

Promotion of Climate Resilience in Rice and Maize

Philippines National Study



Imprint

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ASEAN-German Programme on Response to Climate Change (GAP-CC)
GIZ Office Jakarta
Menara BCA, 46th floor
Jl. MH. Thamrin No. 1
Jakarta 10310, Indonesia
Phone: +62-21-2358-7111
Fax: +62-21-2358-7110
Email: giz-indonesia@giz.de
www.giz.de
www.gapcc.org

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Authors

Dr. Romeo V. Labios
Ms. Donna Bae N. Malayang

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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
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FOR GRADUATE STUDY AND RESEARCH IN AGRICULTURE (SEARCA)

List of Acronyms

AFCC	ASEAN Multi-Sectoral Framework on Climate Change: Agriculture, Fisheries, and Forestry towards Food Security
AIFS	ASEAN Integrated Food Security
AMS	ASEAN Member States
ASEAN	Association of Southeast Asian Nations
AWD	Alternate Wetting and Drying
BAR	Bureau of Agricultural Research
BSWM	Bureau of Soils and Water Management
CCA	Climate Change Adaptation
CCC	Climate Change Commission
DA	Department of Agriculture
FAO	Food and Agriculture Organization
GAP-CC	German-ASEAN Programme on Response to Climate Change: Agriculture, Forestry, and Related Sectors
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ICM	Integrated Crop Management
IPB-CA	Institute of Plant Breeding – College of Agriculture
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
MDG	Millennium Development Goals
NEDA	National Economic Development Authority
OPV	Open Pollinated Varieties
PhilRice	Philippine Rice Research Institute
QPM	Quality Protein Maize
QTL	Quantitative Trait Loci
SCOPSA	Sustainable Corn Production in Sloping Areas
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture
SSNM	Site-specific Nutrient Management
UPLB	University of the Philippines Los Baños

Table of Contents

LIST OF TABLES	vi
LIST OF FIGURES	vii
FOREWORD	viii
ACKNOWLEDGMENT	ix
EXECUTIVE SUMMARY	x
I. INTRODUCTION	1
1.1 Climate Change in Southeast Asia	2
1.2 Climate Change in the Philippines	4
1.3 Rice and Corn Production in the Philippines	5
1.4 Objectives of the Study	8
1.5 Methodology	8
II. VALUE CHAIN MAPPING	12
2.1 Rice Value Chain Map in the Philippines	12
2.2 Corn Value Chain Map in the Philippines	12
III. CLIMATE CHANGE IMPACTS AND VULNERABILITIES	15
3.1 Climate Change Impacts on Agriculture in the Philippines	15
3.2 Climate Change Impacts on Rice Production and Post-production	16
3.3 Climate Change Impacts on Corn Production and Post-production	19
IV. INSTITUTIONAL CHALLENGES AND AREAS OF REGIONAL COLLABORATION	23
4.1 Institutional Challenges	23
4.2 Areas for Regional Collaboration	23
V. CASE STUDIES ON GOOD PRACTICES	24
5.1 Rice	24
5.1.1 PalayCheck System	25
5.1.2 Palayamanan Plus	25
5.1.3 Alternate Wetting and Drying Technique	26
5.1.4 Climate-ready Rice Varieties	26

Table of Contents

5.2 Corn	27
5.2.1 Site-specific Nutrient Management	28
5.2.2 Village-type Dryer	28
5.2.3 Sustainable Corn Production in Sloping Areas	29
5.2.4 White Corn for Food and Village-type White Corn Mill	29
5.3 Gender Component	31
5.3.1 Coping Strategies	32
5.3.2 Making Climate Finance Gender-sensitive	33
VI. CONCLUSION	33
BIBLIOGRAPHY	35

List of Tables

Table	Title	Page
1	Major rice production systems in the Philippines	7
2	Major corn production systems in the Philippines	7
3	Historical and projected trends of rice in selected climate variables in the Philippines	17
4	Impacts on rice production and the vulnerability rating	18
5	Historical and projected trends of corn in selected climate variables in the Philippines	20
6	Impacts on corn production and the vulnerability rating	21
7	Structuring good practice adaptation options in rice	24
8	Structuring good practice adaptation options in corn	27

List of Figures

Figure	Title	Page
1	Map of the ASEAN region	3
2	Observed mean annual temperature anomalies in the Philippines, 1951–2010	5
3	Production quantity of rice and corn, 1961–2012	6
4	Area harvested of rice and corn, 1961–2012	6
5	Six-step methodology for scoping the adaptive capacity of value chains	9
6	First national consultative meeting on 11 February 2014 at DA-BAR, Quezon City	10
7	Second national consultative meeting on 17 February 2014 at DA-BAR, Quezon City	10
8	Third national consultative meeting on 20 March 2014 at SEARCA, Los Baños	11
9	Fourth national consultative meeting on 14 April 2014 at SEARCA, Los Baños	11
10	Basic functions in a rice sub-sector value chain	12
11	Yellow corn value/supply chain in the Philippines	13
12	White corn value/supply chain in the Philippines	13

Foreword

The Bureau of Agricultural Research of the Department of Agriculture is proud to endorse this national study of promotion of resilience of rice and maize (corn). 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 GIZ through the German-ASEAN Programme on Response to Climate Change (GAPCC). This initiative allowed us to review adaptive practices that ensure impacts of climate change to food security is minimized.

Climate change affects the Philippines through the increase in frequency and intensity of extreme weather conditions such as droughts, floods and tropical cyclones that will place large populations and key sectors in the region at risk, especially the agriculture sector. Climate change adaptation best practices for commodities such as rice and maize were considered for this study. For irrigated rice, the following are considered as good practices: PalayCheck, Palayamanan Plus, and controlled irrigation or Alternate Wetting and Drying (AWD); while for rainfed rice are Palayamanan Plus, controlled irrigation/AWD, and use of climate resilient varieties. For yellow corn are: Site Specific Nutrient Management (SSNM), village type drier, and Sustainable Corn Production in Sloping Areas (SCOPSA); while for white corn, white corn for food and village type white corn mill.

We hope that the practices from the Philippines will be upscaled in several areas, and shared with our neighboring countries at ASEAN through regional collaboration of joint measures such as research and information exchange to benefit the people of the Philippines and the nearby countries within the region.



Dr. Nicomedes P. Eleazar, CESO IV
Director
Bureau of Agricultural Research
Department of Agriculture

Acknowledgment

This document is a product of a series of consultations with a team of technical experts and research managers from the Philippine Department of Agriculture (DA) and its attached agencies, Bureau of Agricultural Research (BAR) and Bureau of Soils and Water Management (BSWM); National Economic Development Authority (NEDA); Philippine Rice Research Institute (PhilRice); Food and Agriculture Organization (FAO) – Manila; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH – Philippines; International Rice Research Institute (IRRI); and University of the Philippines Los Baños (UPLB). We are grateful to the experts and the participants for sharing their knowledge and expertise in developing this material. We would also like to extend our sincerest appreciation to everyone who contributed to the completion of this report in one way or another.

Executive Summary

In Southeast Asia, climate change has augmented the frequency and intensity of extreme weather conditions such as droughts, floods, and tropical cyclones. As an additional stressor on livelihoods, ecosystems, and infrastructure, it will place large populations and key sectors in the region at risk (USAID 2010). As climate change vulnerability varies substantially across the region of the Association of Southeast Asian Nations (ASEAN), it is imperative to strengthen the resilience of people and ecosystems, and enhance the adaptive capacity of farmers and fishermen to cope with the imminent threat of climate change (AFCC 2009).

A team of technical experts and research managers from the Philippine DA and its attached agencies, BAR and BSWM; NEDA; PhilRice; FAO – Manila; GIZ – Philippines; IRRI; and UPLB was consulted to determine regional and national climate change vulnerabilities as well as climate change adaptation (CCA) in the Philippines. Four national consultative meetings were held on 11 and 17 February 2014 at DA-BAR, Quezon City and 20 March 2014 and 14 April 2014 at the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), Los Baños.

Lessons learned, good practices to be adopted or adapted and scaled up, and new collaborative initiatives to be undertaken were discussed to ensure environment and food security in Southeast Asia, as well as other regions that are experiencing the adverse impacts of climate change (SEARCA 2012).

This study focused on rice and corn, which are the two most important grain crops in the Philippines. Rice, the major staple food in the country, is grown mainly in irrigated and rainfed ecosystems. In 2013, irrigated lowland rice was grown to about 3.2 million hectares (ha) with a total production of 13.82 million tons (t) and an average grain yield of 4.27 t/ha, while rainfed lowland rice was grown to about 1.4 million ha with a total production of 4.39 million t and an average yield of 3.15 t/ha. Yellow corn is the major source of feed materials for the livestock sector, while white corn is also a staple food in the country. In 2013, yellow corn was grown to 1.3 million ha with a total production of 5.24 million t and an average yield of 3.86 t/ha, while white corn was grown to 1.27 million ha with a total production of 4.87 million t and an average yield of 1.67 t/ha.

Climate hazards affecting rice and corn production include increase in temperature; increase in frequency, intensity, and duration of extreme climate events such as droughts, floods, and tropical storms; changes in the intensity, timing, and spatial distribution of rainfall; warming temperatures; soil degradation; increase in weather variability; and sea level rise resulting in saltwater intrusion and loss of agricultural land (PhilRice 2011, 2012).

The following case studies on good practices in CCA options for rice and corn were prioritized: for irrigated rice, (1) PalayCheck System, (2) Palayamanan Plus, and (3) controlled irrigation or alternate wetting and drying (AWD) technique; for rainfed rice, (1) Palayamanan Plus, (2) controlled irrigation or AWD technique, and (3) climate-ready varieties; for yellow corn, (1) Site-specific Nutrient Management (SSNM), (2) village-type dryer, and (3) sustainable corn production in sloping areas (SCOPSA); and for white corn, (1) promoting wider adaptation of white corn for food or alternative staple food, and (2) village-type white corn mill. These case studies are described in detail in subsequent sections of this document.

This report presents the results of the study, discusses climate change vulnerability, reviews CCA and mitigation practices, and evaluates existing policy responses to and initiatives on climate change.

I. INTRODUCTION

Climate change is one of the greatest development challenges of today. It requires immediate attention because it has discernible and worsening effects on communities, including increasing severity of droughts and floods, rising sea level, displacement of large populations, and changes to growing seasons (IPCC 2007). In addition, climate change will compound existing obstacles to development and exacerbate the divisions between men and women in communities that are already vulnerable (UNDP 2011).

The International Panel on Climate Change (IPCC) (2007) defines the phenomenon as a statistically significant variation that persists for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events, and a slow yet continuous rise in global mean surface temperature that may include cooling or warming. It may also result from natural factors (e.g., volcanic eruption and changes in solar energy), natural processes within the climate system (e.g., changes in ocean and wind circulation), and human activities (e.g., agriculture and burning of fossil fuels) (Landicho et al. 2010; PhilRice 2011).

According to the Fourth Assessment Report of the IPCC, sea levels have risen rapidly in the past century, especially in the last 25 years (IPCC 2007). Climate change and climate variability are among the top issues that pose real threats to the environment and human systems, specifically agricultural production, biodiversity, and health, among others (IPCC 2007). Extreme climatic events (e.g., more frequent and destructive typhoons, prolonged wet and dry seasons, and higher incidence of pest and disease outbreaks) affect agricultural production systems negatively,

leading to food and livelihood shortages that threaten environment and food security. This phenomenon has and will continue to affect Southeast Asia where the project focuses on seven ASEAN Member States (AMS), namely, Cambodia, Indonesia, Lao PDR, Myanmar, the Philippines, Thailand, and Vietnam, to ensure long-term food security and improve farmer livelihoods.

ASEAN leaders adopted the ASEAN Integrated Food Security (AIFS) Framework to ensure long-term food security, which has long been an important agenda of ASEAN, and improve farmer livelihoods. Within the AIFS Framework, ASEAN established the ASEAN Multi-Sectoral Framework on Climate Change: Agriculture, Fisheries, and Forestry towards Food Security (AFCC). The AFCC aims to contribute to food security through the sustainable and efficient use of land, forest, water, and aquatic resources by minimizing the risks to and impacts of their contributions to climate change.

During the 8th ASEAN Technical Working Group Meeting held in Singapore in 2013, the Thai DA endorsed a proposal entitled Production System Approach for Sustainable Productivity and Enhanced Resilience to Climate Change. The proposal was approved by the German-ASEAN Programme on Response to Climate Change: Agriculture, Forestry, and Related Sectors (GAP-CC). The proposal was further developed, and the title was changed to Promotion of Climate Resilience of Rice and Other Crops. This national study is based on the GAP-CC implementation proposal.

GAP-CC strives to support ASEAN in advancing the implementation of regionally coordinated strategies and policies for food

security and climate protection in agricultural and forestry sectors within AMS. It developed a regional food security index, which includes climate change effects, to provide ASEAN decision-makers with a comparable regional overview of food security vulnerability for the three most important food crops: rice, corn, and cassava. It is based on the regional food security index that the staples have been selected to support Thailand's project proposal at the regional level.

As a member of ASEAN, the Philippines is committed to address and act on climate change by integrating it systematically in all phases of policy formation, development planning, and research and development (R&D). The general goal is to build the country's adaptive capacity, strengthen its resilience to climate change, and optimize its mitigation opportunities.

In 2009, the Philippine Congress passed the Climate Change Act. The Climate Change Commission (CCC) was then established to develop policies and coordinate government programs on climate change. The CCC formed the National Climate Change Action Plan that serves as a road map for all climate change programs in the Philippines. Strengthening reforms to fully integrate the climate change agenda in the planning and budgeting of

the government will bolster the country's resilience to the impacts of a warming world, and make communities less vulnerable to sea level rise, degradation of marine ecosystems, and extreme weather events (CCC 2011; DA 2013b; PAGASA 2011).

The Climate Change Act of 2009 (R.A. 9729) mandates the "mainstreaming of climate change in policy formation, such that policies and measures that address climate change are integrated in development planning and sectoral decision-making." To fulfill the mandate, the DA came up with four strategic objectives to make its plans and programs climate-proof or compliant to climate change. DA programs and projects across all functions and agencies should take the necessary steps to migrate from the usual planning framework (DA 2013b).

All general circulation models predict an enhanced hydrological cycle and an increase in area-averaged annual mean rainfall in Asia. This is expected to exacerbate pressure on the region's natural resources that are already under severe stress from increasing population. Developing countries will be the most vulnerable as they have limited resources and capacity to adapt to the effects of climate change (Lasco et al. 2010).

1.1 Climate Change in Southeast Asia

Growing evidence of climate change around the world and in Southeast Asia compels all sectors to act and ensure the sustainability of lifelines, which include natural systems and food resources, rural livelihoods, and human resources. Southeast Asia, particularly

AMS (Figure 1), is therefore challenged to increase its capacities and expertise to attain the Millennium Development Goals (MDG), specifically those that pertain to eradicating extreme poverty and hunger, and ensuring environmental sustainability (SEARCA 2012).



Figure 1. Map of the ASEAN region

The Fourth Assessment Report of the IPCC (2007) states that Southeast Asia is expected to be seriously affected by adverse climate change impacts, since most of the economies in the region rely on agriculture and natural resources (IFAD 2009). Annually, Southeast Asia experiences climate extremes, particularly floods, droughts, and tropical cyclones, making large areas in the region highly prone to flooding and influenced by monsoons. Such climatic forces will severely threaten the livelihoods of poor rural dwellers, who have limited adaptive capacity.

Climate change is expected to affect agriculture in Southeast Asia in several ways. For example, irrigation systems will be affected by changes in rainfall and runoff. Subsequently, water quality and supply will be altered. The region already faces water stresses; hence, future climate change impacts on regional rainfall will have both direct and indirect effects on agriculture (IFAD 2009).

The Philippines is facing an increase in

temperature from 2°C to 4°C, and studies suggest both potential gains and losses. For example, at less than 2°C, agricultural losses are predicted to occur in the Philippines, while rice yields are projected to increase in Indonesia and Malaysia. In fact, although climate change impacts could result in significant changes in crop yields, production, storage, and distribution, the net effect of the changes around the region is uncertain because of local differences in growing season and crop management, among others (IFAD 2009).

In general, climate studies indicate increasing rainfall throughout the region. However, despite increases in rainfall, a rise in temperature may threaten agricultural productivity, stressing crops and reducing yields.

In particular, scientific studies have documented that major cereal and tree crops are highly sensitive to changes in temperature,

moisture, and carbon dioxide (CO₂) concentration of the magnitudes projected for the region. For example, projected impacts on rice and wheat yields suggest that any increase in production associated with CO₂ fertilization will be more than offset by reductions in yield

resulting from temperature and/or moisture changes (IFAD 2009). Such agricultural impacts particularly affect low-income rural populations that depend on traditional agricultural systems or marginal lands.

1.2 Climate Change in the Philippines

The Philippines, which has a total land area of 300,000 square kilometers, is an archipelago composed of 7,100 islands that are clustered into the three major island groups of Luzon, Visayas, and Mindanao (Jose and Cruz 1999). The country is susceptible to the harsh impacts of climate change because its population and economic activity are highly concentrated in coastal areas; it relies heavily on agriculture in providing livelihoods for a large segment of its population; and it depends greatly on natural resources (NEDA 2013).

The Philippines is one of the countries that are considered highly vulnerable to climate change. It has experienced numerous weather-related disturbances and disasters. In recent years, the typhoons have been unusually heavy and devastating to the country. In its analysis of natural disaster hotspots, the Hazard Management Unit of the World Bank (2005) found that the Philippines is among the countries where a large percentage of the population resides in disaster-prone areas. Many highly populated areas are exposed to multiple hazards: 22.3 percent of the land area is exposed to three or more hazards, and in that area, 36.4 percent of the population is exposed. Areas where two or more hazards are prevalent comprise 62.2 percent of the total area where 73.8 percent of the population is exposed (Rudinas et al. 2013).

Based on the report of the Philippine Atmospheric, Geophysical, and Astronomical Services Administration from 1951 to 2006, maximum, minimum, and mean annual temperatures increased by 0.35°C, 0.89°C, and 0.61°C, respectively. Minimum temperatures rose to as high as thrice the

increase in maximum temperatures. From 1961 to 2003, there was a significant increase in the frequency of hot days and nights, and a decrease in the number of cold nights and days (PAGASA 2011; PhilRice 2011).

The annual mean rainfall and number of rainy days, as well as the inter-annual variability of the onset of rainfall, have been rising. Increasing occurrences of extreme rains have caused flash floods, landslides, and inundation of low-lying areas. In addition, typhoons have become increasingly frequent. In the last few decades, about 15 to 20 typhoons per year entered the Philippines' area of responsibility (PAGASA 2011). Droughts, normally associated with El Niño, have also become more intense.

The outcomes of climate change threaten to undermine the Philippines' development prospects and exacerbate the vulnerability of its poorer communities. With projected changes in precipitation, temperature, intensity of tropical cyclones, and frequency of extreme weather events, considerable efforts are required to prepare the Philippines in dealing with climate change consequences on different climate-sensitive sectors. Adaptation will be an integral part of the country's response to the threats of climate change (PAGASA 2011).

Central to achieving the outcomes of the Philippines' implementation of the MDG Fund Joint Programme, Strengthening the Philippines' Institutional Capacity to Adapt to Climate Change, is developing the capacity of local government units to mainstream CCA in their development plans, programs, and activities. CCA planning and implementation

will require detailed information on plausible future climates (e.g., changes in temperatures, rainfall, and frequency of extreme weather events). Referred to as climate change scenarios, this type of climate information is generated from climate simulations (PAGASA 2011).

As in most parts of the globe, the Philippines

has also exhibited increasing temperatures (Figure 2). The graph of observed mean temperature anomalies (or departures from the 1971 to 2000 normal values) from 1951 to 2010 indicate an increase of 0.648°C or an average increase of 0.0108°C annually (Cinco et al. 2013; PAGASA 2011).

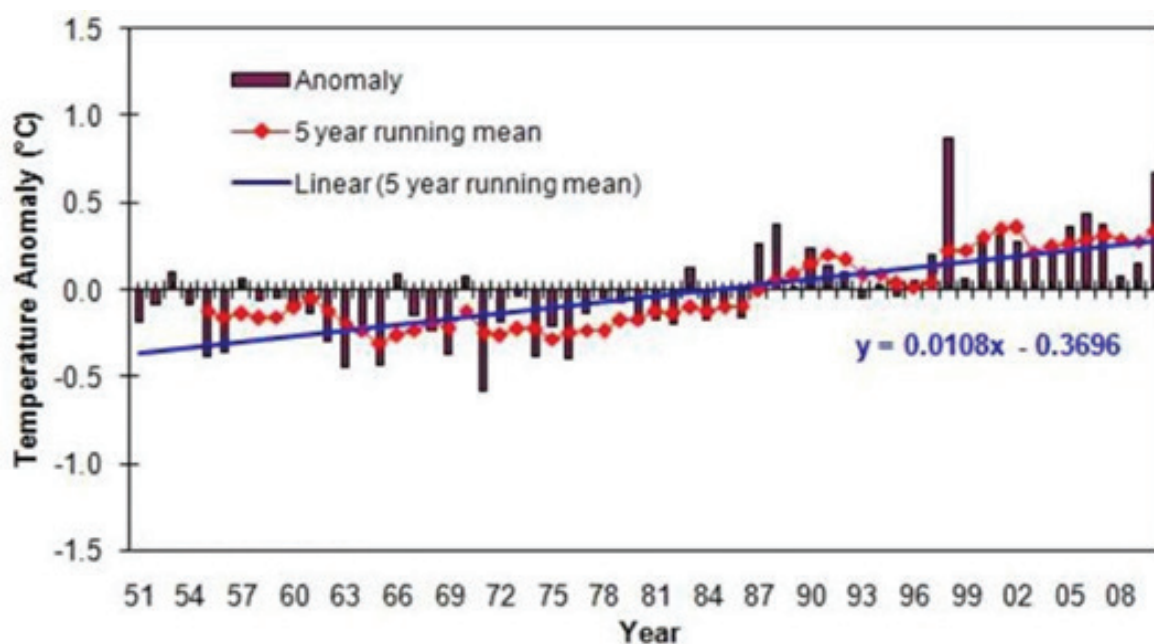


Figure 2. Observed mean annual temperature anomalies in the Philippines, 1951–2010

Note: The values from 1951 to 2010 were compared with the normal values from 1971 to 2000.

Source: PAGASA-DOST (2011)

Studies have shown that climate change threatens the stability and productivity of agricultural production. In many areas of the world where agricultural productivity is already low and the means of coping with

adverse events are limited, climate change is expected to reduce productivity to even lower levels and make production more erratic (Cline 2007; Fisher et al. 2002; IPCC 2007; Stern 2006).

1.3 Rice and Corn Production in the Philippines

Rice (*Oryza sativa* L.) and corn (*Zea mays* L.) are the two most important grain crops in the Philippines. Rice is the country's major staple food, while corn is the primary source of feed materials for the country's livestock industry. In 2004, the areas devoted to rice and corn production were 4.1 million ha and 2.5 million ha, respectively, amounting to an annual production of 14.5 million t and 5.4

million t, respectively (BAS 2004). Based on official statistics, the projected population of the country for the year 2005 was 85.2 million (NSO 2005). This population consumed about 8.2 million t of rice and 0.3 million t of corn for food alone (FAO 2006). Hence, it is important to quantify the effects of climate change on productivity for these two crops (Lansigan and Salvacion 2007). Data on the quantity of

rice and corn production in the last 50 years showed an increasing trend (FAO 2014) (Figure 3). Rice harvested area decreased at some point, particularly during the early 1980s and

late 1990s, but eventually increased, while corn harvested area followed a decreasing trend since the 1990s (FAO 2014) (Figure 4).

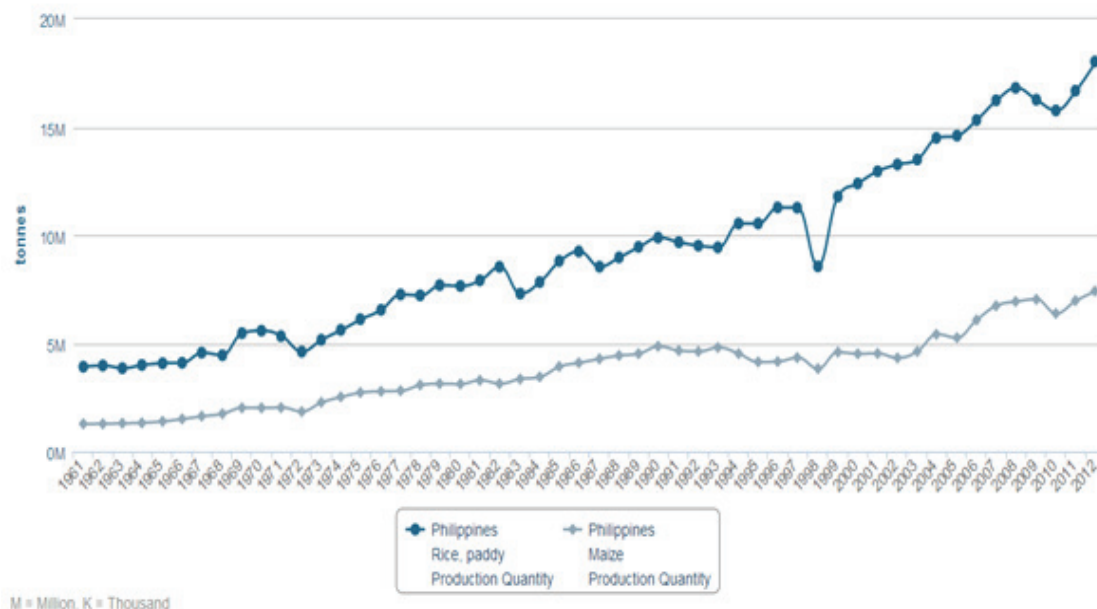


Figure 3. Production quantity of rice and corn, 1961–2012

Source: FAOSTAT (2014)

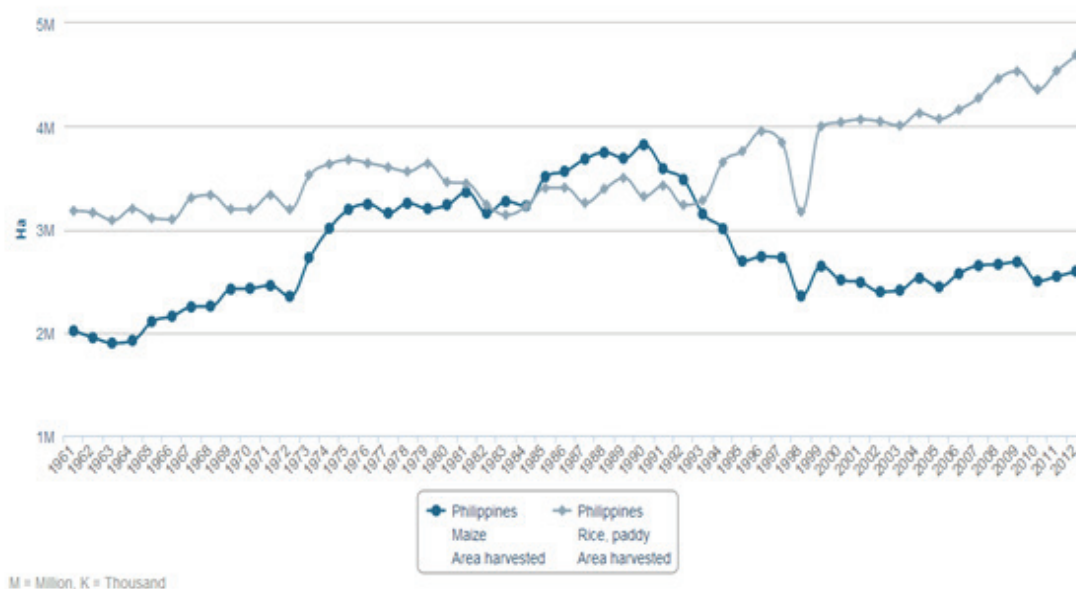


Figure 4. Area harvested of rice and corn, 1961–2012

Source: FAOSTAT (2014)

The Philippines is a large rice producer, but it is forced to rely on imports to compensate for the difference as demand outpaces supply. In fact, the country is one of the largest rice importers in the world, leaving it particularly vulnerable to high and volatile rice prices.

Corn is the second most important crop in the Philippines. Yellow corn is mainly used and traded as raw material for animal feeds (almost 70% of the annual national corn production). White corn serves as the main staple food for about 15 percent of the country's total population, mostly in Visayas and Mindanao (DA 2013a). Some 600,000

farm households depend on corn as a major source of livelihood, in addition to transport services, traders, processors, and agricultural input suppliers who directly benefit from corn production, processing, marketing, and distribution.

As of 2013, the total production for irrigated, rainfed, and upland rice were 13,823,145 t, 4,392,864 t, and 223,398 t, respectively (PSA-BAS 2014) (Table 1). The total production for yellow corn and white corn were 5,248,020 t and 2,129,056 t, respectively (PSA-BAS 2014) (Table 2).

Table 1. Major rice production systems in the Philippines

Production system type	National production volume			National production value (PHP 44.14 = USD 1)	Assessment of impact on national/regional consumption (1–3)	Indication/estimate of relative vulnerability to climate change (1–3)
	Production (t)	Area harvested (ha)	Yield (million t/ha)			
Irrigated	13,823,145 ^a 12,730,856 ^b	3,236,336 ^a 3,107,249 ^b	4.27 ^a 4.09 ^b	PHP 314,022,000.98 ^a USD 7,113,729.04 ^a	High	High
Rainfed	4,392,864 ^a 4,128,953 ^b	1,395,367 ^a 1,375,376 ^b	3.15 ^a 3.00 ^b		Low	High
Upland	223,398 ^a 223,896 ^c	114,379 ^a 111,508 ^c	1.95 ^a 2.01 ^c		Low	High

Source: ^aBAS Data (2013), ^bBAS Data (2009–2013), ^cBAS Data for Upland Rice (2010–2013)

Table 2. Major corn production systems in the Philippines

Production system type	National production volume			National production value (PHP 44.14 = USD 1)	Assessment of impact on national/regional consumption (1–3)	Indication/estimate of relative vulnerability to climate change (1–3)
	Production (t)	Area harvested (ha)	Yield (million t/ha)			
Yellow	5,248,020 ^a 4,847,127 ^b	1,285,029 ^a 1,253,865 ^b	4.08 ^a 3.86 ^b	PHP 90,221,000.69 ^a USD 2,043,973.74 ^a	High	High
White	2,129,056 ^a 2,186,064 ^b	1,278,606 ^a 1,323,135 ^b	1.67 ^a 1.65 ^b	PHP 33,830,700 ^b USD 766,440.87 ^b	High	High

Source: ^aBAS Data (2013), ^bBAS Data (2009–2013)

During the last quarter of 2013, corn was among the crops sub-sector with big output increment, along with pineapple, mango, and tobacco. Rice production, on the other hand, reached 11.36 million t in the first nine months

of the year (PSA-BAS 2014). Crop simulation modeling showed that rice productivity is expected to decline because of climate change (Peñalba et al. 2012).

1.4 Objectives of the Study

In support of promoting climate resilience of rice and other crops, the project provides a national and regional platform to enhance cross-sectoral knowledge-sharing and cooperation among Ministries of Agriculture, other relevant ministries, and the scientific community. The objective is to identify areas of collaboration and priorities for the development of ASEAN regional coordinated strategies to address climate change in agriculture and selected crops to increase food security.

The main goal of the consultative meetings was to bring together researchers, academicians, policy-makers, and planners to exchange information towards enhanced capacity in rice and corn production in the Philippines

in the face of climate change and its impacts, particularly on food security.

The goals included exchanging knowledge on climate change and adaptation strategies, gathering information and experiences into an integrative body of knowledge, identifying location-specific knowledge and adaptation strategies that may be scaled up to other regions, and promoting partnerships and linkages among different sectors for collaborative activities on CCA.

In general, the study aimed to provide information on the status of national-level vulnerability of AMS, which are among the countries that are most susceptible to the impacts of climate change.

1.5 Methodology

The methodology used in this study was developed as part of the GAP-CC project, which seeks to review and develop the adaptive capacity of stakeholders and identify priority areas for selected AMS. Overall, the program aimed to facilitate a process of regional agreement among AMS on where adaptive capacity should be prioritized and addressed through cooperation.

The methodology sought to cover the following objectives:

- To identify good practices in the ASEAN region that address climate change-related vulnerabilities that could lead to food insecurity in critical regional food crops (i.e., rice, corn, and cassava) using a value chain mapping approach

Output A: Good practice case studies on improving the adaptive capacity of rice, corn, and cassava supply in AMS

- To identify where vulnerabilities exist or are likely to exist in the supply of the identified food crops, focusing primarily on production and related inputs and secondly on post-production activities, specifically drawing out where regional collaboration will be most valuable

Output B: List areas of vulnerability related to the production of rice, corn, and cassava, as well as regional mechanisms for cooperation and action to address the identified vulnerabilities

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

Output C: Targeted dissemination of research outputs to stakeholders across the AMS to facilitate knowledge-sharing, cooperation, and communication on building adaptive capacities

At the AMS level, the following methodology highlighted the proposed support from GAP-

CC as input to the regional platform. Research institutions that are experts in value chain analysis in selected sectors and climate change were selected to undertake these studies. Further capacity-building and technical guidance were provided by GIZ, resource persons, and other institutions involved.

This study applied a six-step process in assessing where adaptive capacity is needed in the value chain now and in the climate-affected future, as well as what level of adaptive capacity currently exists in the country (Figure 5).

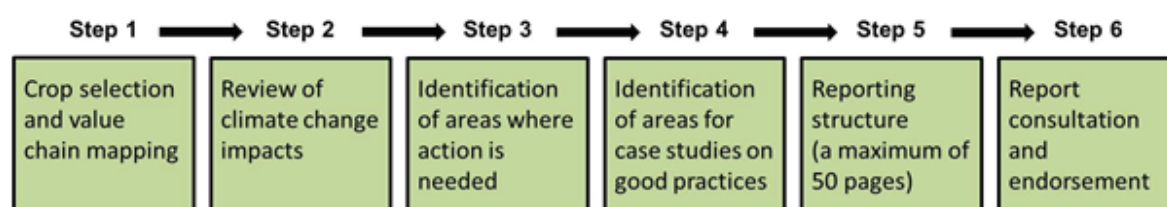


Figure 5. Six-step methodology for scoping the adaptive capacity of value chain

The study was implemented in consultation with relevant stakeholders at the national level to obtain relevant input. The nature of climate change impacts and respective responses requires leadership at the highest level, and close collaboration and coordination between sectors. Since climate change impacts and potential adaptation and mitigation responses can be very site-specific, respective action should be taken at sub-national and local levels. The framework was set to promote cross-sectoral and inter-departmental coordination and cooperation.

The methodology used was designed to maximize existing information, studies, and experience in the Philippines. There was no primary research intended as each step of the methodology involved literature review, particularly the compilation of past studies on climate change impacts, adaptation strategies, and measures (i.e., good practices);

the judgment of the stakeholders; and the judgment of other experts that participated in the consultative meetings.

Four national consultative meetings were held on the following dates in the following venues, and with the following number of participants:

- 11 February 2014 at DA-BAR with 30 participants (19 males and 11 females)
- 17 February 2014 at DA-BAR with 30 participants (20 males and 10 females)
- 20 March 2014 at the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) with 20 participants (13 males and 7 females)

- 14 April 2014 at SEARCA with 33 participants (22 males and 9 females)

These meetings, which were attended by experts who are involved in rice and corn

programs, were held to identify rice and corn issues related to climate change as well as good agricultural practices for adaptation and mitigation of climate change impacts (Figures 6 to 9).



Figure 6. First national consultative meeting on 11 February 2014 at DA-BAR, Quezon City



Figure 7. Second national consultative meeting on 17 February 2014 at DA-BAR, Quezon City



Figure 8. Third national consultative meeting on 20 March 2014 at SEARCA, Los Baños



Figure 9. Fourth national consultative meeting on 14 April 2014 at SEARCA, Los Baños

II. VALUE CHAIN MAPPING

2.1 Rice Value Chain Map in the Philippines

The value chain of rice is the sequence of events from its production to processing, to its marketing and consumption. Rice input suppliers, producers, and marketing channels usually constitute the basic value chain processes for a rice sub-sector (Figure 10). Seed

variety is the most important input of the rice industry (Regalado and Romero 2012). The rice value chain uses wide-ranging labor. In the rice supply chain, the logistics are identified as drying, transporting, milling, packaging, and storage.

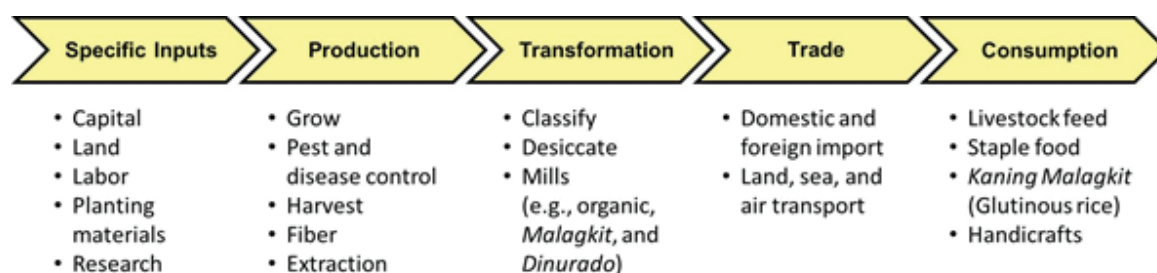


Figure 10. Basic functions in a rice sub-sector value chain

Source: GTZ (2005)

In the Philippines, studies on the rice value chain are scarce. Recently, a study was conducted on the rapid appraisal that was based on an interview with selected players in various levels of the rice value chain, specifically from Pangasinan and Nueva Ecija to Metro Manila. Findings revealed that the paddy rice supply chain is multi-layered, with many competing players in each layer and no evidence of any cartel-like behavior in the areas studied. Margins are limited to 2 percent or less of raw materials at all levels before

retail. The profits are enhanced by volume, fast turnover of stocks, integration of operations across levels, and investments for quality consistency. The greatest threats to current players are weather risks and continuing tight local paddy supplies that spawn greater competition and raise management costs. The increased costs also highlight the lower-cost option of bringing in foreign rice that manifests in rampant smuggling given the government's quantitative restrictions on rice imports (Dela Peña 2014).

2.2 Corn Value Chain Map in the Philippines

A clearer understanding of the Philippines' corn industry is possible by separating yellow corn from white corn (flint type). Yellow corn and white corn are mainly used for animal feeds and human food, respectively. Most of the white corn produced by marginal farmers is consumed at the household level. There are

very few seed companies working on white corn hybrid because of lack of market. The marginal farmers could not afford to buy hybrid seeds or fertilizers. Native varieties are mostly early maturing, low yielding, and tolerant to stresses, but they exhibit good eating quality (Salazar 2011).

Excess yellow corn production from the southern parts of the Philippines used to be shipped to the majority of feed mills in the central and northern parts of the country. The government had instead intensified production in the northern parts due to high transport cost from the south (Salazar 2011).

In the yellow corn value/supply chain, the players commonly involved are input suppliers, farmers, traders and processors, big traders and contributors, and consumers (Figure 11). The same set of key players constitutes the value/supply chain for white corn (Figure 12).

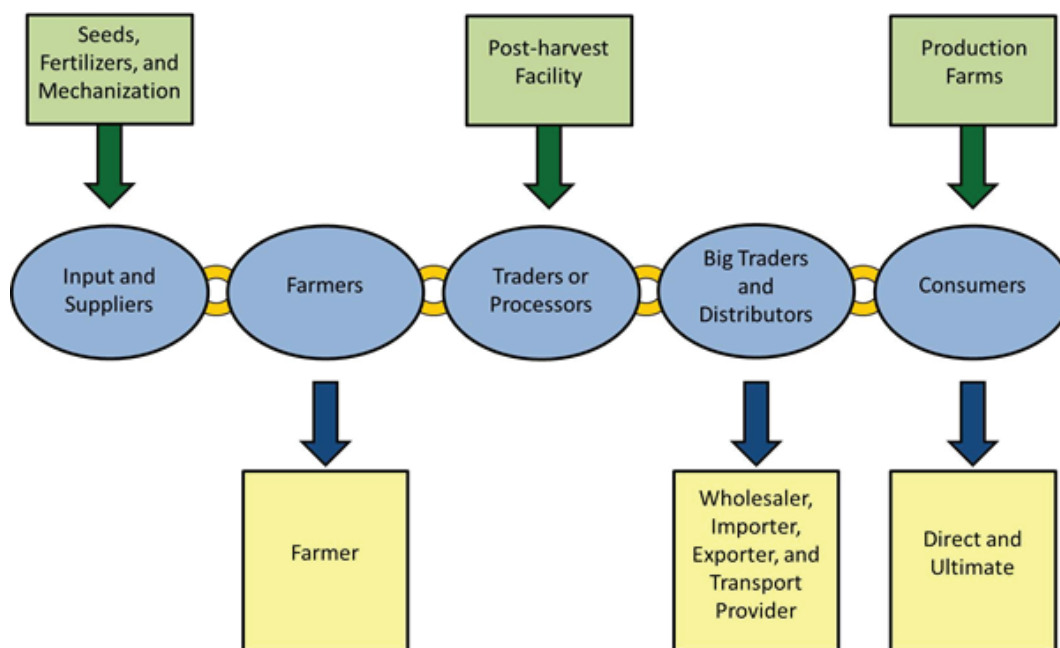


Figure 11. Yellow corn value/supply chain in the Philippines
Source: Salazar (2011)

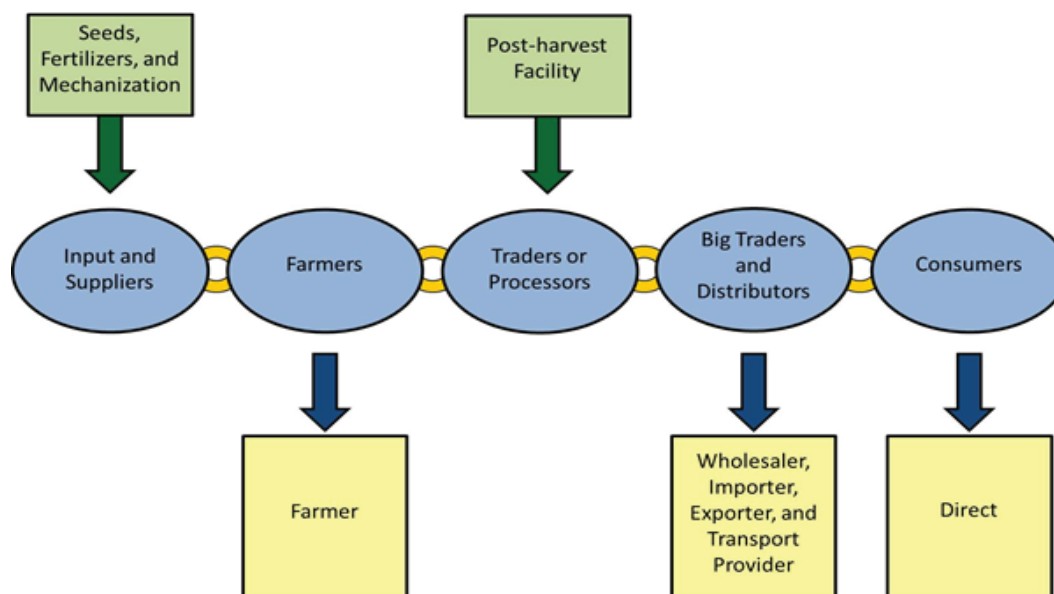


Figure 12. White corn value/supply chain in the Philippines
Source: Salazar (2011)

The end of the chain will largely determine the beginning of the chain. A total of 1,282,045 ha of land are devoted to yellow corn farming. It is mainly a component of feeds for the livestock industry.

As a consequence of the impending increase in demand for meat, yellow corn production will intensify. However, the supply of yellow corn in the world market is uncertain because the grain is used for ethanol production by the world's biggest corn supplier: the United States. Also, climate change prohibits the reliance on the supply and price of feed wheat in East Europe and Australia.

According to Salazar et al. (2012), the pressing need to be self-sufficient in yellow corn opens areas for research, development, and extension (RDE) based also on the above supply/value chains. Common RDE needs for corn include enhancing the quality of yellow corn and post-harvest processing facilities, particularly for drying, shelling, and storage, since the high amount of rainfall during the wet season from May to August has serious implications to corn grain quality. Aflatoxin contamination is common in areas with no mechanical dryer. Until the requisite affordable and efficient drying and storage facilities become available, most of the productivity increase will go to post-harvest losses. This will be detrimental to the producers and users. Another RDE need is on grain pest and disease control, which can be addressed through appropriate pest control

measures (e.g., chemical and biological) as well as genetic improvement (e.g., development of resistant cultivars).

Knowing what other countries, suppliers, and consumers are doing and will be doing will aid in determining what direction the local corn industry should take for the benefit of the consumers, producers, and all the stakeholders in the yellow corn supply chain (Salazar et al. 2012).

The situation for white corn is different. White corn is produced mostly by marginal corn farmers and consumed at the household level. There are also very few seed companies working on white corn hybrids because of lack of market. White corn farmers are usually poor and could not afford to buy hybrid seeds or fertilizers. The R&D thematic areas are similar to yellow corn, but projects such as the development of white corn open pollinated varieties (OPV) that are tolerant to biotic (e.g., pests and diseases) and abiotic (e.g., droughts) stresses should be highlighted. Such studies will definitely show the nutritional advantage of corn as food to enhance the market of white corn, which will be advantageous to consumers and producers; farming system studies to augment the income of white corn farmers; and post-harvest processing technologies, especially since the product is consumed directly by humans (Salazar et al. 2012).

III. CLIMATE CHANGE IMPACTS AND VULNERABILITIES

3.1 Climate Change Impacts on Agriculture in the Philippines

Agriculture is an important driver of the Philippines' economy. More than one-third of the country's inhabitants depend on agriculture and fishing for a living. There are already trends of increasing number of hot days and warm nights, but decreasing number of cold days and cool nights. Both maximum and minimum temperatures are generally getting warmer. Other extreme weather or climate events like intense rains have become more frequent.

Agricultural crop production and post-production are highly influenced by climate (Chalinor et al. 2007; Hoogenboom 2003; Lansigan et al. 2007; Lansigan and Salvacion 2007; Sivakumar and Hansen 2007a). Farmers rely on existing weather conditions to implement different farm activities, starting from pre-production to post-harvest. At the crop level, the existing weather pattern determines not only the rate of crop growth and development but also the rate and development of different pests and diseases (Shapiro et al. 2007; Zhao et al. 2005). According to Moeletsi et al. (2013), the vulnerability of agricultural production is higher today than ever before because of increasing population, high input cost, and changing climate across the globe.

In the Philippines, the effects of global climate change include increase in temperature; increase in frequency, intensity, and duration of extreme climate events such as droughts, floods, and tropical storms; changes in the intensity, timing, and spatial distribution of rainfall; warming temperatures; soil degradation; increasing weather variability; and sea level rise resulting in saltwater intrusion and loss of agricultural land (PhilRice 2011, 2012).

Long-term changes in temperature and precipitation patterns that are caused by climate change are expected to shift production seasons, pest and disease patterns, and modify the set of feasible crops. In turn, these will affect production, prices, incomes, and ultimately, livelihoods and lives. Climate change impacts include increased floods and droughts, soil degradation, water shortages, and possible increases in destructive pests and diseases. Agriculture must become central to future discussions on climate change because it contributes a significant proportion of greenhouse gas (GHG) emissions (Rudinas et al. 2013).

Soil erosion that will lead to soil nutrients mining, lower soil productivity, and consequently, lower crop yields are some of the impacts of climate change on Philippine agriculture (Perez 2009). The identified adaptation strategies such as crop diversification, change of crop or crop variety, and crop insurance are anticipatory. Providing subsidies is another adaptation strategy.

Impacts on water resources are water shortages and water quality degradation. Adaptation practices would be to reiterate existing policy to prioritize abstraction from surface water to remove the pressures from groundwater sources (e.g., Natural Water Resources Board, Metropolitan Waterworks and Sewerage System, and other agencies). The adoption of new environment-friendly technology for efficient water use and water conservation (e.g., small water impounding projects, small farm reservoirs, and AWD technique) should also be encouraged.

Changes in weather patterns because of anticipated climatic change will exert huge

impact on agricultural production systems. Such impacts were already demonstrated in different climate change impact studies (e.g., Chalinor et al., 2007; Lobell et al. 2007; Mearns 2000; Olesen and Bindi 2002; Reddy et al. 2000; Reynolds 2010; Thorton et al. 2006; Yadav et al. 2011). In the Philippines, the works of Buan et al. (1996), Centeno et al. (1995), Lansigan and Salvacion (2007), and Salvacion (2013a; 2013b) show that climate change will affect the yield and suitability of rice and corn negatively. This can be a serious threat to the country's food security. According to De los Santos et al. (2007), rice and corn production losses from El Niño events alone range from USD 0.5 million to USD 0.76 million. Therefore, it is imperative to develop different measures and systems to minimize such negative effects and economic losses.

Advances in information technology, cropping systems modeling, geographic information systems, and field sensors can be combined to develop decision-support models and early warning systems that will help farmers and policy-makers develop sound, science-based judgment under uncertain situations brought about by climate change. The development of a “smarter Forestry Agricultural Resource Management System” that integrates different decision-support models into a single setup is the realization of the needed early warning systems. Sivakumar and Hansen (2007b) showcased the uses of different decision-support models and early warning systems in addressing the impacts of climate variability in agriculture in different countries across the globe.

3.2 Climate Change Impacts on Rice Production and Post-production

Climate change will devastate the rice production and post-production sectors if it is not addressed properly. Low rice supply, along with increasing rice demand, affects both food security and national economy (PhilRice 2011). The historical and projected trends in rice in selected climate variables in the Philippines are shown in Table 3.

PhilRice established the Climate Change Center in 2011 by virtue of PhilRice Administrative Order No. 2011-04. Its mandate is to “develop and extend a comprehensive and judicious understanding of the current and

future impacts of climate change, including variability and extremes on the Philippine rice farming system, and to cushion its possible negative effects on the realization of rice self-sufficiency” (PhilRice 2012). Droughts affect all stages of rice growth and development. The strong effects on grain yield are largely due to the reduction of spikelet fertility and panicle exertion. Frequent droughts not only reduce water supplies but also increase the amount of water needed for plant transpiration. The most significant drought occurrence was the 1997–1998 El Niño, during which rice yield declined considerably (Table 4).

Table 3. Historical and projected trends in rice in selected climate variables in the Philippines

Variable	Specific climate risk/opportunity	Historical trend	Projections	Confidence	References
Evapotranspiration	Amount of irrigation Frequency of irrigation	Slight increase Shift with season			IPCC (2007)
Temperature	High temperature Extreme heat days (highly correlated with yield)	Increasing temperatures Increasing frequency of extreme temperature	Projected increase of 1°C–1.1°C in the next 50 years	High	DOST-PAGASA (2011) IPCC (2007) PhilRice (2012)
Solar radiation (SR)	High SR increases yield during flowering stage	Constant but with seasonal variation			DOST-PAGASA (2011) IPCC (2007) IPCC (2001) NASA (2013)
Precipitation by season (rainfall)	Typhoons Floods Droughts Soil erosion Salinity	Increasing in total average Occurrences of extremes	Increasing frequency of occurrences of extremes Rainfall intensity increase Mid-season temporal drought Increase of 3–5 percent by 2020 Rainfall variability Rainfall intensity increase (during rainy season) Prolonged droughts (during dry season)	High	DOST-PAGASA (2011) IPCC (2007)
Relative humidity (RH)	High RH, high occurrence of new and emerging pest and disease High RH, high risk on seed deterioration	Minor increase Almost constant	Slight shift with season following changes in rainfall and temperature pattern	High	DOST-PAGASA (2011) IPCC (2007)
Wind speed	Typhoons	Occasional Year-round Increasing frequency of destructive typhoons	Increasing frequency of destructive typhoons Typhoon occurrences not limited to wet season but distributed throughout the year	High	DOST-PAGASA (2011) IPCC (2007)
Surface water level (sources)	Increasing runoff causes increased soil erosion Decreasing levels cause a decrease in irrigation Low cropping intensity	Decreasing sources and water levels due to prolonged droughts	Continuous decrease in water level unless high intensity rainfall (during wet season) can be collected and stored	High	Experts' opinion Personal communication
Groundwater level	Increasing runoff causes increased soil erosion Alternative source of irrigation Saltwater intrusion in coastal areas	During dry season, especially with El Niño		Medium	Experts' opinion Personal communication

Table 4. Impacts on rice production and the vulnerability rating

System of interest	Geographical location	Climate change trend/signal	Biophysical impact	Socio-economic impact	Exposure	Sensitivity	Ability to respond	Vulnerability rating	References
Rainwater harvest (R) Small farm reservoir or rainfall interceptor pond Small water impounding project Diversion dam	National	Erratic rainfall	Lack of irrigation for production	Lower rice yield	High	High	Medium	Very high	Experts' opinion Personal communication
Irrigation (I)	National	Extremely high temperature Temperature rise High variability (erratic) rainfall	Decreased cropping intensity (decreased irrigated area during dry season, floods during wet season)	Decreased total yield Poor performance Degradation of irrigation systems	High	High	Medium	Very high	PhilRice (2011)
Varieties more resilient to salinity, drought, and submergence (I&R)	National	Susceptible to abiotic stresses	Lack of suitable tolerant varieties	Lower yield Lower grain quality	High	High	Medium	Very high	PhilRice (2011, 2012)
Varieties more resilient to pest and diseases (I&R)	National	Susceptible to biotic stresses	Lack of suitable tolerant varieties	Lower yield Lower grain quality	High	High	Medium	Very high	PhilRice (2011, 2012)
Nutrient management (I&R)	National	Symptoms of deficiency	Declining soil fertility	Lower yield Lower grain quality	High	High	High	High	IRRI (2010) PhilRice (2012)

Rice diseases (e.g., rice blast, sheath, and culm blight) could become more widespread. Altered wind patterns may change the spread of wind-borne pests, bacteria, and fungi that are agents of crop disease. Crop-pest interactions may shift as the timing of development stages in both hosts and pests are altered. The possible increases in pest infestations may bring about greater use of chemical pesticides to control them. Climate change may also affect weed ecology, the evolution of weed species over time, and the competitiveness of C3 versus C4 weed species (PhilRice 2011).

The combined effects of increases in temperature and rainfall on rice production vary depending on time, location, eco-zone, cropping season, and planting schedule. Rainfed upland rice production during the wet season proved to be the most vulnerable

to climate change, disrupting the cropping calendar and thus resulting to greater loss in rice production in this eco-zone (Peñalba et al. 2012).

Peñalba et al. (2012) recommended adjustment of cropping calendar; rotation and diversification of crops; construction of small farm reservoirs; zero tillage for more effective water infiltration; and prevention of soil erosion, especially for upland rainfed conditions. In addition, the study also recommended the use of drought-resistant and submergence-tolerant varieties as appropriate. The researchers also pushed for farmers' education to improve the acceptability of alternative conservation farm technologies and help them make informed decisions on technologies that they can adopt to respond to projected climatic changes.

3.3 Climate Change Impacts on Corn Production and Post-production

Corn is the second major cereal crop in the Philippines. It provides 75 percent of the calories the world consumes, along with rice, soybean, and wheat. Climate scientists, especially in the United States, agree that long-term weather patterns will continue to change, but there is great uncertainty and very minimal research regarding how these global climate changes will influence cropping systems.

As identified during the consultative meetings,

temperature, solar radiation, rainfall, relative humidity, wind speed, and groundwater level are among the climate variables that may affect corn production and post-production (Table 5). Such climate variables will heavily affect corn productivity in marginal and unfavorable growing areas. As such, climate-ready varieties, an integrated farming systems approach, soil and water conservation measures, and post-production technologies may be needed to address these variables (Table 6).

Table 5. Historical and projected trends in corn in selected climate variables in the Philippines

Variable	Specific climate risk/opportunity	Historical trend	Projections	Confidence	References
Temperature	High temperature Extreme heat days (highly correlated with yield)	Increasing temperatures Increasing frequency of extreme temperature	Projected increase of 1°C–1.1°C in the next 50 years	High	DOST-PAGASA (2011) IPCC (2007) PhilRice (2012)
Solar radiation (SR)	High SR increases yield during flowering stage	Constant but with seasonal variation			DOST-PAGASA (2011) IPCC (2001, 2007) NASA (2013)
Precipitation by season (rainfall)	Typhoons Floods Droughts Soil erosion Salinity	Increasing in total average Occurrences of extremes	Increasing frequency of occurrences of extremes Rainfall intensity increase Mid-season temporal drought Increase of 3–5 percent by 2020 Rainfall variability Rainfall intensity increase (during rainy season) Prolonged droughts (during dry season)	High	DOST-PAGASA (2011) IPCC (2007)
Relative humidity (RH)	High RH, occurrence of new and emerging pest and disease High RH, high risk on seed deterioration	Minor increase Almost constant	Slight shift with season following changes in rainfall and temperature pattern	High	DOST-PAGASA (2011) IPCC (2007)
Wind speed	High wind speed during wet season, particularly during flowering stage, leads to corn barrenness (infertility) Typhoons	Low High	Increasing frequency of destructive typhoons Typhoon occurrences not limited to wet season but distributed throughout the year	Medium High	IPCC (2007)
Groundwater level	Increasing runoff causes increased soil erosion Alternative source of irrigation Saltwater intrusion in coastal areas	During dry season, especially with El Niño		Medium	Experts' opinion Personal communication

Table 6. Impacts on corn production and the vulnerability rating

System of interest	Geographical location	Climate change trend/signal	Biophysical impact	Socio-economic impact	Exposure	Sensitivity	Ability to respond	Vulnerability rating	References
Corn production in sloping areas	National	Soil erosion Landslides Loss of top soil Siltation	Land degradation Decreased soil fertility and productivity	Lower yield Increased poverty incidence	Medium	High	Low	Very high	Experts' opinion Paredes (2014) Personal communication Rola et.al. (2008)
Varieties more resilient to pest and diseases	National	Increasing occurrences of extreme weather conditions (e.g., drought and typhoons) during critical growth stages	Worsening of pest and disease problems	Lower yield Increased production cost	Low	Low	High	Very low	Experts' opinion Personal communication
Poor productivity in marginal areas (drought, water logging, acidity, and salinity)	National	Increasing occurrences of extreme weather conditions (e.g., drought and typhoons) during critical growth stages	Declining soil productivity in stress-prone areas	Lower yield and income for the farmers	High	High	Low	Very high	Experts' opinion Personal communication
Farming systems	National	Unpredictable weather extremes during the cropping season	Declining overall farm productivity	Lower yield and income for the farmers	High	Medium	Medium	High	Experts' opinion Personal communication
On-farm crop storage	National	Unpredictable weather	Increasing mycotoxin occurrence	Post-harvest losses	High	Medium	High	Medium	Experts' opinion Personal communication

Climatic variability, pests, and diseases are the main challenges confronting local farmers. Since most corn-producing areas are rainfed, they depend greatly on rains to experience a good cropping season. Those without supplemental irrigation will face a greater risk of getting their standing crop wiped out during prolonged dry spells or droughts. Excessive rains and flooding could also destroy the season's crop easily. When the two most economically significant pests of the corn crop—the Asiatic corn borer and weeds—are included in the mix, the concerns become magnified.

In the United States, a study conducted and headed by Morton (2011) focused on a regionally coordinated functional network developing science-based knowledge that addresses climate mitigation and adaptation; informs policy development; and guides on-farm, watershed-level, and public decision-making in corn-based cropping systems. One of the objectives was to apply models

to research data and climate scenarios to identify impacts and outcomes that could affect the sustainability and economic vitality of corn-based cropping systems. Knowledge gains of farmer beliefs and concerns about climate change, attitudes toward adaptive and mitigating strategies and practices, and decision support need to inform the development of tools and practices that support long-term sustainability of crop production.

Results showed that climate and climate-related information were undoubtedly among the major factors being considered by farmers in their crop production activities. Climate change was observed to affect corn prices. Researchers also found that climate change is likely to have far greater influence on the volatility of corn prices over the next three decades than factors that have been recently blamed for prices swings (e.g., oil prices, trade policies, and government biofuel mandates) (Jordan 2012).

IV. INSTITUTIONAL CHALLENGES AND AREAS FOR REGIONAL COLLABORATION

4.1 Institutional Challenges

The following institutional challenges were identified during the consultative meetings:

- (1) Enhancing RDE programs at the national level to include breeding climate-ready rice and corn varieties using best management production and post-production practices
- (2) Intensifying the conduct of documentation studies and other relevant research to further generate information, lessons, and experiences that will strengthen CCA in rice and corn
- (3) Addressing the intimate connections between climate change, agriculture, and rural poverty to understand gender and climate financing in the Philippines

4.2 Areas for Regional Collaboration

The following are areas of regional collaboration that may need support:

- (1) Strengthening regional centers and information networks to support CCA initiatives and projects
- (2) Strengthening South to South collaboration through the following:
 - a. Germplasm exchange between partner countries in Southeast Asia
 - b. Building capacities on CCA
 - c. Information/technology/expert exchange

V. CASE STUDIES OF GOOD PRACTICES

Given the apparent effects of climate change on agricultural production, scientists and researchers are exerting sizeable efforts to identify the best adaptation measures to combat them.

McCarthy et al. (2001) and Smit and Wandel (2006) define adaptation as an adjustment in ecological, social, and economic systems in response to climate stimuli and their effects. More specifically, adaptation refers to process, action, or outcome in a system (e.g., household, community, sector, region, and country) to better cope with, manage, or adjust to some changing condition, stress, hazard, risk, or opportunity. An example of CCA is maintaining biological diversity (PhilRice

2011).

Mitigation, on the other hand, is a human intervention or action aimed at lowering the level of GHGs in the atmosphere, or enhancing GHG “sinks” or carbon storage. Planting trees is an example of a mitigation strategy as it avoids GHG emission by increasing carbon storage (PhilRice 2011). CCA involves changing behavior at various levels: individuals, groups, organizations, institutions, and governments.

5.1 Rice

Table 7 shows the prioritized good practices for rice in the Philippines: PalayCheck, Palayamanan Plus, controlled irrigation or AWD technique, and climate-ready varieties.

Table 7. Structuring good practice adaptation options in rice

Case study	Brief description	Criteria satisfied	Regional relevance	Impact on women (-ve/+ve / neutral)	References
Irrigated rice					
1	PalayCheck	Adaptation (refer to manual)	Very high	+	PhilRice (2011)
2	Palayamanan Plus	Adaptation (HH food and income, food security)	High	+	Corales et al. (2005) PhilRice (2011)
3	Controlled irrigation or AWD technique	Adaptation (water shortage) Mitigation (reduce GHG emission)	High	Neutral	Siopongco et al. (2013)
Rainfed rice					
1	Palayamanan Plus	Adaptation (HH food and income, food security)	High	+	Corales et al. (2005) PhilRice (2011)
2	Controlled irrigation or AWD technique	Adaptation (water shortage) Mitigation (reduce GHG emission)	High	Neutral	Siopongco et al. (2013) IRRI Technical Bulletin
3	Climate-ready varieties	Adaptation (biotic and abiotic stress tolerance)	Very high	+	Brar et al. (2009) Gamuyao et al. (2012) Gregorio (2010) Gregorio et al. (2002) Ismail et al. (2010) Islam et al. (2011) Ismail et al. (2012) Mackill et al. (2012) Manzanilla et al. (2011) Singh et al. (2009) Thomson et al. (2010) Wassman et al. (2009a, 2009b) Ye et al. (2010, 2012)

Note: The practices identified in this table were sourced from a series of consultations with the heads of the DA and its attached agencies, especially those involved in climate change, rice, and corn programs; and R&D focal persons from DA regional offices. The criteria in the third column refer to the criteria and indicators for Appraisal of Adaptation Measures (Annex 7) based on/adopted from the Guidance Manual for Climate Change Adaptation Case Studies- ASEAN.

5.1.1 PalayCheck System

Rice production, which can offset major impacts of climate change by increasing farmers' productivity and profitability, can be improved through the adoption of an integrated crop management (ICM) system for rice. PalayCheck is a dynamic ICM system that presents easy-to-follow practices to achieve respective key checks as well as improve crop yield and input efficiency. In addition, this promising technology has high potential for climate change mitigation in irrigated lowland rice farming systems (PhilRice 2011, 2012).

PalayCheck is similar to Australia's Ricecheck, which helped increase the country's yield from about 6 t/ha in 1987 to almost 10 t/ha in 2000. In 2004, the Philippines' version of Ricecheck was developed through a series of workshops and consultations with rice experts, extension workers, and farmers. Palaytandaan served as base material. From its inception in 2004, PalayCheck was tested in some 30 sites with almost 1,000 farmers nationwide eventually recommending it for scaling up. The average yield increased by at least 1 t/ha in pilot sites. The results showed that the more checks achieved, the higher the yield. PalayCheck served as the platform for the Location-specific Technology Development project of PhilRice.

PalayCheck encourages farmers to manage crops based on targets, and provides recommendations on how to attain the targets based on best management practices for a particular agro-ecological condition. The recommendations are localized at the farmer level, taking into account the interactions among practices and other factors affecting yield, grain quality, and environment. In addition, PalayCheck provides a collaborative learning framework for farmers to improve their understanding of production principles and management skills to enable technology localization, with facilitation from technically competent resource persons.

5.1.2 PalayamananPlus

One of the possible strategies to reduce the impacts of climate change on rice production is the adoption of a diversified integrated rice-based farming system. Recent studies showed that income from one hectare of rice monocropping is insufficient to meet even the financial requirements of a family of five. At present, it is projected that a farming family should earn at least PHP 90,000 or farm two hectares of land to sustain the family's financial needs. As a response, PhilRice has embarked on Palayamanan, a term coined from palay (rice) and kayamanan (wealth), to help the farmers meet their needs.

PhilRice developed Palayamanan, a model to help farmers in rainfed and upland areas sustain their livelihoods and better cope with adverse impacts of climate change. Palayamanan is a farming system that highlights the purposive integration of various farm components such as rice and other crops, livestock, aquaculture, biomass waste recycling, and other income-generating means (PhilRice 2011, 2012).

Palayamanan is the modern concept of bahay-kubo or nipa house, but it is elevated to a higher level of integration. It combines rice with other high-value crops, trees, fish, poultry, livestock, and biomass recycling. It espouses the efficient use of available farm resources and highlights the interconnectivity between each resource and by-product through available modern technologies. It is not a new system of farming but an old paradigm that many farmers have been practicing for a long time. However, despite its benefits to the farmers and the environment, most farmers have not adopted it because of the popularity of the monoculture system (rice-rice) and the lack of knowledge on how to implement it.

Palayamanan, along with AWD and PalayCheck, are included in the technologies and practices in rice identified by PhilRice (2012). It is considered a strategy to diversify

the farmers' sources of food and income to enhance their resilience to climate change (Appendix 1).

5.1.3 Alternate Wetting and Drying (AWD) Technique

AWD is one of the key climate change mitigation strategies that benefit small farmers. It is a water-saving technique for use in rice production, especially during drought conditions. It also minimizes GHG emissions in paddy fields. Water-saving techniques provide ways to change practices to improve the livelihoods of many farmers. It is regarded as one of the more important rice cultivation methods that can dramatically save freshwater irrigation in this century (Siopongco et al. 2013). In addition to AWD, other water-saving techniques include controlled irrigation, small farm reservoir, and rainwater harvesting.

Irrigation has become a very costly input in rice production because of the rising cost of fuel. In producing one kilogram (kg) of paddy, it is estimated that a farmer has to use 3,000–5,000 liters of water to keep ponded water during the growth stage of plants. Therefore, farmers irrigate frequently and keep the field flooded at all times.

IRRI, in cooperation with national research institutions, developed the AWD technique. The ample adoption of this technique can improve the use of irrigation water so that the cropping intensity could be increased from 119 percent to 160 percent (related to the maximum of 200% in double cropping systems) (IRRI 2014; Siopongco et al. 2013).

In this practice, the crop is intermittently submerged and dried from 20 days after sowing until two weeks before flowering, which means that fields are allowed to drain until water below the surface reaches down to 15 centimeters before re-flooding. In this controlled drainage setup, the crop is still spared from the debilitating effects of droughts.

Compared with conventional flooding, water savings in AWD could be as much as 25 percent. This will result in a reallocation of saved water to nearby fields or other purposes (e.g., household use). Moreover, AWD technique has been proven to mitigate methane emissions. The GHG methane is produced anaerobically by methanogenic bacteria that thrive well in paddy rice fields. Flooded rice fields are a large source of methane emissions. In fact, they are the second largest anthropogenic source after ruminant livestock. AWD can reduce methane emissions by up to 50 percent because periodic aeration of the soil inhibits methane-producing bacteria (Siopongco et al. 2013).

5.1.4 Climate-ready Rice Varieties

The Philippines' rice productivity losses are compounded by biotic (e.g., pests) and abiotic (e.g., droughts, heat, erratic rainfall patterns, increasing risks from typhoon- and rainfall-induced floods, sea level rise, and saltwater intrusions) stresses brought about by the changing climate (Wassman et al. 2009a, 2009b). To mitigate losses caused by abiotic stress, IRRI developed rice breeding lines that are tolerant to submergence, salinity, heat, and droughts. The SUB1A gene, derived from FR13A (a rice variety from Odisha, India), confers tolerance of up to two weeks of complete submergence. Varieties with the SUB1A gene have the same yield and other characteristics as the original varieties, and they can be used to replace these varieties in flood-prone areas (Mackill et al. 2012; Manzanilla et al. 2011; Singh et al. 2009). Saline-tolerant rice, aided by the Saltol gene, can survive in saline-prone environments with salt of at least EC 4 dS/m (0.3% salt) (Gregorio 2010; Gregorio et al. 2002; Islam et al. 2011; Ismail et al. 2010; Thomson et al. 2010). Combining Saltol and SUB1 in one genetic background seems feasible with no apparent negative impacts on agronomic traits, and this will help develop more stable varieties adapted to coastal zones (Gregorio et al. 2002). Rice breeding lines with tolerance of drought conditions conferred by drought

quantitative trait loci (QTL) are also available, and some materials have been released as varieties in India and the Philippines. QTL for heat tolerance at the flowering stage have been mapped (Ye et al. 2010, 2012). For direct seeding, particularly where water is applied to suppress weeds, tolerance of anaerobic germination can improve early seedling establishment (Ismail et al. 2012). Materials with stronger tolerance for adverse soil conditions of excess Fe, deficient P, and deficient Zn are also in the pipeline. The isolation of the *Pstol1* gene (Phosphorus starvation tolerance 1) from variety Kasalath has shown its role in improving root growth and distribution in phosphorus-deficient soils and increasing yield by as much as 20 percent (Gamuyao et al. 2012). However, all these important traits can help farmers only through smart breeding by fast-tracking introgression into high-yielding rice, and evaluating their adaptation at target sites in the country.

Marker-assisted breeding allows breeders to introduce a gene of interest into a commercial variety in two backcross generations, thereby speeding up product development by two to three years. Aside from the traits mentioned above, markers have been available for resistance to biotic factors. For planthoppers, the genetics of resistance to brown planthopper, white-backed planthopper, green leafhopper, and other leafhoppers has been studied and many resistance genes have been identified (Brar et al. 2009).

In spite of flashfloods or submergence and long-term inundation in rice-producing areas in Southeast Asia, rice productivity can be sustained and even improved. This can be achieved by applying systematic and participatory methods in identifying and selecting appropriate and adopted rice varieties under local conditions, along with best management practices.

5.2 Corn

Table 8 shows the prioritized good practices for corn in the Philippines: SSNM, village-type corn dryer, SCOPSA, white corn for food, and village-type white corn mill.

Table 8. Structuring good practice adaptation options in corn

Case study	Brief description	Criteria satisfied	Regional relevance	Impact on women (-ve/+ve / neutral)	References
Yellow corn					
1	SSNM	Mitigation (increase nutrient efficiency, reduce GHG emission)	High	+	DA-BAR (2013) Ocampo (2010) Pasuquin et al. (2010) Witt et al. (2008, 2009)
2	Village-type dryer	Adaptation and mitigation (erratic rainfall, grain quality efficiency)	High	+	
3	SCOPSA	Adaptation and mitigation (conserve soil moisture, reduce GHG emission)	High	+	BSWM
White corn					
1	White corn for food Village-type white corn mill	Adaptation (corn grits as product serve as staple food)	High	+	UPLB Horizon (2014)
2	SCOPSA	Adaptation and mitigation (conserve soil moisture, reduce GHG emission)	High	+	BSWM

Note: The practices identified in this table were sourced from a series of consultations with the heads of the DA and its attached agencies, especially those involved in climate change, rice, and corn programs; and R&D focal persons from DA regional offices. The criteria in the third column refer to the criteria and indicators for Appraisal of Adaptation Measures (Annex 7) based on/adopted from the Guidance Manual for Climate Change Adaptation Case Studies- ASEAN.

5.2.1 Site-specific Nutrient Management (SSNM)

SSNM is an approach that advocates the use of available organic nutrient sources (e.g., crop residue and manure) and inorganic fertilizers.

There is a growing demand for corn not only in the Philippines but in the whole of Asia. There is significant potential for corn production in the favorable irrigated and rainfed environments, although knowledge on yield potential, exploitable yield gaps, and constraints to improving productivity at the field level are still limited. With SSNM, farmers strive to adjust fertilizer use to optimally fill the deficit between the nutrient needs of a high-yielding crop and the nutrient supply from naturally occurring indigenous sources (e.g., soil, crop residue, manure, and irrigation water). The principles of SSNM for corn were developed through a series of researcher-managed on-farm and on-station experiments covering a wide range of biophysical and socioeconomic conditions. Experimental data were obtained and updated as more data became available, and used to develop site-specific fertilizer recommendations for evaluation at project sites (DA-BAR 2013; Pasuquin et al. 2010; Witt et al. 2008; Witt et al. 2009).

Specifically, SSNM aims to (1) utilize indigenous nutrient sources available on-farm; (2) apply adequate amounts of fertilizer containing nitrogen (N), phosphorous (P), potassium (K), and other nutrients to minimize nutrient-related constraints and achieve high yield; (3) achieve high profitability in the short and medium term; (4) avoid the luxury uptake of nutrients by the crop; and (5) minimize depletion of soil fertility (Pasuquin et al. 2010; Witt et al. 2008; Witt et al. 2009).

A new, computer-based decision support tool was developed to assist local experts in formulating fertilizer guidelines for tropical hybrid corn based on the principles of SSNM. The software, The Nutrient Expert for Hybrid Maize, allows scientists and extension experts to jointly develop novel nutrient management strategies for evaluation (DA-BAR 2013).

The SSNM approach further advocates

the sufficient use of fertilizer P and K to overcome deficiencies (fertilizer use based on yield response like for N), accounting to some extent for the nutrient removal with harvested products to avoid the mining of soil P and K. Site-specific adjustment of nutrient management guidelines and robust approaches to an improved quantitative understanding of nutrient requirements to fill the deficit between plant demand and soil indigenous nutrient supply seem crucial in achieving high yield and profit. Wider scale evaluation of SSNM has begun using farmer participatory approaches at existing project sites, which is an important step towards wider scale delivery of more knowledge-intensive technologies like SSNM for corn in the research-extension continuum of the International Plant Nutrition Institute and its partners in Southeast Asia (DA-BAR 2013; Ocampo et al. 2010; Pasuquin et al. 2010; Witt et al. 2008; Witt et al. 2009).

5.2.2 Village-type Dryer

The three national strategic areas to spur the development of the corn industry in the Philippines include the (1) expansion of production area; (2) improvement of productivity through the provision of high-yielding varieties, appropriate cultural practices, and full mechanization, among others; and (3) reduction of post-harvest losses.

Thirty-seven percent of post-harvest losses in corn are caused by drying. This is followed by storage, which comprises 24 percent of the total loss. Part of the government's program objectives is to reduce the national average post-harvest loss by decreasing drying loss and improve milling recovery, since high post-harvest losses coupled with the limited post-harvest facilities were identified as part of major problems in the Philippine corn industry (Amongo 2011; De Luna 2013; Gragasin 2013).

In spite of the various advancements in mechanization technologies, the level of agricultural mechanization in the Philippines in terms of available mechanical power in the farm is still low compared to other

Asian countries. In corn production, land preparation and threshing are done using a manually operated mechanical power source, while milling is highly mechanized. The bulk of the cost of production, particularly in yellow corn, goes to labor, which includes post-production activities such as harvesting, drying, and shelling (Amongo 2011; De Luna 2013).

5.2.3 Sustainable Corn Production in Sloping Areas (SCOPSA)

GHG emissions can be significantly reduced and carbon sequestered through the adoption of climate-friendly agronomic practices (e.g., crop-residue management and no-tillage farming) and improved use of organic and chemical fertilizers.

Conservation tillage, particularly zero tillage, was introduced in the area to offset the production cost during land preparation. It is one of the technology interventions tested on-farm to evaluate its performance versus conventional tillage and the farmers' practice of growing corn after rice in the area. Generally, the conservation tillage trial aims to aid in the formulation of location-specific and ecologically sound management practices and technology options for sustained corn-based productivity. Specifically, it aims to evaluate the effect of various tillage practices on the growth and yield of yellow and green corn (Labios et al. 2002).

Corn has become an emerging cash crop in the last five years due to the introduction of various corn production technologies. Many idle or barren lands were used to cultivate corn. It was observed that the expansion of corn areas in sloping lands and protected areas augmented the farmers' income, but appropriate soil and water conservation measures were absent. Combined with high rainfall intensities, unsustainable farming practices, and other human-induced factors, impacts to land and soils became very apparent in recent years. These include top soil removal through erosion, formation of

gullies, and nutrient depletion. Consequential damage or off-site impacts include siltation and pollution of dams, lakes, rivers, and other waterways; flooding; and water scarcity. Essentially, there is a need to "balance" targets on corn production, as well as conservation and management of soil and water resources, by adopting soil and water conservation measures in sloping lands (Contreras 2013; DA-BSWM 2013).

Therefore, it is important for various sectors to work together and promote SCOPSA through raising awareness, building capacity, and demonstrating technology. It will involve the adoption of a land use management approach that integrates technologies within the socio-economic conditions and biophysical limitations of upland areas for the sustainable development of soil and water resources for corn production. It will consider a farming system that adopts appropriate land use management options and the right mix of soil and water conservation practices (Contreras 2013; DA-BSWM 2013).

The goal is to enhance the productivity level of corn farmers utilizing sustainable adaptive corn-based technologies in sloping areas. The program covers corn areas vulnerable to soil erosion in various locations in the country (Baccay 2014; Rola et al. 2011). The specific details of this approach, which were drafted by DA-BSWM, can be found in Guidelines on the Promotion and Implementation of SCOPSA (DA-BSWM 2013) (Appendix 6).

5.2.4 White Corn for Food and Village-type White Corn Mill

In the Philippines, yellow and white corn varieties are generally planted. Yellow corn (e.g., young corn, popcorn, and sweet corn) are edible, but most of this variety is intended for industrial use (e.g., feeds and raw materials for industrial products). The yellow corn variety is favored as feeds over white corn because it gives poultry and livestock meat a good color.

White corn, on the other hand, is used as a

substitute for rice in times of hardship. In places where rice is the main staple, white corn is consumed as vegetable or snacks. White corn is commonly referred to as the “poor man’s rice.” In the Philippines, white corn is favored as a staple or a substitute for rice because of its taste and eating quality, while hybrid yellow corn is produced primarily for 50 percent of livestock mixed feeds. Other colored corn (e.g., purple) is not grown widely in the Philippines.

From 2000 to 2011, corn consumption ranged from 1 million t to 1.7 million t, whereas white corn production ranged from 1.8 million t to 2.5 million t. More white corn was produced than consumed. This is probably part of the reason why DA started promoting white corn as an alternative to rice in 2010. Apart from surplus production, it is thought that diversifying the diet (i.e., consuming white corn in particular) will help in curbing the country’s rice shortfall and help reduce rice imports (DA 2013a).

DA is also promoting white corn as a healthier staple than rice because of its low glycemic index. White corn is slower to digest, resulting in a gradual release of glucose into the bloodstreams and lessening the risks of diabetes, which is a major cause of death in the Philippines (DA 2013a).

White corn also contains more protein, lysine and tryptophan, dietary fiber, minerals, and antioxidants than rice. Lysine aids in building muscle tissue, recovery from injury or surgery, and effective calcium absorption. It also helps the body produce antibodies, enzymes, and hormones, while tryptophan is needed for normal growth in infants (Jamias 2014).

After recognizing the value of white corn as a staple food, several government programs have promoted it as an alternative to rice. For example, the program Adaptation and Dissemination of Newly Developed and Improved White Corn Varieties as Alternative Source as Staple Food was established to support the production of white corn and expand its promotion at the national level, including establishing a more stable supply

of white corn and producing varieties to suit different regional preferences (Labios et al. 2013a, 2013b).

Filipino farmers traditionally plant OPV of white corn that allow them to save seeds from their harvest for the next planting season. Traditional OPV planting also makes it possible for farmers to exchange seeds and breed varieties that are better adapted to the environment.

Corn has been touted as “poor man’s rice” for years. The rice shortage in the 1960s that forced many Filipinos to eat inferior rice mixed with rough corn grits left a harsh memory. With the exception of those living in Visayas, where white corn is a staple food for 14 million or 20 percent of the population, many Filipinos will eat corn as rice only if rice is unavailable.

The demand for rice increases significantly each year. With demand superseding supply, the government imports stocks from other countries to fill in the gaps and keep prices at stable rates. Given this, the government exerts effort to look into other potential sources of staple food crops to lessen the demand for rice and achieve food security in the midst of climate change. Next to rice, white corn has been the most potential source of staple food in the Philippines, where about 20 percent of the population uses white corn for food. It is a food staple considered second to rice and even more favorable for its health benefits (Balangen 2012; Battad 2012; Cabrera 2013; DA 2012; Jamias 2014).

Plant breeders from the Institute of Plant Breeding of the Crop Science Cluster, College of Agriculture (IPB-CA) at UPLB have also been transforming white corn. They have developed Quality Protein Maize (QPM) Var 6, a variety that contains high-protein for feeding poor, malnourished children and with traits that can sustain a healthy lifestyle for athletes and health aficionados. Developed in 2006, QPM Var 6 contains 66.2 percent more lysine than the normal white corn. QPM Var 6 has 0.374 grams (g) of lysine, while white corn has 0.225 g. Protein is needed to balance

the often high carbohydrate intake of most marginalized families because they cannot afford viands. Further, the QPM also has more dietary fiber, minerals, and antioxidants than rice alone (Jamias 2014). Aside from its nutritional values, QPM Var 6 has benefits for ordinary farmers. As an OPV, farmers do not have to buy seeds every time they need to plant because they can save their seeds for the next season (Jamias 2014).

QPM Var 6 has relatively high yields compared to other corn varieties: 5.84 t/ha in Luzon, 5.45 t/ha in Visayas, and 4.47 t/ha in Mindanao. A farmer can harvest in 105 days during the dry season or in 100 days during the wet season. Further, the variety is resistant to diseases such as rust and stalk rot. The shelling recovery from the cobs is 76 percent (Jamias 2014). Another important trait is that corn needs less water than rice, which eases the pressure on irrigation needs. With rice shortages and the crop becoming an expensive commodity in the country, these scenarios offer an opportunity to show that corn could be the staple food (Jamias 2014).

To eat QPM Var 6, the corn kernels are milled into grits. Based on numerous taste tests conducted by the Institute of Human Nutrition and Food of the College of Human Ecology at UPLB, the best mix of rice and corn is 70 percent rice and 30 percent corn grits, making the rice-corn blend taste and look like pure rice (Jamias 2014).

Small farmers were kept in mind about the milling of corn grits. In 2008, UPLB, through the College of Engineering and Agro-Industrial Technology, designed a portable mini corn miller that can be operated by a cooperative or women, especially in the uplands. The grit size of the white corn is crucial to allow it to cook well with rice. DA, through the AgriPinoy Corn Program, allocated about PHP 1 million per region for the purchase and distribution of the improved mini rice corn mill to allow more farmers to produce corn grits (Jamias 2014).

Hunger is more prevalent in rural areas than in urban areas. Farmers in distant locations still have to travel far to buy staple food. Farmers in remote areas have the opportunity to grow corn, but commercial corn mills are very expensive and found only in commercial centers. Therefore, farmers trade their meager produce to survive. By making an inexpensive corn mill that could produce good quality grits available to them, farmers could have ready access to food using their own produce (Jamias 2014). The machine can mill 150 kg of grains per hour with 64.8 percent recovery. In one day, the mill can generate an adequate amount of corn grits to feed more than 1,000 people at 300 g per person consumption per day.

In promoting QPM seed planting, developing and utilizing improved mini white corn mills and eating the rice-corn blend go hand in hand. DA, a long-time partner of the IPB-CA, poured funds into the project to produce and distribute IPB Var 6 seeds around the country and promote it in multimedia platforms. White corn was included in the Food Staples Sufficiency Program of DA to mitigate rice importation (Balangen 2012; Battad 2012; Cabrera 2013; DA 2012; Jamias 2014).

Most of the good practices identified were designed without considering the impacts of climate change.

5.3 Gender Component

Women are expected to be particularly vulnerable to future changes in climate, but they also have certain knowledge and skills that can contribute to climate solutions. Integrating a gender perspective into CCA planning and decision-making is important because of the critical roles women play in supporting households and communities.

Women are often the main actors in managing natural resources such as agriculture, forestry,

and fisheries, which are sectors that will be seriously affected by droughts, variable precipitation, and flooding, among others (Laddey et al. 2011; Peralta 2008). Noting that 70 percent of the world's farmers are women, and in Asia women are responsible for 65 percent of food security, women contribute significant labor in cultivating rice and collecting products from the natural environment (e.g., shellfish) (Laddey et al. 2011).

Gender and climate financing in the Philippines can only be understood by addressing the intimate connections between climate change, agriculture, and rural poverty.

5.3.1 Coping Strategies

It is women who have led their households and communities in developing agricultural coping strategies, including food preservation, mixed cropping and cropping diversification, water harvesting and irrigation, growing reliance on wild fruits and forest products, and cultivating at higher levels. Financial coping strategies include shifting from crop production, taking out loans, selling off livestock, seeking government financial assistance, reducing food consumption, and migrating to other sources of work and income (Laddey et al. 2011).

5.3.2 Making Climate Finance Gender-sensitive

At the national level, successful climate strategies, policies, and programs must link with efforts to combat poverty and land degradation as well as enhance food security and access to safe water. Thus, financing to deal with climate change must be situated within the broader context of development financing and development goals: gender equality, poverty eradication, and sustainable development (Peralta 2008). Gender-responsive climate finance at the national level requires sufficient and appropriate global funds and mechanisms that have so far lacked gender considerations.

According to Peralta (2008), the study on gender and climate change finance in the Philippines concluded that proposals for ensuring women and gender is adequately addressed in national climate-financing policies, programs, and frameworks. These include the following:

- (1) Creating mechanisms that guarantee women's equal access to negotiating, developing, managing, and implementing adaptation and mitigation financing
- (2) Including disaggregated indicators on mitigation and adaptation funds targeting and monitoring benefits to women
- (3) Developing principles and procedures to protect and encourage women's access to national adaptation programs and projects
- (4) Conducting gender impact assessments of adaptation and mitigation strategies
- (5) Implementing the "polluter pays" and "shared but differentiated" principles
- (6) Ensuring that mitigation strategies include financing new, green technologies as well as developing and enforcing necessary regulations on GHG emissions

Any effective, long-term response to the climate crisis will require fundamental transformations in production and consumption patterns, particularly in the developed world but also for developing countries like the Philippines. Change lies within the rural and coastal communities and women's organizations that are already facing up to the challenges and risks posed by climate change through a wide range of actions: agricultural adaptation, awareness-building, community organization, and political advocacy (Peralta 2008).

V. CONCLUSION

The following institutional challenges were identified during the consultative meetings:

(1) Enhancing RDE programs at the national level to include breeding climate-ready rice and corn varieties using best production and post-production management practices

(2) Intensifying the conduct of documentation studies and other relevant research to further generate information, lessons, and experiences that will strengthen CCA in rice and corn

(3) Addressing the intimate connections between climate change, agriculture, and rural poverty to understand gender and climate financing in the Philippines

The following are areas of regional collaboration that may need support:

(1) Strengthening regional centers and information networks to support CCA initiatives and projects

(2) Strengthening South to South collaboration through the following:

- a. Germplasm exchange between partner countries in Southeast Asia
- b. Building capacity on CCA

c. Information/technology/expert exchange

In addition, crop insurance can serve as a guarantee for climate risk needs of farmers, agricultural workers, and other stakeholders.

Climate change is a complex problem that requires a multitude of solutions with sustainable development at the core. An integrated mitigation-adaptation framework should be anchored on a sustainable agenda, which would translate into “no regrets” options and serve the long-term interests of the country regardless of the ultimate impacts of climate change. This framework should involve the following:

(1) Activating CCA policies to mitigate adverse effects and increase resilience in field crop production

(2) Breeding new varieties of pest- and disease-resistant crops that are adapted to heat, salinity, and droughts, and with a short growing season to reduce their water requirements

(3) Active participation in climate change-related international agreements and programs

(4) Increased interest in climate change research

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