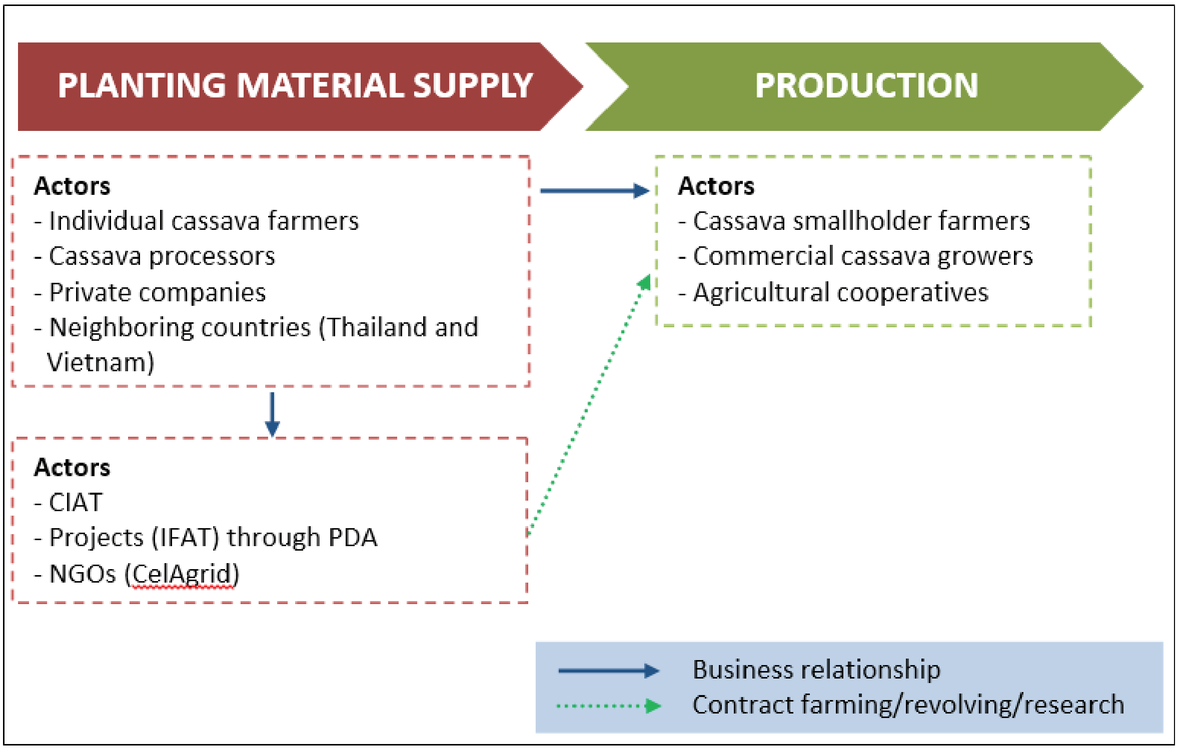

Figure 5. Cassava value chain in Cambodia

III. REVIEW OF CLIMATE CHANGE IMPACTS AND VULNERABILITIES

This study used the following terms as defined by the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2007; Low 2007):

- **Vulnerability to climate change** – The degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptability.

- **Exposure** – The nature and degree to which a system is exposed to significant climatic variations.

- **Sensitivity** – The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli.

- **Adaptive capacity** – The ability of a system to adjust to climate change, including climate variability and extremes; moderate the potential damage from it; take advantage of its opportunities; or cope with its consequences.

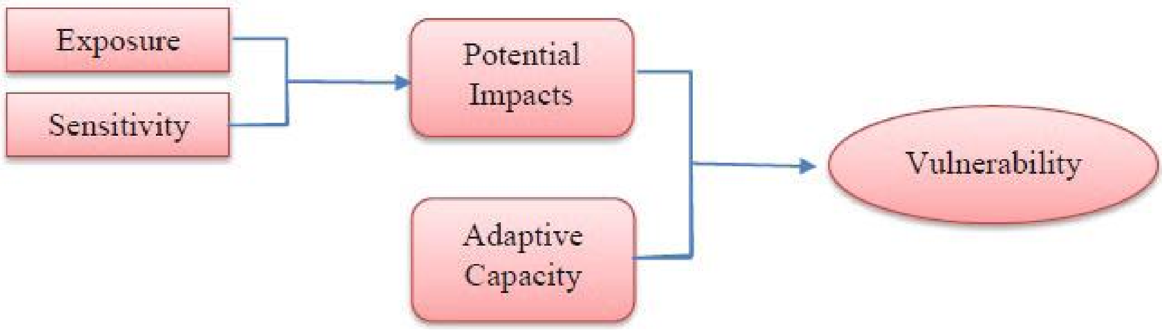

Figure 6. Climate change impacts and vulnerability

Based on a report by IPCC (2001), Cambodia is one of the AMS that are most vulnerable to the impacts of climate change. Its high vulnerability to climate change can be attributed to its socio-economic factors and adaptive capacity.

Cambodia is an agrarian country where agriculture accounts for about one third of the national GDP. Its economy is highly dependent on agriculture and natural resources. Approximately 80 percent of the population live in rural areas, where farming is the main source of income. Farm productivity in the country is low in terms of area and labor. In an unpublished survey conducted by Suvedi and Sarom (2012), rainfed lowland rice farmers occupied an average cultivated land of about 2.59 ha per household. This figure is relatively higher than the figure determined by the National Institute of Statistics (2011), who reported that 46 percent of the sample occupied less than 1 ha per household. Both findings still classify Cambodian farmers as smallholders.

Cambodia faces the sensitive issue of income inequality among its people as well as between cities and rural areas. In an assessment conducted by the Ministry ofEnvironment (MOE) and United Nations Development Programme (UNDP) (2011), the share of national wealth between the richest and the poorest 20 percent of the population displayed a clearly skewed distribution. It has also been reported that more than 30 percent of the Cambodian population live below the national poverty line of USD 1 per day. The poverty incidence is found to be higher in the rural areas, where people are more likely to be less educated and solely dependent on farming for their livelihoods (RGC 2010). Poor farming communities with limited resources for coping and adaptation are the most sensitive to climate change. According to Roberts and Parks (2007), as cited in MOE and UNDP (2011), "Countries with high levels of income inequality experience the effects of climate disasters more profoundly than more equal societies."

Climate hazards frequently experienced in Cambodia include floods, droughts, and wind storms. In coastal areas, underground water salinization and saltwater intrusion are the common problems. Floods and droughts are occurring more frequently and at a higher intensity throughout the country under changing climate conditions. The successive and combined occurrences of these hazards have resulted in considerable economic, human, and property losses as well as food insecurity.

Cambodia has already experienced changes in climate patterns in the form of unusually high temperature, higher rainfall with strong thunderstorms, occurrence of a number of typhoons, and frequency of other extreme weather events. Seasonal water shortages, drought spells, and floods have become more common and severe as saltwater intrusion. Such changes are expected to negatively affect natural ecosystems, agriculture, and food production, and magnify the problem of supplying food to a growing population. The impacts of such changes are likely to be severe in Cambodia where many communities derive their income from agriculture and natural resources.

From 1960 to 2005, the average temperature in Cambodia increased by 0.8ºC. Yearly within that period, hot days and nights increased by 12.6 percent and 17.2 percent, respectively, while cold days and nights decreased (McSweeney et al. 2008).

Similarly, the mean monthly rainfall increased by 15 mm over a 20-year period (1986–2006). The trends appear to be rising, but accurate information on climate change in Cambodia is very limited. Available information is often drawn from global or regional models, with varying degrees of relevance at the national level. Quantitative information is lacking and most of the data are presented in terms of broad potential trends in climatic conditions. Nevertheless, it is predicted that both temperature and rainfall in the country will increase, but the changes will vary according to geographic location.

UNDP Cambodia (2012) studied climate changes spanning 30–40 years through a vulnerability reduction assessment of 145 villages in 15 provinces and with more than 3,400 respondents. The assessment found that the length and frequency of droughts, frequency of high and increasing temperatures, and occurrence of widespread insect infestations have increased and continue to rise (Figure 7).

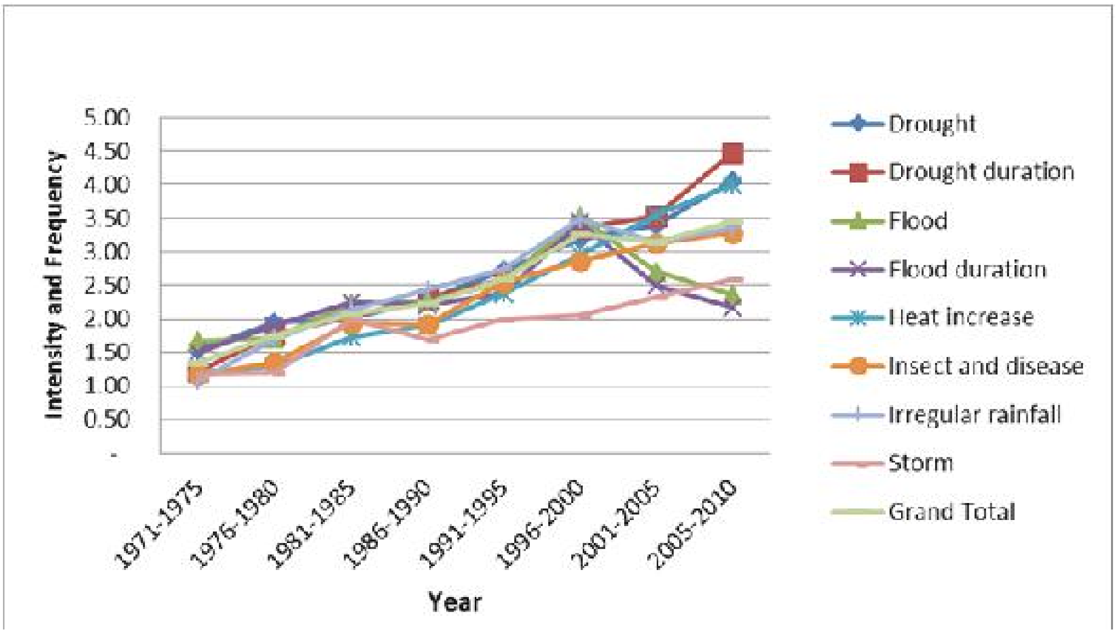

Figure 7. Climate change trends in Cambodia
Source: Adopted from UNDP (2012)

Floods have decreased in the last few years. However, unlike droughts, the effects of floods usually extend beyond agriculture. For instance, one of the worst floods in Cambodia in recent history occurred in 2000. It affected an estimated 3 million people and damaged infrastructure, excluding lost production and other secondary impact costs of more than USD 150 million (MOE and UNDP 2011). Such scenarios show that climate change and its impacts are a reality for Cambodians, especially farmers.

Farmers throughout the country have been noticing marked changes in the climate for the past 40 years (MOE and UNDP 2011). Data on the extent of crop damage from 1995 to 2013 from MAFF suggest a rising trend in the intensity of damages caused by floods, droughts, and insects, particularly from 2006 onwards (Table 4). In addition, results revealed that overall crop damage in rice production is primarily caused by floods (91.26%), followed by droughts (7.66%) and insects (1.08%).

Table 4. Rice crop areas damaged by droughts, floods, and insects, 1995–2013

Year	Damaged area (ha)			
	Droughts	Floods	Pests and diseases	Total
1995	9	147	0	156
1996	-	-	-	0
1997	98	39	0	137
1998	368	30	0	399
1999	9	50	0	60
2000	7	401	0	408
2001	66	197	0	262
2002	78	85	0	163
2003	57	4	0	61
2004	247	11	0	258
2005	7	21	0	27
2006	9,347	17,515	3,382	30,244
2007	5,653	31,008	1,092	37,753
2008	1,653	1,310	193	3,156
2009	66	143	59	268
2010	2,934	17,357	298	20,589
2011	53	267,184	0	267,237
2012	19,420	16,510	95	36,025
2013	178	127,634	548	128,360
Total damage	40,250	479,646	5,667	535,563
% of damage	7.66	91.26	1.08	100

Source: Annual Reports, MAFF (1996–2013)

Despite some variations, it is clear that the damages increased in 19 years. Floods and droughts were the two major persistent climate-related disasters in Cambodian farming during this period. Despite having variable intensities, both hazards negatively affected rice crops every year from 1995 to 2013. The magnitude of their impact increased markedly after 2006. The more catastrophic damages caused by floods were recorded in 2011, when about 267,000 ha or 11 percent of wet season rice production were eradicated. In the following year, droughts destroyed nearly 20,000 ha of rice cultivation (Table 5).

Table 5. Areas damaged by droughts, floods, and pest and diseases relative to the total planted area

Year	Total planted area (ha)	Droughts		Floods		Pests and diseases	
		ha	%	ha	%	ha	%
1995	1,869,991	9	0.0005	147	0.0079	0	0.0000
1996	1,936,900	-	0.0000	-	0.0000	-	0.0000
1997	1,827,328	98	0.0054	39	0.0021	0	0.0000
1998	1,873,093	368	0.0196	30	0.0016	0	0.0000
1999	1,915,592	9	0.0005	50	0.0026	0	0.0000
2000	2,058,648	7	0.0003	401	0.0195	0	0.0000
2001	1,926,004	66	0.0034	197	0.0102	0	0.0000
2002	1,821,225	78	0.0043	85	0.0047	0	0.0000
2003	2,030,735	57	0.0028	4	0.0002	0	0.0000
2004	2,048,360	247	0.0121	11	0.0005	0	0.0000
2005	2,116,098	7	0.0003	21	0.0010	0	0.0000
2006	2,212,015	9,347	0.4226	17,515	0.7918	3,382	0.1529
2007	2,241,114	5,653	0.2522	31,008	1.3836	1,092	0.0487
2008	2,255,104	1,653	0.0733	1,310	0.0581	193	0.0086
2009	2,334,228	66	0.0028	143	0.0061	59	0.0025
2010	2,391,016	2,934	0.1227	17,357	0.7259	298	0.0125
2011	2,496,569	53	0.0021	267,184	10.7020	0	0.0000
2012	2,512,038	19,420	0.7731	16,510	0.6572	95	0.0038
2013	2,567,723	178	0.0069	127,634	4.9707	548	0.0213

Source: Annual Reports, MAFF (1996–2013)

The adverse effects of climate change on cassava production are also rising. The damaged cassava production area increased from less than 4,000 ha in 2010 to more than 40,000 ha in 2013, while the damaged cassava planted area steadily increased from less than 2 percent in 2010 to more than 10 percent in 2013 (Table 6).

Table 6. Damages to cassava production in Cambodia, 2010–2013

Areas (ha)	2010	2011	2012	2013
Planted area (ha)	190,525	391,714	361,854	421,375
Harvested area (ha)	186,789	369,518	337,800	377,239
Damaged area (ha)	3,736	22,196	24,054	44,136
Relative to planted area (%)	1.96	5.67	6.65	10.47

Source: Annual Reports, MAFF (2011–2013)

The mean annual temperature throughout the country is expected to increase by 0.3ºC–0.8 ºC by 2030, 0.7ºC–2.7oC by 2060, and 1.4ºC–4.3 ºC by 2100 (MOE and UNDP/GEF 2001; MRC 2009). The mean annual rainfall throughout the country is also predicted to increase, especially during the wet season (Table 7).

Table 7. Historical and projected trends in selected climate variables in Cambodia

Variable	Specific climate risk/ opportunity	Historical trend	Projections	References
Mean temperature	Extremely high temperature Droughts Freshwater shortage Pest and disease outbreak	Increased	Increase of 0.3ºC–0.8ºC by 2030	MOE (2001) MRC (2009)
Minimum temperature	Lower rice yield	Increased	Increase	MOE and UNDP (2011) IRRI (2008)
Wet season rainfall	Droughts Floods Disease outbreak Land degradation Nutrient leaching	Increased	Increase of 3–35 percent by 2100	MOE (2002)
Dry season rainfall	Droughts Pest outbreak	Decreased	Decrease	MOWRAM (1997–2011)
Number of rainy days	Droughts High-intensity floods	Decreased	Decrease	MOWRAM (1997–2011)
Saltwater intrusion	Increased salinity in rice fields	Increased	More than 10 percent of the rice production area will be under sea water in 2005	MOE and UNDP/ GEF (2001)

Increasing rainfall and varying extremes are mainly projected in the central agricultural plain, which stretches from the southeast to the northwest. The increase in rainfall will be higher in the lowlands (4%–8%) than in the highlands and coastal areas (0%–4%) in 2025 (MOE and UNDP/GEF 2001).

Despite increases in rainfall, more dry spells with greater extremes between wet and dry seasons are projected. As with other AMS, floods and droughts are expected to increase in terms of frequency, severity, and duration. Seasonal water shortages and floods, as well as saltwater intrusion due to storm surges and sea level rise, are expected to worsen. If the sea level increases by 1 meter, about 10 percent of coastal rice production areas in the country will be inundated and 44 km2 of Koh Kong province will permanently be submerged (MOE and UNDP/GEF 2001). As a result of the changing climate, these changes will profoundly affect agricultural production in the country.

Cambodia's low capacity to adapt to climate change can be categorized in different areas. People in rural areas still make their own decisions, within their families and their own communities, about how they should respond to climate change. In most cases, they lack knowledge on climate change, which limits their preparedness and adaptive capacity. Discussions with farmers in different parts of the country revealed that farmers have their own methods of coping with the changing climate, such as praying for rain during drought conditions; collecting water from big streams, lakes, or rivers; or taking more baths when days are hotter, among others.

Early warning systems for floods exist, especially along the Mekong River, but early warning systems for droughts remain underdeveloped (MOE and UNDP 2011). As such, establishing and disseminating climate change information should also be prioritized. Cambodian farmers who rely heavily on seasonal changes in rainfall will greatly benefit from weather forecasting, which will enable them to make informed decisions on when to plant their crops or which crops or rice varieties to plant when anticipating a drought year or season.

The farmers' low capacity to adapt to climate change can also be attributed to their lack of access to irrigation systems. Aside from the limited coverage of irrigation systems over crop production areas, particularly rice, the efficiency of existing irrigation systems is also an issue. In a survey conducted in 2009, the respondents perceived that of the developed irrigation systems, only 6 percent functioned properly, 62 percent did not function, and 32 percent partially functioned (MOE and UNDP 2011).

With the increasing frequency, intensity, and duration of floods and droughts as well as saltwater intrusion into the land, the most effective adaptive response to these climate risks is to develop appropriate adaptive technologies that can sustain food supply to smallholder rural communities. However, the country's national research system is weak and incapable of effectively responding to the challenges of climate change. CARDI, the most prominent national agricultural research system and the only crop-based research institute in Cambodia, is critically under-resourced as evidenced by the number of rice varieties it has released. From 1990 to 2000, when CARDI was fully funded by an Australian aid program, it released 34 varieties at an average rate of 3.4 per year. From 2001 to 2013, when it no longer received funding from the aid program, it released only five varieties without new potential varieties in the pipeline (CARDI 2000–2012; MAFF 2014).

Climate change will seriously affect agricultural production in Cambodia. Despite having no specific model about the impacts of climate change on the country's agriculture, the potential scenarios and impacts were identified (Table 8) (Sarom 2013).

Table 8. Climate change scenarios and their impacts on agricultural production

Scenarios	Potential impacts on agricultural/rice production
Current	• Floods account for 91 percent of the damages to rice areas (MAFF 1995–2013). • Droughts account for 8 percent of the damages to rice areas (MAFF 1995–2013). • Pests and diseases account for 1 percent of the damages to rice cultivated areas (MAFF 1995 –2013) and more than 10 percent of the damages to total cassava planted areas (MAFF 2013).
Increases in the mean annual temperature	• A rise in temperature will suppress yield and lead to changes in crop water requirement. Hotter and dryer conditions may increase the amount of water required by plants. • The number of extremely hot days may increase in the coming years. If extremely hot days occur during flowering, the plant may experience floret sterility and consequently produce low yield with poor grain quality (in rice). • The incidence of pest and diseases may increase in rice and cassava production systems.
Changes in rainfall patterns (rainfall during the wet season will increase, with more variability in time and location, while the dry season will be longer and drier)	• The rice production system and its productivity may change. Wet season crops may increase and decrease in some areas. • The productivity of rainfed lowland rice and dry season rice may increase and decrease, respectively. • A decline in water surface during the dry season may lead to high use of groundwater. Over exploitation of this may lead to environmental problems, such as heavy metal and sand contamination and salinity. • As a result of more intense rainfall and long droughts, damages caused by pest and diseases may increase in incidence and severity and with different patterns. • Floods and droughts will be more intense and more frequent, with unpredictable

Table 8. cont....

Scenarios	Potential impacts on agricultural/rice production
	drought spells during the wet season and unexpected rainfall during the dry season. • The onset of the seasons will be less predictable.
Sea water rises and saltwater intrusion into freshwater streams and agricultural lands	• Cropping patterns will change. The current rice varieties used in present cultivation areas may no longer be suitable. • Natural ecosystems in the coastal zones may change as more salt-loving plant species dominate the areas. • Freshwater supply for farming activities may become inadequate.

Based on the assessments of climate change impacts on agricultural production in Cambodia, including the projected trends that will likely affect production, different climate-related hazard scenarios were drawn. Such hazards faced by rice and cassava production, their biophysical impacts, the CCA options to be undertaken, and the actors that should be involved in implementing the CCA options are listed in Tables 9 and 10.

Table 9. Climate-related hazards in the rice value chain

Climate related hazards	Biophysical impacts	Adaptation options	Relevant actors
Droughts	Low yield and poor grain quality due to weak/reduced growth, delayed flowering, and high sterility	• Use resistant varieties • Develop rainwater and floodwater harvesting techniques	• Researchers (CARDI) • Agricultural extension services and relevant technical departments (GDA) • Academicians and students (RUA) • PDA • Provincial Department of Water Resources and Meteorology • NGOs (CelAgrid and ABK) • IRRI • Farmers and farmer associations • Farmer water associations
Floods	Low yield and poor grain quality due to weak/reduced growth, delayed flowering, and high sterility	• Use resistant varieties • Establish alternate cropping systems	
Pest and disease outbreaks	Low yield and poor grain quality due to weak/reduced growth	• Use resistant rice varieties	
Heat/high Temperature	Low yield and poor grain quality due to high sterility	• Use resistant rice varieties • Establish rice-sesbania intercropping systems	
Freshwater scarcity	Low yield and poor grain quality due to wilting, stunting, and death of plants	• Develop rainwater and floodwater harvesting techniques • Establish crop-based farming systems • Develop varieties with high water use efficiency	
Salinity	Low yield and poor grain quality due to stunting and high sterility	• Use resistant rice varieties • Use saline-tolerant crops • Apply integrated nutrient management • Build barrage	

Table 10. Climate-related hazards in the cassava value chain

Climate related hazards	Biophysical impact	Adaptation options	Relevant actors
Pest and disease outbreaks	Low yield and poor root quality due to weak growth and deformation	• Use healthy planting materials	• Researchers (CARDI) • Agricultural extension services and relevant technical departments (GDA) • Academicians and students (RUA) • PDA • NGOs (CelAgrid and ABK) • CIAT • Farmers and farmer associations
Heavy rainfall	Low yield and poor root quality due to slow growth of the cassava plant	• Apply contour intercropping • Develop cover systems • Raise bed planting	
Land degradation/ soil erosion	Low yield and poor root quality due to weak growth	• Apply contour intercropping • Develop mulching systems	
Lower fertility	Low yield and poor root quality due to stunting	• Apply integrated nutrient management • Establish integrated farming systems • Develop mulching systems	
Droughts	Low yield and poor root quality due to slow growth of the cassava plant	• Use tolerant varieties • Calendar planting • Manage planting materials	

The climate change impact assessment and vulnerability rating (Annex 1) for rice and cassava production are presented in Tables 11 and 12.

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

System of interest	Climate change trend	Socio-economic impact	Exposure	Sensitivity	Ability to respond	Vulnerability rating (1–3)
Increase rice productivity	Increasing floods	High	High	High	Low	3
	Increasing droughts	High	High	High	Low	3
	More acute water shortages	High	High	High	Low	3
	Pests and diseases	Medium	Medium	Medium	Medium	2
	Salinity	Low	Low	Medium	Medium	1
Diversify farming systems	Increasing floods	High	High	High	Low	3
	Increasing droughts	High	High	High	Low	3
	Pests and diseases	Medium	Medium	Medium	Medium	2

***Note: I**n the vulnerability rating, the following descriptions apply: 1 – Low (any impact upon the production system is likely to be manageable), 2 – Medium (without intervention, the production system is likely to suffer problems in the future), and 3 – High (the production system is already experiencing significant problems with extreme weather events and these are very likely to become more severe in the future).

Table 12. Climate change impact assessment and vulnerability rating for cassava production

System of interest	Climate change trend	Socio-economic impact	Exposure	Sensitivity	Ability to respond	Vulnerability rating (1–3)
Increase cassava productivity	Soil erosion	High	Medium	High	Low	3
	High temperature	Medium	Low	Medium	Low	3
	Pests and diseases	High	High	Medium	Low	3
	High rainfall	Medium	High	Medium	Medium	1
Develop contour intercropping systems	Soil erosion	High	Medium	High	Low	3
	High rainfall	High	High	High	Low	3
	Pests and diseases	Medium	Medium	Medium	Medium	2

Note: In the vulnerability rating, the following descriptions apply: 1 – Low (any impact upon the production system is likely to be manageable), 2 – Medium (without intervention, the production system is likely to suffer problems in the future), and 3 – High (the production system is already experiencing significant problems with extreme weather events and these are very likely to become more severe in the future).

IV. AREAS OF REGIONAL COLLABORATION

Factors such as population growth, economy, and politics are specific to each country, but climate-related problems are similar across the region. Assessments by researchers and perceptions of people in rural areas indicate that climate change is real (UNDP 2012). The region is already experiencing frequent floods, droughts, thunderstorms, and typhoons; increasing temperatures; higher inland salinity; and more extensive pest and disease outbreaks.

Concerns regarding the national and regional impacts of climate change have been raised after the following incidents: the devastating Typhoon Ketsana in Cambodia (2009) and Typhoon Haiyan in the Philippines (2013); severe floods in Cambodia, Thailand, and Vietnam (2011); and late onset of rain in Cambodia (2010). Considering that most ASEAN economies are agriculture-based and have a large population of farmers, climate change remains the main threat to food security in the region. Consequently, its adverse impacts can influence the lives of millions of farmers, particularly smallholders. Regional collaboration is necessary in identifying the best CCA and mitigation measures to help farmers cope with environmental changes.

For Cambodia, there are areas where regional collaboration is required. In both rice and cassava value chains, financial assistance for scaling up adaptation practices is essential. This could be in the form of a regional testing platform, which could be financed by multilateral donor institutions or ASEAN. Technical assistance through short- and long-term training courses, and/or placement of experienced regional experts to support the implementation of research programs, is highly welcome. Information sharing is another form of regional collaboration that may be mutually beneficial for all AMS.

In return, the Cambodian team is willing to provide technical or advisory support to other AMS. Rice production in Cambodia is frequently confronted with floods and droughts, making technical expertise in this field plentiful in the country. CARDI, which has been working extensively on developing stress-tolerant rice varieties, is also a wealthy source of expertise.

V. CASE STUDIES ON GOOD PRACTICES

Agricultural activities in Cambodia are mainly conducted by smallholder farmers on a small piece of owned land or on rented land (NIS 2011; Suvedi and Sarom 2012). These farmers, who are generally economically resource poor, are among the people that are most vulnerable to climate change. Climate change threatens agricultural production, particularly rice and cassava production, with numerous climate risks such as floods, droughts, pest and disease outbreaks, saltwater intrusion, extremely hot days, land degradation, and nutrient depletion, among others. However, despite the significant degree of risk and uncertainty brought about by climate change, there are practices that can be adapted using the "no regrets" approach. This section describes five good adaptation practices in Cambodia.

5.1 Rice

5.1.1 Model Farming (Integrated Farming System)

Description:

Model farming is a fully integrated farming system approach. A piece of land (from 0.5 ha to 1 ha) is divided into lowland and upland cropping areas. Rice is cultivated in the lowland area, while legumes and vegetables are cultivated in the upland area. A canal system, which is formed within and around the farm, has dual functions: irrigation and drainage. The canal system is linked to a pond, which serves as a rainwater harvester during the wet season and a water source for irrigation during the dry season. A tube well can be installed next to the pond in case more water is needed. The pond, from which fish can swim through the canal system to find food (insects) in the rice fields, is also used as a fish-breeding refuge. An animal shed can be built in one corner of the farm. Any type of animal (e.g., cattle, pig, and chicken) can be raised and their wastes can be used to fertilize farm soil. In another corner of the farm, a farm house with a small farm shed can be built.

Background and climate hazard addressed:

In Cambodia, water shortages commonly occur throughout the year. The results of one study revealed that 81 percent and 54 percent of the households interviewed suffered from shortages of water for agricultural and personal uses, respectively (MOE 2006). Given the effects of climate change and as predicted by some environmental models, freshwater supply is highly at risk. It is expected that there will be serious complications in many parts of the world, including Southeast Asia, particularly in large river basins that are likely to decrease (Low 2007). Therefore, along with population growth, increasing demand arising from higher standards of living, and farming activities, water shortages could adversely affect the country's development. As droughts become longer and more intense, the flow of major river systems and their tributaries is seriously affected (MOE and UNDP 2011).

Increasing temperatures, which is normally associated with high evaporation, also slows growth and fertilization. This can significantly reduce yields. Studies conducted at the International Rice Research Institute (IRRI) and in different AMS suggest that, on the average, rice yield can be expected to =decrease by 10 percent for every 1ºC increase in minimum temperature during the growing season (Peng et al. 2004; MOE and UNDP 2011). Lower rice productivity is highly likely. Therefore, with fewer cultivated areas and significant yield reduction due to low water availability, the food security of rural populations will certainly be affected. Migration to the city will consequently increase. Model farming is thus proposed as a climate change resilience model to aid in CCA and mitigation. It aims to successfully build the adaptive capacities of rural communities to climate change through promoting diversification within their own available agricultural land, improving their access to new agricultural and water management technologies, and enhancing their skills in linking production and market. Model farming seeks to contribute to the sustainable production of food crops under changing growing conditions.

Table 13. Criteria for the selection of model farming as a good practice

Criteria	Indicators/sub-criteria	Narrative descriptions
Effectiveness of adaptation	Adaptation function	The practice enhances resilience and augments economic opportunities for farmers.
	Robustness to uncertainty	The practice is effective under different climate scenarios and socio-economic scenarios.
	Flexibility	Subsequent adjustments can be made if all the conditions change or if the changes are different from those that were initially expected.
Side effects	No regrets	The practice contributes to more effective water management and is beneficial in terms of diversifying crops-based animal and fish production.
	Win-win	The practice contributes to closing the gap between water availability and demand.
	Positive spillover effects	The practice has a positive effect on community water management and local markets.
	Negative spillover effects	None
	Trade-offs	None
Efficiency/costs and benefits	Low regrets	The practice requires a relatively high investment that will be paid off shortly after it is established.
Framework conditions for decision making	Equity and legitimacy	The practice is more beneficial to women because they do not need to work very far from their house and have most of the things they need for their kitchen.
	Are decision-making procedures accepted by those affected? Are stakeholders involved in decision making?	The practice can be done only if the farmers wish to adopt it.
Feasibility of implementation	What are the barriers to implementing, scaling up, and replicating the practice at the regional level?	There are financial limitations.
Alternatives		There is no cheaper alternative.
Priority and urgency	The impacts of climate change have been felt	Water supply is a concern in farming communities, especially when the dry season is longer, because drought spells become more severe and temperatures are extremely high.

Value chain function:
This practice addresses the production segment within the rice value chain. However, by increasing rice and other crop productions, the system can also serve as a supplier of different agricultural products for household consumption and markets.

Beneficiary:
Farmers and farming communities will directly benefit from adopting this system. Diversified farm production will allow them to experience food security, while diversified food crops will help provide the appropriate nutritional value.

Expected change in the value chain as a result of implementing this practice:
The farmers' adaptive capacity will improve with their diversified incomes. This is possible because through increased farm productivity, improved certainty of water utilization, and enhanced knowledge on integrated farm production, farmers will certainly earn more than when they used traditional methods.

This practice has the following main barriers:

- This practice requires the strong involvement of farmers, which is not possible in most circumstances.
- This practice requires a high initial investment, which many farmers could not afford.
- The migration of young rural population to cities and other counties will lead to labor shortage within rural families.
- The funds for scaling up and extending the technology within the country are insufficient.

This practice has the following enablers:

- CARDI, the leading national agricultural research institute that developed this model, can assist the Provincial Department of Agriculture (PDA) to implement this practice at the local level.
- Crop diversification and water saving is listed in the government strategy.
- IRRI, which is active in the region, might be interested to support this initiative.

Regional support: This practice can be tested in other countries, but financial and technical support from multilateral donors and other AMS are important.

Stakeholders and their role:

- CARDI should improve and extend the practice to a wider range of farmers.
- The Royal University of Agriculture (RUA) should work closely with CARDI to train students and farmers.
- GDA should work with CARDI in disseminating the practice throughout the country.
- PDA should support local farmers who wish to adapt this practice at the village level.

Gender implications:
It applies to both genders. There will be many activities to be carried out indistinctively by both men and women, although women may have more work to do than men.

5.1.2 Use of Submergence-tolerant Varieties

Description:
The use of rice varieties that are tolerant to submergence in rice fields for a certain period is recommended. This is one of the cheapest options for farmers as well as one of the most effective adaptation measures against floods in the rainfed lowland areas of Cambodia.

Background:
Floods can seriously damage national rice production. Wet season rice, which occupies more than 83.5 percent of the total rice production area in Cambodia, is divided into three sub-ecosystems: rainfed lowland rice, deepwater rice, and upland rice. Rainfed lowland rice, which has a share of more than 90 percent of the total wet season rice production, encounters a number of climate-related disasters during its life cycle, including floods. Floods cause plants of susceptible varieties to either slow down their growth or wildly elongate. If this occurs regularly, flowering can be delayed and associated with high sterility, consequently leading to poor grain production and low yield. Data from

1995 to 2013 revealed that floods occurred yearly during the 19-year period. The intensity of the damages ranged from about 1 percent to about 11 percent. The more catastrophic damages caused by floods were recorded in 2011, when about 267,000 ha or about 11 percent of wet season rice production were eradicated.

Climate hazard addressed:
Floods and submergence are considered the main causes of low yield in the country's crop production, which is mainly rainfed. Damages caused by floods were as high as 11 percent of the total production. Developing varieties that are tolerant to this abiotic stress will improve rice productivity in the country.

Table 14. Criteria for the selection of the use of submergence-tolerant varieties as a good practice

Criteria	Indicators/sub-criteria	Narrative descriptions
Effectiveness of adaptation	Adaptation function	The practice enhances resilience and augments economic opportunities for farmers.
	Robustness to uncertainty	The practice is effective under different climate scenarios (e.g., flood-prone environments).
	Flexibility	Subsequent adjustments can be made if all the conditions change or if the changes are different from those that were initially expected.
Side effects	No regrets	The practice contributes to more effective crop management.
	Win-win	The practice improves the livelihoods of rainfed lowland rice farmers, who are generally resource poor.
	Positive spillover effects	The practice builds capacity in developing varieties that are resistant or tolerant to the effects of climate change.
	Negative spillover effects	None
	Trade-offs	None
Efficiency/costs and benefits	Low regrets	Extensive adaptation trials under local conditions are required before a variety is selected.
Framework conditions for decision making	Equity and legitimacy	It is a win-win situation for all.
	Are decision-making procedures accepted by those affected? Are stakeholders involved in decision making?	The practice can be done only if the farmers wish to adopt it.
Feasibility of implementation	What are the barriers to implementing, scaling up, and replicating the practice at the regional level?	There are financial limitations. A germplasm of flood-tolerant varieties is also needed.
Alternatives		There is no cheaper alternative.
Priority and urgency	The impacts of floods have been felt	Damages caused by floods are becoming more severe.

Value chain function:
This practice addresses the production segment of the rice value chain.

Beneficiary:
Farmers and farming communities will directly benefit from adopting this practice. The availability and use of submergence-tolerant rice varieties will augment rice production.

Expected change in the value chain as a result of implementing this practice:
The adoption submergence-tolerant rice varieties will greatly benefit rice farmers in rainfed lowland areas in Cambodia.

This practice has the following main barriers:

- A variety that is tolerant to a longer duration of floods (more than 15 days) has not yet been developed.
- There is no universal rice variety that can adapt to all situations because the rainfed lowland environment is very diverse.
- The national government has allocated only a small portion of the budget for research.

This practice has the following enablers:

- CARDI, as a national agricultural research institute has developed and released a number of varieties with different degrees of tolerance to submergence. Phka Rumduol, Phka Rumchek, and CAR 9, the three varieties that are widely known for their premium quality, are moderately tolerant to floods (CARDI 2009). They can be used as the basis for improving tolerance.
- This challenge is aligned with the rice policy of the government
- IRRI, which is active in the region, might be interested to support this initiative.

Regional support:
Technical support in developing a germplasm bank of submergence-tolerant rice varieties is needed from other AMS. Financial support from multilateral donors is also essential to achieve the desired outcome.

Stakeholders and their role:

- CARDI should develop rice varieties that are suitable for various flooding scenarios in the country.
- RUA should work closely with CARDI to train students and farmers.
- GDA should provide policy support to enhance the adoption of this practice.
- PDA should support local farmers who wish to adapt this practice at the village level.

Gender implications:
It applies to both genders. There is no gender discrimination as both genders will benefit if the activity is funded.

5.1.3 Use of Drought-tolerant Varieties

Description:
The use of rice varieties that are tolerant to droughts is recommended. This is one of the cheapest options for farmers and one of the most effectiveadaptation measures against droughts in the rainfed lowland areas of Cambodia.

Background:
Drought is the second most hazardous climate threat to rice production in Cambodia. It adversely affects plant development by reducing growth and biomass as well as delaying flowering. High sterility is very common and is strongly linked to yield reduction. Most of the time, affected rice crops produce grains of poor quality. Drought effects are highly variable. They can occur at different growth stages of the rice plant or have different duration and level of severity. The effects can be more hazardous if droughts occur after floods and/or at high temperature. On the average, damages caused by droughts are 8 percent of the total damages caused by climate-related factors. Droughts damaged about 20,000 ha of wet season rice area in 2012.

Climate hazard addressed:
Floods and droughts cause the greatest economic damages to rice production in the country, which is mainly rainfed. The extent

of damage can vary per year, but damages occur yearly. Developing varieties that are tolerant to this abiotic stress will improve rice productivity in the country.

Table 15. Criteria for the selection of the use of drought-tolerant varieties as a good practice

Criteria	Indicators/sub-criteria	Narrative descriptions
Effectiveness of adaptation	Adaptation function	The practice enhances resilience and augments economic opportunities for farmers.
	Robustness to uncertainty	The practice is effective under different climate scenarios (e.g., flood-prone environments).
	Flexibility	Subsequent adjustments can be made if all the conditions change or if the changes are different from those that were initially expected.
Side effects	No regrets	The practice contributes to more effective crop management.
	Win-win	The practice improves the livelihoods of rainfed lowland rice farmers, who are generally resource poor.
	Positive spillover effects	The practice builds capacity in developing varieties that are resistant or tolerant to the effects of climate change.
	Negative spillover effects	None
	Trade-offs	None
Efficiency/costs and benefits	Low regrets	Extensive adaptation trials under local conditions are required before a variety is selected.
Framework conditions for decision making	Equity and legitimacy	It is a win-win situation for all.
	Are decision-making procedures accepted by those affected? Are stakeholders involved in decision making?	The practice can be done only if the farmers wish to adopt it.
Feasibility of implementation	What are the barriers to implementing, scaling up, and replicating the practice at the regional level?	There are financial limitations. A germplasm of flood-tolerant varieties is also needed.
Alternatives		There is no cheaper alternative.
Priority and urgency	The impacts of floods have been felt	Damages caused by floods are becoming more severe.

Value chain function:
This practice addresses the production segment within the rice value chain.

Beneficiary:
Farmers and farming communities will directly benefit from adopting this practice. The availability and use of drought-tolerant rice varieties will augment rice production.

Expected change in the value chain as a result of implementing this practice:
The adoption drought-tolerant rice varieties will greatly benefit rice farmers in rainfed lowland areas in Cambodia.

This practice has the following main barriers:

- A variety that features high tolerance to droughts and the preferred eating quality has not yet been developed.
- There is no universal rice variety that can adapt to all situations because the rainfed lowland environment is very diverse.
- The national government has allocated only a small portion of the budget for research.

This practice has the following enablers:

- CARDI, as a national research institute has developed and released CAR 3 and CAR 4, two varieties with different degrees of tolerance to droughts (CARDI 2009). However, these varieties are only moderately resistant and lack the quality parameters required by famers and markets. Therefore, alternative varieties that can replace CAR 3 and CAR 4 are needed. This challenge is aligned with the general rice policy of the government, The Promotion of Paddy Production and Rice Export.

- IRRI, which is active in the region, particularly in the area of developing drought-tolerant varieties, might be interested to support this initiative

Regional support:
Technical support in developing a germplasm bank of drought-tolerant rice varieties is needed from other AMS. Financial support from multilateral donors is also essential to achieve the desired outcome

Stakeholders and their role:

- CARDI should develop rice varieties that are suitable for various drought scenarios in the country.
- RUA should work closely with CARDI to train students and farmers.
- GDA should provide policy support to enhance the adoption of this practice.
- PDA should support local farmers who wish to adapt this practice at the village level.

Gender implications:
It applies to both genders. There is no gender discrimination as both genders will benefit if the activity is funded.

5.2 Cassava

5.2.1 Use of Healthy Planting Materials

Description: The use of healthy planting materials is considered the most effective method in controlling pests and diseases, particularly mealy bug and cassava witches' broom, in cassava production. Clean planting material production through different techniques can be employed.

Background: Cassava production in Cambodia used to be farmstead crop production that was done mainly in the backyard of farmers' houses. Before cassava production became commercialized, there were no reports on any damages caused by pests and diseases. A rapid boom in cassava production in Cambodia and in the region brought new threats from pests and diseases from South America, where the crop originated. Pests and diseases spread as infected cassava planting materials were moved from one place to another without any protocol on sanitation. Several pests and diseases emerged and attacked cassava production, including the pink mealy bug and cassava witches' broom. Therefore, clean planting materials are vital in achieving successful cassava production. Though the extent of damages caused by the mealy bug and cassava witches' broom has not been quantitatively reported, they significantly threaten the country's cassava production.

Climate hazard addressed:
Pests and diseases, particularly the mealy bug and cassava witches' broom, can reduce cassava yield, starch yield, and the quality of both. The production of clean seeds is vital in achieving sustainable cassava production, especially for smallholder farmers.

Table 16. Criteria for the selection of the use of healthy planting materials as a good practice

Criteria	Indicators/sub-criteria	Narrative descriptions
Effectiveness of adaptation	Adaptation function	This practice reduces the risk of planting materials being affected by pests and diseases.
	Robustness to uncertainty	The practice is effective under different climate scenarios.
	Flexibility	Subsequent adjustments can be made if all the conditions change or if the changes are different from those that were initially expected.
Side effects	No regrets	The practice contributes to more effective crop management.
	Win-win	The practice encourages cassava planting material production.
	Positive spillover effects	The practice has a positive effect on national clean planting material production, which could consequently reduce oil and air pollution through cassava planting material transportation from Vietnam and Thailand. Another spillover effect is the development of new cassava varieties with higher starch content.
	Negative spillover effects	None
	Trade-offs	None
Efficiency/costs and benefits	Low regrets	The practice requires extensive analytical work in identifying the most effective methods to produce healthy planting materials.
Framework conditions for decision making	Equity and legitimacy	It is a win-win situation for all.
	Are decision-making procedures accepted by those affected? Are stakeholders involved in decision making?	The practice can be applied by cassava farmers who are also interested in cassava varieties with higher starch content.
Feasibility of implementation	What are the barriers to implementing, scaling up, and replicating the practice at the regional level?	There are financial limitations.
Alternatives		There is no cheaper alternative.
Priority and urgency	Damage caused by emerged pests and diseases in cassava production is reported in the recent year	The rising trend in damages to planting areas is alarming and hampers sustainable cassava production.

Value chain function:
This practice addresses the input supply section within the cassava value chain.

Beneficiary:
Smallholder cassava farmers will directly benefit from adopting this practice. Increased availability of and access to clean planting materials will allow farmers to increase their crop yield. Increased crop yield will lead to increased income.

Expected change in the value chain as a result of implementing this practice:
The use of clean planting materials will reduce production damages caused by pests and diseases, and consequently improve household income.

This practice has the following main barriers:

- An effective method for early detection of pathogens has not yet been developed.
- There is no single effective method for eradicating all pathogens.
- Funding for conducting research on this practice is also a concern.

This practice has the following enablers:

- The International Center for Tropical Agriculture (CIAT) is willing to assist in developing the tool for this practice.
- GDA, CARDI, and RUA, which are actively working in the area, can be effective and efficient instruments for this initiative.

Regional support:
Emerging pests and diseases in cassava production is a regional issue. As a problem that transcends national borders, it requires a regional solution that can only be achieved through regional collaboration.

Stakeholders and their role:

- CIAT should continue developing the most appropriate tool for clean planting material production.
- CARDI, RUA, and GDA should work closely with CIAT in developing the tool and extend it to all cassava farmers in the country.
- PDA should support local farmers who wish to adapt this practice at the village level.

Gender implications:
It applies to both genders. There is no gender discrimination as both genders will benefit if the activity is funded.

5.2.2 Contour Intercropping

Description:
Cassava is planted on established vegetative or cropping contours. A scrub leguminous plant Leucaena is planted in one hedge row at high density and follows a row of lemon grass on top of the slope. These complementary plant hedgerows provide ground to minimize soil erosion and nutrient leaching, especially during heavy rains. Leucaena is known as a nitrogen-fixing plant that can enrich mono-cropping or unfertilized cassava production. It is planted to protect the cassava planting area from erosion. In addition, its leaves are rich in protein that can be used for animal production, while lemon grass can be used for culinary purposes. The size of the contours varies depending on the sloping pattern—the steeper the slope, the closer the contour. Nevertheless, this practice may not be appropriate if the slope is steeper than 30 degrees. To prevent the cassava plantation area from being in direct contact with rain, a fast-growing crop such as pumpkin should be planted simultaneously with cassava.

Background and climate hazard addressed:
In Cambodia, cassava is mainly produced in the northern uplands. It is planted chiefly in sloping areas where the slopes range from gentle to very steep. As the plant generally has a slow initial growth, erosion and soil nutrient depletion can occur if production practices are in their favor. Damages caused by soil nutrient depletion and erosion threaten future cassava production in the country. As research on this crop is limited, there is no reliable quantitative evidence of the damages. Nevertheless, it is a serious problem, especially in the course of climate change, as the areas experience rainfall of high intensity.

Table 17. Criteria for the selection of contour intercropping as a good practice

Criteria	Indicators/sub-criteria	Narrative descriptions
Effectiveness of adaptation	Adaptation function	The practice reduces the risk of soil erosion. It also enhances resilience and augments economic opportunities for farmers.
	Robustness to uncertainty	The practice is effective under different climate scenarios in sloping areas.
	Flexibility	Subsequent adjustments can be made if all the conditions change or if the changes are different from those that were initially expected.
Side effects	No regrets	The practice contributes to more sustainable soil management.
	Win-win	The practice improves the livelihoods of rainfed upland farmers, whose main source of household income is cassava cultivation.
	Positive spillover effects	The practice builds capacity in developing varieties that are resistant or tolerant to the effects of climate change.
	Negative spillover effects	None
	Trade-offs	None
Efficiency/costs and benefits	Low regrets	The practice requires a relatively high investment during the first year of application. The costs will decrease in subsequent years.
Framework conditions for decision making	Equity and legitimacy	It is a win-win situation for all.
	Are decision-making procedures accepted by those affected? Do they involve stakeholders in decision making?	This practice can only be done if the farmers wish to adopt it.
Feasibility of implementation	What are the barriers to implementing, scaling up, and replicating the practice at the regional level?	There are financial limitations.
Alternatives		There is no cheaper alternative.
Priority and urgency	The impacts of soil erosion have been observed	Soil damages caused by surface flow of rainwater from upper to lower areas have been rising.

Value chain function:
This practice addresses the production segment within the cassava value chain.

Beneficiary:
The adoption of contour intercropping will reduce the damages caused by soil nutrient depletion and erosion. It will aid cassava farmers in achieving sustainable production.

Expected change in the value chain as a result of implementing this practice:
Contour intercropping will promote sustainable cassava production with minimal nutrient leaching and erosion.

This practice has the following main barriers:

- The farmers might not fullyparticipate in contour intercropping because of lack of technical knowledge, limited financial resources, and complexity of application.
- Funding to test the suitability and appropriateness of this practice in sloping cassava production is also a concern.

This practice has the following enablers:

- CIAT, which is very active in this area, might be interested to support this initiative.
- GDA, CARDI, and RUA, which are actively working in the area, can be effective and efficient instruments for this initiative.

Regional support:
This practice can be adopted as is or with modifications in most sloping agricultural areas in the region. Financial and technical support from multilateral donors and other AMS are important, especially in scaling up the practice at the national and regional levels.

Stakeholders and their role:

- CIAT should provide technical and financial assistance in developing and testing this practice at the production level.
- CARDI and RUA should work closely with CIAT to test this practice in various locations with different sloping conditions.
- GDA, through its extension department, should help disseminate this practice to cassava farming communities.
- PDA should support local farmers who wish to adapt this practice at the village level.

Gender implications:
It applies to both genders. There is no gender discrimination as both genders will benefit if the activity is funded.

VI. CONCLUSION

Climate change is a global issue. All AMS, especially Cambodia, are now experiencing its impacts in the form of highly unusual and devastating typhoons, floods, droughts, pest and disease outbreaks, and other climate-related extremes, among others. The substantial human and property losses caused by climate risks will significantly affect the livelihoods of millions of resource-poor farmers who are prone to various climate hazards. It is projected that a continued change in climate will have dire consequences on crop production. There is an urgent need to identify good practices in CCA to sustain the production of rice and cassava, the two crops that are most susceptible to climate change.

Given that the climate problems encountered by AMS are similar, good practices in CCA that are effective in one country can also be successful in other countries in the region. The following platforms for regional collaboration can be considered:

(1) Given that the level of economic development among AMS varies, an exchange of experts for a certain period or allocation of experts from more advanced to less developed AMS may help stimulate regional integration to effectively address regional issues such as climate change. Some AMS are highly developed and equipped with better human resources and infrastructure than others.

(2) The establishment of an ASEAN ministry or council for climate change science may advance efforts in dealing with the impacts and identifying adaptation and mitigation strategies for the benefit of the entire region.

(3) The establishment of a regional research center on climate change in one of the AMS may improve regional collaboration. The main role of this center is to coordinate all AMS to work toward solving specific regional issues that are economically important.

The five suggested good practices are applicable to situations in Cambodia, but they can be modified to suit local conditions in other AMS. For replication, a technical consortium between countries can be formed to assist in refining such practices to ensure adaptability, proper allocation of resources, value for money, and effective problem solving, among others.

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ANNEX 1
MATRIX FOR ESTIMATING VULNERABILITY RATING

Exposure	Sensitivity	Ability to respond	Vulnerability rating
High	High	High	High
High	High	Medium	Very high
High	High	Low	Very high
High	Medium	High	Medium
High	Medium	Medium	High
High	Medium	Low	Very high
High	Low	High	Low
High	Low	Medium	Medium
High	Low	Low	High
Medium	High	High	Medium
Medium	High	Medium	High
Medium	High	Low	Very high
Medium	Medium	High	Low
Medium	Medium	Medium	Medium
Medium	Medium	Low	High
Medium	Low	High	Very Low
Medium	Low	Medium	Low
Medium	Low	Low	Medium
Low	High	High	Low
Low	High	Medium	Medium
Low	High	Low	High
Low	Medium	High	Very Low
Low	Medium	Medium	Low
Low	Medium	Low	Medium
Low	Low	High	Very Low
Low	Low	Medium	Very Low
Low	Low	Low	Low

ANNEX 2
CAMBODIA NATIONAL TASK FORCE

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Mr. Lor Bunna	Head, Agronomy and Farming Systems, CARDI
Dr. Pol Chanty	Head, Training Centre, CARDI
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