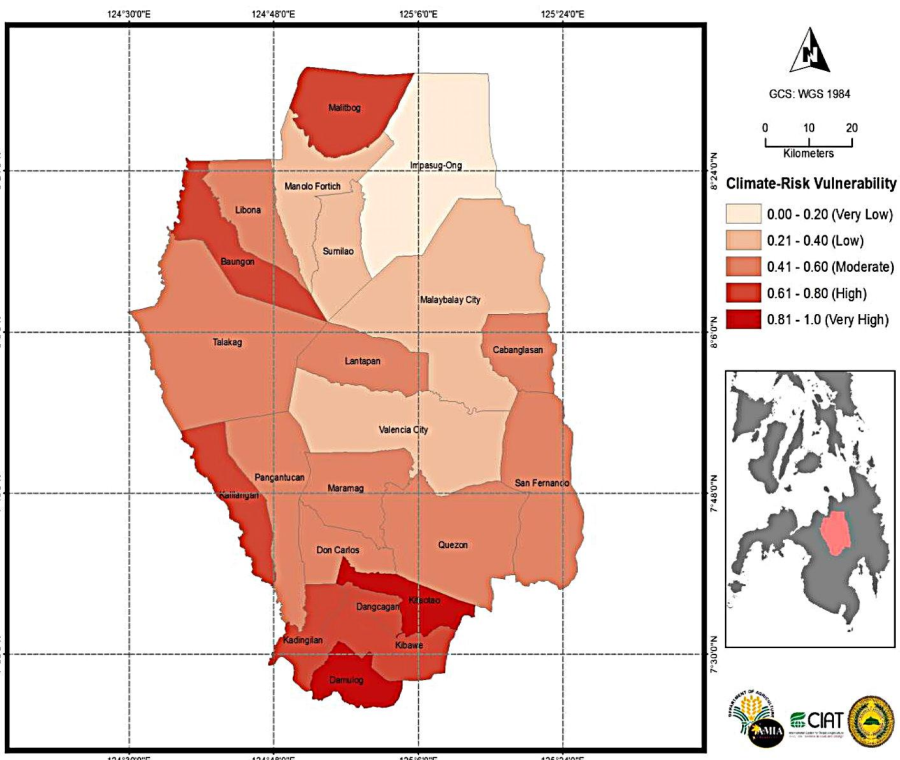
REGION 10 CLIMATE-RESILIENT AGRICULTURE (CRA) ASSESSMENT, TARGETING & PRIORITIZATION FOR THE ADAPTATION AND MITIGATION INITIATIVE IN AGRICULTURE (AMIA) PHASE 2: FOCUS ON BUKIDNON PROVINCE

Angela Grace Toledo-Bruno, PhD.
For. Joseph C. Paquit, MS.
Thea Arbie S. Rivera, MS.
Raquel O. Salingay, MS
Keven Patrivell S. Tañara
Jedilyn M. Tandog

REGION 10 CLIMATE-RESILIENT AGRICULTURE (CRA) ASSESSMENT, TARGETING & PRIORITIZATION FOR THE ADAPTATION AND MITIGATION INITIATIVE IN AGRICULTURE (AMIA) PHASE 2: FOCUS ON BUKIDNON PROVINCE



Overview

Geologically a combination of plains, mountains, rolling hills and coastal areas, Northern Mindanao comprises the provinces of Bukidnon, Camiguin, Lanao del Norte, Misamis Occidental and Misamis Oriental.

The agriculture sector employs 40 percent of the region's labor force (Regional Economic Situationer, 2014). Climatic condition and natural resources of the region make possible the production of its major crops: pineapple, banana, and corn, ranking first, second and third, respectively in the country (PSA, 2015).

The province of Bukidnon tops in the production of most agricultural commodities in the region. It contributed 67 percent of regional supply for corn in 2014. Corn sufficiency level in the province, however, is still at 75 percent.

In the face of agricultural productivity, the region is vulnerable to climatic changes. Drought, flooding and land slides brought economic losses. Climate vulnerability is a function of exposure to climate hazards, sensitivity to risks and strength of adaptive capacity. Exposure and sensitivity are variables difficult to control but adaptive capacity is something that individuals and the community can develop.

In Bukidnon, the municipalities of Damulog and Kitaotao were found highly vulnerable to climate change mainly due to their high sensitivity to climate hazards and low adaptive capacity. The long dry spell from February to late May of 2016 brought the region in a state of calamity. Loss of agricultural investment was estimated at 793 million with losses in corn at 615 million, (Mascarinas, 2016). Rice production was significantly affected without enough water supply. These experiences reflect the growing vulnerability of the agriculture-dependent economy towards climate change.

Prioritized CRA Practice

Addressing regional demand for corn amidst changing climatic condition calls for production practices providing balance between economic sustainability and environmental resiliency. Climate-Resilient Agriculture (CRA) builds on the concept of making farms and the agriculture sector less vulnerable to climate change. CRA stands on its goal for adaptation, mitigation and productivity. One farming practice that meets this criteria is crop diversification.

Crop diversification is a practice of planting two or more crops in the same area of land at the same time. The practice provides alternate on-farm income and maximizes use of resources. In this CRA, banana is planted together with corn at the peripheries, as hedge grow or contour crop in gentle to medium-sloped areas. Corn is planted as main crop for commercial and family consumption while banana is produced to augment farm income. Specifically, the Cardaba banana cultivar is part of the local diet prepared as snack or as substitute to the staple corn and rice. Local demand utilization include processing into snack foods, banana paste and sauce.

As a secondary crop, less labor and material input is allocated for banana. Production inputs comprise few bags of fertilizers. Planting materials are provided by neighboring banana farms or as government subsidy. Maintenance such as under brushing and sucker management is done every two months.

Is corn-banana production a worthy investment? Evidence on economic feasibility of the CRA was conducted in the pilot area of San Jose, Malaybalay City, province of Bukidnon. The selection of the area considers the crop suitability map for corn production, responsiveness of the local government workers, and presence of farmer's organization. Focus Group Discussion (FGD) revealed the practice of the CRA among local farmers.

Summary of Results

CBA Tool Summary Result (1 hectare)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Payback Period	Initial Investment	Social NPV	Social IRR	Scenario in the Analysis	
Value	776 USD	30%	6 years	661 USD	2,398 USD	65%	WITH CRA Conventional Corn Production	WITHOUT CRA Corn-Banana Crop Diversification
Aggregate Analysis	Total corn area*	Current adoption rate	Adoption rate	Aggregate NPV			Period	
	855 ha	7%	57%	2,117,273 USD			10 years	

NB: 866 hectares of cultivated corn area in San Jose (pilot area); Foreign exchange rate PhP48.73 to 1 USD

Republic of the Philippines
CENTRAL MINDANAO UNIVERSITY
University Town, Musuan, Maramag, Bukidnon

Office of the President

September 4, 2017

DR. NICOMEDES P. ELEAZAR, CESO IV
Director
Bureau of Agricultural Research
Department of Agriculture
Diliman, Quezon City

Dear Dir. Eleazar:

This is to officially endorse to your office the terminal report of the project entitled, **"Region 10 Climate-Resilient Agriculture (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province"**. This project officially terminated last June 30, 3017. The implementation of the project has provided an avenue for our researchers enhance their skills in the different research methodologies applied. Further, it connects the university with our partners and stakeholders towards achieving the university vision.

Thank you very much for your support and we look forward to continued partnership for the agriculture sector in Mindanao.

Very truly yours,

MARIA LUISA R. SOLIVEN
University President

Department of Agriculture
Bureau of Agricultural Research
RDMIC Bldg., Elliptical Rd. Cor. Visayas Ave., Diliman, Q.C. 1104
Phone Nos.: (632) 928-8624 & 928-8505 • Fax: (632) 927-5691
Email: barrdegrants@bar.gov.ph • Website: http//www.bar.gov.ph

TERMINAL REPORT

A. BASIC INFORMATION

1. Project Title : **Region 10 Climate-Resilient Agriculture (CRA) Assessment, Targeting and Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province**
2. Proponent (s): Angela Grace Toledo-Bruno, PhD
3. Implementing Agency
   3.1. Lead Agency: Central Mindanao University
   3.2. Collaborating Agencies: DA, CIAT, DA Region RFO X; Bukidnon Provincial Agriculture Office; Malaybalay City Agriculture Office
4. Project Duration: August 2016 – April 2017 (with approved extension: June 30, 2017)
5. Project Location: Bukidnon Province
6. Project Funding
   6.1. Total Approved Budget: Php 999,993.00
   6.2. Total Amount Released: Php 999,993.00
   6.3. Actual Expenses: Php 930,675.44

B. TECHNICAL DESCRIPTION

1. Preliminaries
   1.1. Title Page
   1.2. Summary Sheet
   1.3. Acknowledgment
   1.4. Table of Contents
   1.5. List of Tables, Figures, etc.
   1.6. Abstract
2. Text
   2.1. Introduction
   2.2. Review of Literature
   2.3. Methodology
   2.4. Results and Discussion
   2.5. Summary and Conclusion
   2.6. Bibliography
   2.7. Appendices

C. PROJECT MANAGEMENT

1. Summary of Yearly Comments of Evaluators and Actions Taken by Researcher
2. Problems Encountered and Recommendations
   2.1. Technical
   2.2. Administrative
3. Summary of the Project
4. Audited Financial Report (BAR/QSF-B.01.05a)

REGION 10 CLIMATE-RESILIENT AGRICULTURE (CRA) ASSESSMENT, TARGETING & PRIORITIZATION FOR THE ADAPTATION AND MITIGATION INITIATIVE IN AGRICULTURE (AMIA) PHASE 2:

FOCUS ON BUKIDNON PROVINCE

Department of Agriculture
Bureau of Agricultural Research
RDMIC Bldg., Elliptical Rd. Cor. Visayas Ave., Diliman, Q.C. 1104
Phone Nos.: (632) 928-8624 & 928-8505 • Fax: (632) 927-5691
Email: barrdegrants@bar.gov.ph • Website: http//www.bar.gov.ph

PROJECT SUMMARY SHEET

Name of Project:	**Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative (AMIA) Phase 2: Focus on Bukidnon Province**
Institution:	**Central Mindanao University, Region 10**
Team Leader:	**Angela Grace Toledo-Bruno, PhD**
Members:	**Forester Joseph C. Paquit (GIS Specialist), MS; Thea Arbie S. Rivera, MS (Socio-economics Specialist); Raquel O. Salingay, MS (Crop and Community Specialist); Keven Patrivell Tañara (Laboratory Aide/GIS) and Jedilyn M. Tandog (Enumerator/Admin)**

Objectives	Activities	Outputs	Target Date of Accomplishment	Budget in PhP
1. To strengthen capacities for CRA methodologies of key research and development organizations in the region.	• Capacity strengthening on CRVA • Capacity strengthening on CRA prioritization • Capacity strengthening on CRA knowledge hub development • Capacity strengthening on CRA M&E	Enhanced **capacities** of AMIA partner organizations in the region	• June 2016 – January 2017 • August 206 • February 2017 • June 2017	48,000 12,000 12,000 12,000
2. To assess climate risks in the region's agri-fisheries sector through geospatial & climate modeling tools.	• Collection of secondary data for exposure-sensitivity • Collection of secondary-primary data for adaptive capacity • Preliminary data analysis • Cross-regional/national data analysis workshop	**Geospatially referenced data on climate-risks**: biophysical-agricultural-socioeconomic parameters	• June to August 2016 • August to September 2016 • October 2016	15,300 15,300 32,000 1,000 12,000
3. To determine local stakeholders' perceptions, knowledge & strategies for adapting to climate risks	• Regional-level CRVA stakeholders' validation • Community-level CRVA stakeholders' validation • Regional-level CRA stakeholders' validation • Community-level CRA stakeholders validation	Local stakeholders' CRA-related **demographic/institutional profiles** and **knowledge/perceptions/strategies**	• February to May 2017 • May 2017 • May 2017 • May 2017	17,100 15,300 17,100 32,000 14,300

4. To document and analyze local CRA practices to support AMIA2 knowledge-sharing and investment planning.	• Key informant survey on CRA practices • Cost-benefit and trade-off analyses • National knowledge-sharing event on CRA • Planning workshop for AMIA2	**Data on CRA practices** analyzed for costs-benefits and trade-offs	• August to November 2016 • January to May 2017 • February 2017 • April and June 2017	31,000 24,000 12,000
5. To establish AMIA baseline for outcome monitoring and evaluation (M&E) of CRA communities and livelihoods.	• Survey on target communities and livelihoods • Cross-regional/national data analysis workshop	**M&E baseline data** for CRA communities and livelihoods	• February to May 2017 • April 2017	32,000 55,000

Note: The budget is estimated cost to cover such activities (for details, see project's Audited Financial Report. Other budget components such as PS, EO and other sub-components of MOOE are not included in the computation. Please refer to Budget Summary.

Acknowledgment

The AMIA2@CMU team extends its gratitude to those who have shared their time, resources and expertise in the entire duration of the project. Our thanks to the following:

- Central Mindanao University Administration, through the leadership of the University President Dr. Maria Luisa R. Soliven, for supporting the project
- DA-BAR for funding the project and DA-BAR personnel for accommodating and responding to our financial concerns. Their prompt response is well appreciated (Mr. Danielle Joseph Sisican, Ms. Lyza Quilong-quilong and Ms. Velasco)
- CIAT for sharing technical expertise in capacitating the team to undertake the project
- DA-SWCCO for the support and response to administrative concerns
- DA- Regional Field Office 10 for extending expertise and sharing the data
- Provincial Government of Bukidnon, particularly the Provincial Agriculture Office (PAO) and the Provincial Planning and Development Office (PPDO) for sharing their data and expertise
- Local government of Malaybalay, particularly the City Agriculture Office, for providing local support and facilitating the FGD, KII and validation activities with farmers
- Corn Growers Association of Malaybalay City for sharing their farm practices
- Farmers of Barangay San Jose, Malaybalay City, particularly the respondents and participants of the FGDs, KIIs and validation activities
- Farmers and farmer organizations of Bukidnon for enhancing the data and information

With the huge resources and expertise extended to this project, the team hopes that the output will be translated to policies and programs for a climate-resilient Bukidnon.

Table of Contents

List of Tables

List of Tables

List of Figures

List of Figures

List of Appendices

Abstract

The AMIA Phase 2 project implemented in Region 10 focuses on the Bukidnon Province targeting corn, rice, cacao, tomato and coffee. The project conducted climate risk vulnerability assessment (CRVA) on the province in relation to the five crops and cost-befit analysis on climate-resilient agriculture (CRA) practices on corn production. CRVA findings reveal corn, rice, cacao and tomato have increasing suitability and negative sensitivity in the projected 2050 climate scenario while coffee has decreasing suitability and positive sensitivity. Kitato and Damulog have the highest level of climate risk vulnerability among the municipalities in Bukidnon based from exposure, sensitivity and adaptive capacity variables in the vulnerability equation. The identified CRA practices for corn production are biodynamic agriculture and crop diversification, specifically corn and banana. Results of CBA show both CRAs have positive private NPV, i.e. PhP3,776 and 37,809, and IRR values higher than the 12% discount rate i.e. 17% and 30%, for biodynamic agriculture and crop diversification, respectively. Aggregate social NPV is higher for crop diversification (PhP103,174,716) compared to biodynamic (PhP24,951,041). The findings of this study should be considered in targeting and prioritizing efforts to respond to climate risks in the agriculture sector, particularly in Bukidnon. Efforts should be directed at increasing or enhancing the adaptive capacity as well as lessening adoption cost of the CRA practices such as subsidy for inputs, labor and transportation costs. Crucial to these is the formulation of enabling policies to support climate-resilient agriculture in Bukidnon.

B. TECHNICAL DESCRIPTION

2.1. Introduction

With the impacts of climate change, the "new climate normal" as declared by the PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) will correspondingly affect the agriculture sector. These impacts are intensified in disaster-prone areas as well as in areas that have inappropriate landuse management and agricultural practices. These are common in Bukidnon whose economy is dependent in agriculture and agri-based industries. Thus, there is a need to assess these practices to dovetail it with appropriate adaptation and mitigation initiatives to address the impacts of climate change.

Several initiatives have been done to address climate change impacts in agriculture. National agencies and local government units are supportive to these initiatives. However, existing programs are limited on building resilience among farmers, particularly those that have limited adaptive capacity. Farmers, including agriculturists and technicians, need science-based data on crop vulnerabilities and suitability to respond to the threats of climate change and natural disasters.

The Adaptation and Mitigation Initiative in Agriculture (AMIA) seeks to enable the Department of Agriculture (DA) to plan and implement strategies to support local communities in managing climate risks – from extreme weather events to long-term climatic shifts. Spearheaded by the DA System-wide Climate Change Office (DA SWCCO), AMIA Phase 1 in 2015-16 implemented activities to strengthen capacity of DA to mainstream climate change adaptation and mitigation strategies in its core functions of R&D, extension, and regulation. It is also designing complementary activities for building appropriate climate responsive DA support services.

AMIA Phase 2 (AMIA2) challenge is making climate-resilient agri-fisheries (CRA) an operational strategy through field-level action that directly involves, and affects the livelihoods of, farming communities. The program is launching an integrated and multi-stakeholder effort to operationalize CRA at the community level in 9 target regions.

1. Region I Ilocos
2. Region II Cagayan Valley
3. Region III Central Luzon
4. Region IVA Southern Luzon
5. Region V Bicol
6. Region VI Western Visayas
7. Region X Northern Mindanao
8. Region XI Southern Mindanao
9. Region XVIII Negros

Successful implementation of AMIA2 at the regional level requires the strong collaboration and support of key research and development institutions within the region. This project enables AMIA2 to establish and mobilize regional teams, each led by a local State University/College (SUC), and in partnership with the corresponding Department of Agriculture - Regional Field Office (DA-RFOs). For Region 10-Northern Mindanao, Central Mindanao University (CMU) takes the lead in the project implementation.

The research agenda of the AMIA2 projects include 1) climate-risk vulnerability assessment (CRVA); 2) decision-support platform for CRA; and 3) institutional and policy innovations. The International Center for Tropical Agriculture (CIAT) is the lead organization in the CRVA project.

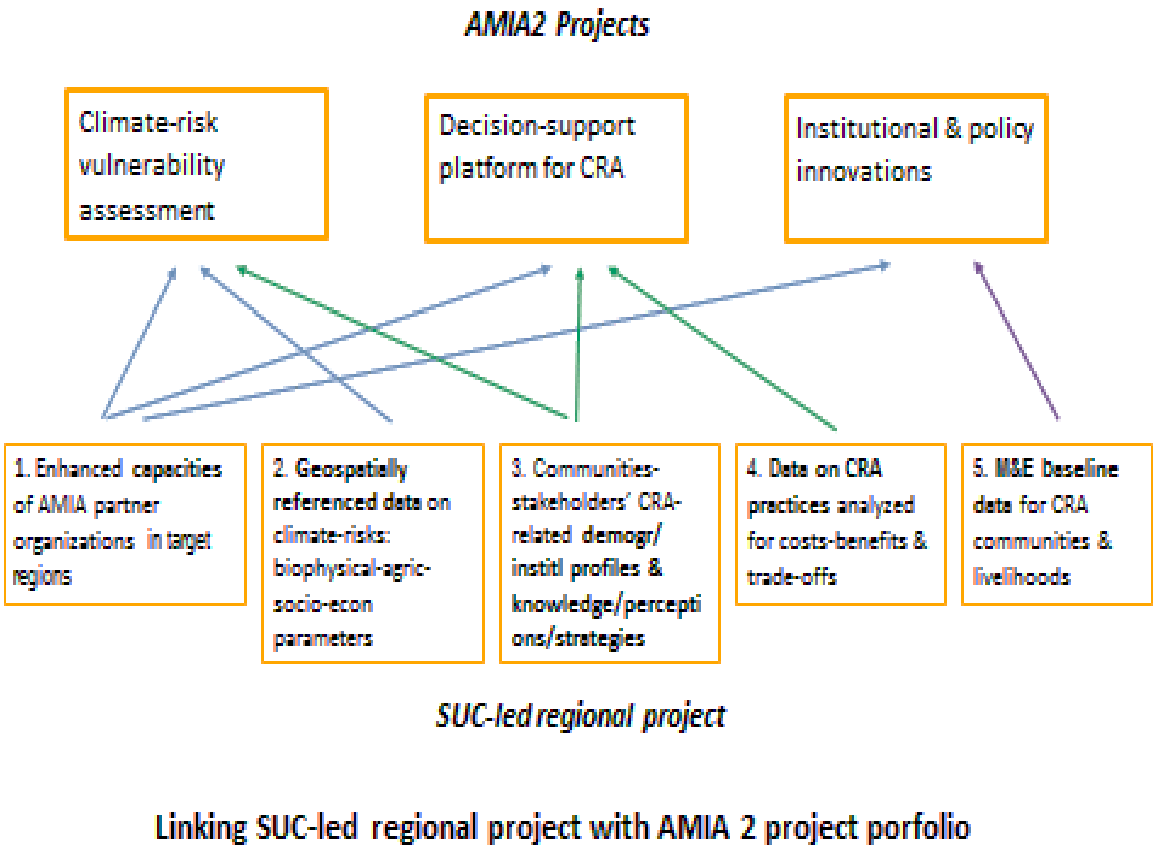


Figure 1. AMIA2 regional project framework

AMIA2 aims to invest in the launching of CRA communities -- as the initial target sites for action learning, supported by an integrated package of climate services and institutions, within a broader food system/value chain setting. Specifically for Bukidnon in the Northern Mindanao region, AMIA2 provided relevant data and information to project beneficiaries, i.e. farmers, farmer organizations, local and regional agricultural offices and local government units, the science-based recommendations for climate adaptation and mitigation initiatives.

The overall objective of this project is to assess, target and prioritize climate-resilient agriculture (CRA) research and development in Region 10 in support of AMIA2. Specifically, this project aims to:

1. strengthen capacities for CRA methodologies of key research and development organizations in the region.
2. assess climate risks in agriculture sector through geospatial and climate modelling tools.
3. determine local stakeholders' perceptions, knowledge and strategies for adapting to climate risks
4. document and analyze local CRA practices to support AMIA2 knowledge-sharing and investment planning.

The project site is Region 10 specifically in the Province of Bukidnon. The project consists of major components such as the climate risk vulnerability assessment (CRVA) and the climate resilient agriculture (CRA) practices. For CRA practices and economic analysis, the project focuses in Malaybalay City due to established contacts and access to data. Crop is specific to corn and two (2) CRA practices, i.e. biodynamic agriculture and crop diversification. Outputs of the project are dependent on the available data shared by DA, LGUs, farmers and farmer organizations. Data collection, analysis and map generation are standardized, using the CIAT-generated methodologies for cross-regional and national analysis on climate risk vulnerability assessment (CRVA) and CRA practices (see Palao, et al, 2017).

2.2. Review of Literature

According to Calalan et al (2014), agriculture and related enterprise rank second as the largest contributor in the regional economy. In 2013, Northern Mindanao contributed 3.73% to the Gross Domestic Product of the country. It is the top producer of pineapple with a 3.63% growth in 2013. Meanwhile, the region also ranked second in banana production and third in chicken and corn production. According to the Philippine Statistics Office (2013), major crops grown in Region 10 include banana, pineapple, corn and palay. Among the five provinces, Bukidnon is considered as agricultural, characterized by vast agricultural areas devoted for crop cultivation and agri-industrialization.

Despite its agricultural productivity, the region is exposed to different climate hazards like typhoon, drought, erosion and pest and diseases due to changing weather conditions, inappropriate cultivation and landuse practices, among others.

In 2011, the region was hit by Typhoon Sendong causing an estimated ~~to~~ loss of PhP 305 million in agriculture. Typhoon Pablo in 2012 caused an estimated PhP 16.3 billion damage in Regions 1, 4b, 6, 7, 10, 11 12 & CARAGA. On February to late May 2016, Bukidnon and other parts of Northern Mindanao were declared under a state of calamity due to the long drought brought about by El Niño. This incidence caused PhP 792,763,000 loss in agriculture investment in 13,811.46 hectares of crop land in Bukidnon, Misamis Oriental and Misamis Occidental provinces (Mascarinas, 2016). These experiences of Northern Mindanao underscore the growing vulnerabilities of agriculture-dependent economy and livelihood of its farming communities.

Several initiatives have already been made on climate change resiliency, e.g. Project Climate Twin Phoenix and INREMP of UNDP covering the Upper Bukidnon river basins (2012); the Northern Mindanao Community Initiatives and Resource Management of IFAD (2009). However, more efforts should be done to build/enhance the capacity of the poor who have low level of adaptive capacities to make better use of available sources (Brömmelhörster, n.d.; Magnan, 2010). A report from IGES and ICLEI (2012) highlights the lack of adaptive capacity towards resilience or self-organization as a major factor in vulnerability to climate change risks and impacts. Thus, the development of such capacity is an important element for climate change adaptation (Adger et al 2003; Dany et al 2012).

PAGASA climate projections still remain a threat to the agriculture sector in Northern

Mindanao. Of the four provinces in the region, Misamis Oriental Province shows the highest projected rainfall decrease of about 18% (see Figure 2). Bukidnon has an apparent decrease of rainfall in the 2020 and 2050 scenarios. This would affect the agriculture-based economy of Northern Mindanao. In fact, the report of Department of Agriculture Regional Field Office (DA-RFO) 10 show low agriculture yield in 2016 due to El Niño affecting about 9,015 farmers in the region. Damage in the form of production loss for crops, i.e. rice, corn, cassava and high-value crops, was estimated at PhP2.4 million. Bukidnon consistently registered the highest production loss of all the provinces in the region, understandably because this province is dominantly agricultural.

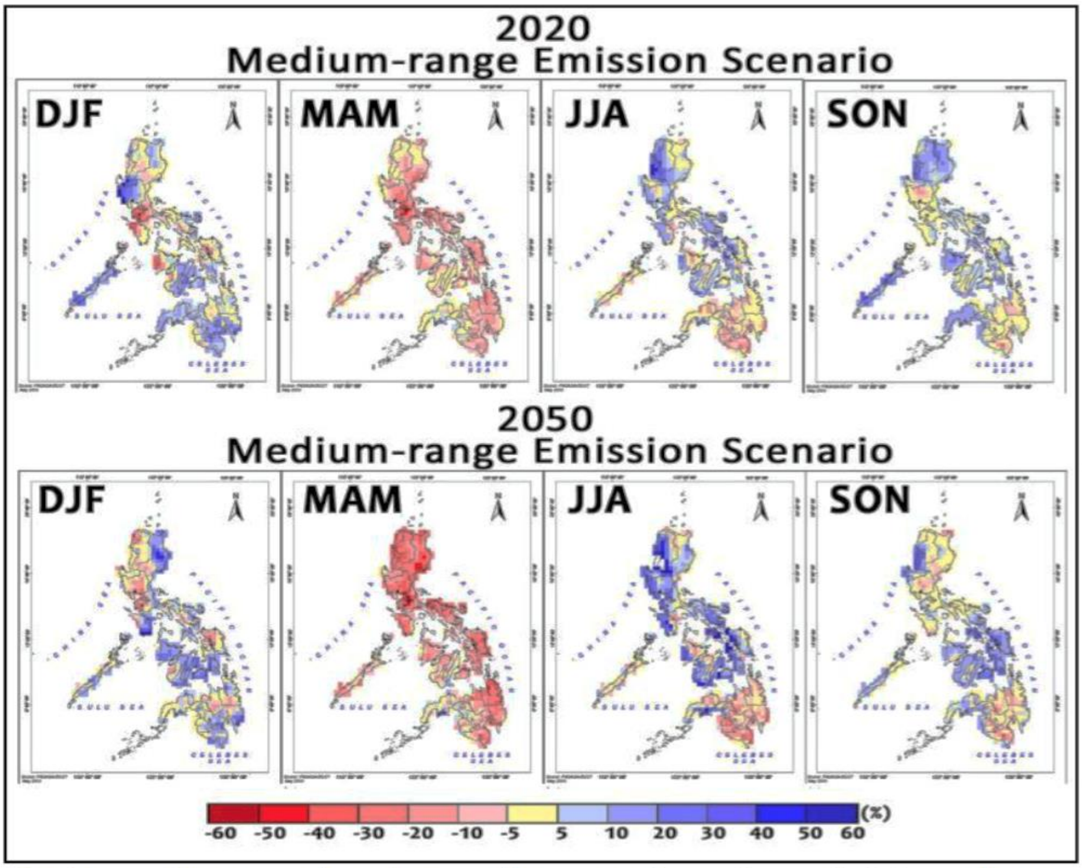


Fig.18: Maps showing the projected rainfall change (increase/decrease) in % in 2020 and 2050 in the Philippines.

Figure 2. Projected rainfall change (increase/decrease) in % in 2020 and 2050 Philippines (PAGASA, 2011)

Table b: Seasonal rainfall change (in %) in 2020 and 2050 under medium-range emission scenario in provinces in Region 10

	OBSERVED BASELINE (1971-2000) mm				CHANGE in 2020 (2006-2035)				CHANGE in 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Region 10												
BUKIDNON	329.7	335.6	653.8	559.5	2.9	-10.3	-4.4	-0.3	-5.1	-13.0	-9.7	-5.8
LANAO DEL NORTE	337.5	350.3	662.5	621.1	9.6	-0.6	-2.2	6.9	2.5	-1.9	1.4	7.1
MISAMIS OCCIDENTAL	392.1	323.4	633.1	728.3	9.1	1.4	-6.1	6.1	5.2	0.3	-5.1	4.6
MISAMIS ORIENTAL	442.5	296.0	615.7	581.1	4.6	-10.4	-3.7	2.9	1.8	-17.8	-5.2	-0.1

Figure 3. PAGASA rainfall projections due to climate change
Source: PAGASA, 2011

In 2012, Bukidnon LGU, in coordination with NEDA 10, has produced its "Sectoral Climate Change Vulnerability Assessment Report" to map out vulnerable areas for natural disasters such as drought, erosion, flooding for forest, biodiversity, water, and agriculture sectors. The assessment uses the formula:

Vulnerability Index = Weighted (Sensitivity Sub-Index + Exposure Sub-Index + Adaptive Capacity Sub-Index).

The Sectoral Report on Vulnerability Assessment generated maps that show municipalities/cities that are categorized as highly vulnerable as summarized in Table 1.

Table 1. Highly vulnerable municipalities/cities of Bukidnon to natural disasters

Sector	Disaster	Highly Vulnerable Municipalities/Cities
Forest	Drought	Libona, Manolo Fortich, Cabanglasan, Quezon, Kitaotao, Maramag, Dangcagan and Damulog
	Landslide	All municipalities/cities
	Flood	Kalilangan, Valencia City
Biodiversity	Forest fire	Cabanglasan, San Fernando, Quezon, Kitaotao
	Diseases and Pests	Kitaotao
Water	Drought	All cities/municipalities
	Flooding	Lantapan, Sumilao, Impasugong, Manolo Fortich, Libona, Baungon, Talakag
Agriculture	Drought	All cities/municipalities
	Erosion	All cities/municipalities except Valencia, Maramag, Kadingilan

Source: Bukidnon LGU and NEDA-10, 2012

However, in a study conducted by Toledo-Bruno, et al (2015), these disasters occur in specific areas within the identified city/municipality. The vulnerability is intensified in these areas where there are low adaptive capacity due to limited funds and other resources particularly in remote barangays.

Communities have varied adaptive capacity because of the interplay of economic, social and environmental dynamics. Analysis of the adaptive capacity is an important component of CRVA because it enables planners to look at which capitals need improvement to enhance the resiliency of communities in an area. The analysis of Climate-Risk Vulnerability (CRV) can be aided by geospatial means. Geographic Information System (GIS), alongside other tools, have been revolutionizing the way information is analyzed and presented. Assessing CRV would require the modelling of species distribution (SDM). Various modelling tools of such specification are available, however, some were proven to be more robust than others. A popular modelling tool called Maxent is typically utilized in many SDM studies (Paquit, 2017). Maxent can model crop suitability to build and assess scenarios due to changes in climate parameters.

2.3. Methodology

2.3.1. Study Area

Region 10 (Northern Mindanao) is composed of five provinces, nine cities, 84 municipalities and 2022 barangays. Its regional center is located at Cagayan de Oro City. Region 10 is geologically a combination of plains, mountains, rolling hills and coastal areas. Generally, rainfall in Northern Mindanao is evenly distributed throughout the year. It has abundant vegetation, natural water sources, and high elevation areas that contribute to the region's cool, mild, and invigorating climate.

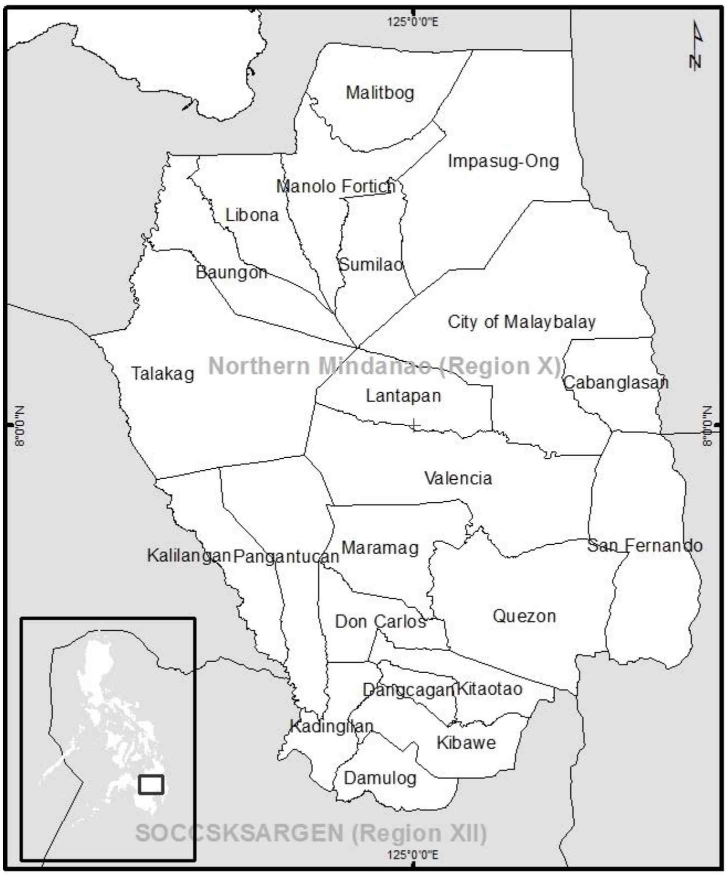


Figure 4. Map of Bukidnon Province

CRVA of the AMIA Phase 2 in Northern Mindanao (Region 10) is focused in the province of Bukidnon. Bukidnon is a landlocked province without coastlines. It extends geographically from 7°20' – 8°40' N to 124°30' – 125°30' E, with land area of 918, 715 hectares (calculated in GIS) representing 2.76 % of the country's total land area. The province comprises 20 municipalities and 2 component cities. The province is bordered by forests where headwaters of various rivers originate. Dubbed as the watershed province, Bukidnon harbours headwaters of major river basins such as the Mindanao, Tagoloan, Cagayan and Davao river basins. A large part of the land area of the province is gently rolling grassland and plains, which generate agricultural production for the region and the entire country.

Records of PAG-ASA from 2006-2011 revealed that this province has two prevailing types of climatic variations in the rainfall pattern existing between the northern and southern sections. The northern part falls under the third or intermediate A type. The southern part, beginning from Malaybalay, falls under the fourth type of intermediate B type (Bukidnon LGU, 2015).

Bukidnon is largely agricultural and considered the "food basket" of Mindanao. As an agriculture-based economy, this province hosts a diversity of agri-industrial crops and livestock. Bukidnon is the biggest producer of corn, sugarcane, pineapple, banana, cassava, tomato and rubber. For this project, the CRVA is focused on rice, corn, tomato, cacao and coffee. The selection is based on the dominance of crops in the province as well as on the generation of data for other crops for cross-regional analysis under the AMIA2 project.

As a pilot study, documentation of CRA practices was conducted in Barangay San Jose, Malaybalay City, Bukidnon. Malaybalay City is a first class municipality and the capital of the province of Bukidnon. The city is geographically bordered in the east by the municipality of Cabanglasan and the Pantaron Range, on the west by the municipality of Lantapan and the Mountains of Kitanglad Range, the municipality of Impasugsong on the north and Valencia City and San Fernando on the south (PhilGIS, 2017). PhilGIS (2017) data reveals that about 40% of Malaybalay City is cultivated. Barangay San Jose is one of the 46 barangays of Malaybalay City. It is located along the National Highway at 8.103563 latitude and 125.128604 longitude. Corn is the major produce of the city covering about 43% of the total cultivated land, with an average production of 4.13 metric tons/hectare (Malaybalay LGU, 2013).

Barangay San Jose is classified as urbanizing barangay but agricultural production areas are located in the inner *sitio* (villages) characterized by rolling and gently to moderately sloping land. Agricultural activities of farmers in San Jose are dominantly on crop production with animal raising. Crops planted ranges from staple grains, vegetables, root crops, fruits and industrial crops. As of 2015 data, corn, vegetables and industrial crops cover most of the cultivated land. In terms of vegetables, commonly grown is squash with 164 hectares and covering 61% of land planted for vegetables. Rubber as an industrial crop comprises 262 hectares or 10% of the total cropland. Banana, on the other hand, covers 59 hectares (AEW Annual Assessment Report CY 2015, 2015).

As a major commodity in the area, corn occupies a total of 1,879 hectares in 2015. Among the various crops, it occupies almost three-fourths of the total crop production area. In 2016, an average of 517 farmers alternatively produces yellow and white corn varieties in 855 hectares of land. Assistance and support from the Department of Agriculture (DA) include distribution of OPV corn seeds, calamity assistance from flooding and drought, distribution of corn seeds with urea and complete fertilizers, Farmer's Field School (FFS), school-on-the air and value-adding activities in corn, crop insurance seminar and assistance from the Philippine Crop Insurance Corporation.

2.3.2. Methodology per Objective

Methodologies adopted in this project integrate both the natural and social science methods to capture the information for the CRVA and CRA practices. Table 2 summarizes the methods used per objective of the project.

Table 2. Methodology for CRVA and CRA

Objectives	Methodology
To strengthen capacities for CRA methodologies of key research and development organizations in the region.	Training, workshops and learning events on climate risk vulnerability assessment (CRVA); climate resilient agriculture (CRA) prioritization; and CRA monitoring and evaluation, participated by project team members and selected stakeholders.
To assess climate risks in the region's agriculture (crop) sector through geospatial & climate modelling tools.	Collection, processing, and organization of geo-referenced data from primary and secondary sources. Tools include GIS and

Objectives	Methodology
	modelling (e.g. Maxent).
To determine local stakeholders' perceptions, knowledge & strategies for adapting to climate risks	Stakeholders' meetings, focus group discussions and key informant interviews to collect supplementary data and validate results of CRVA.
To document and analyze local CRA practices to support AMIA2 knowledge-sharing and investment planning.	Data collection through Key Informant Interviews, expert consultations and literature reviews. Economic assessment of CRA practices through cost-benefit analysis. Output generated will serve as input to decision-support platform.
To establish AMIA baseline for outcome monitoring and evaluation (M&E) of CRA communities and livelihoods.	Surveys to target CRA communities (i.e. corn farmers)

In response to the methodologies, the team is composed of the following CMU faculty researchers with corresponding expertise:

Angela Grace Toledo-Bruno, PhD – Environmental Science/Project Leader
Raquel O. Salingay, MS – Crop Specialist
Thea Arbie S. Rivera, MS – Socio-economics Specialist
For. Joseph C. Paquit, MS – GIS Specialist

The team is aided by a Laboratory Aide (Keven Patrivell J.Tañara) to focus on mapping and an Enumerator (Jedilyn M. Tandog) to assist in fieldwork activities. The team also maintained close coordination with local agricultural offices in Malaybalay City and the Bukidnon Province including DA RFO-10. The offices of the municipal/city agriculture, Provincial Planning and Development and municipal/city LGUs provided the data on crop production and in the adaptive capacity variables. The data are supplemented by other secondary sources such as the DA AMIA 1 outputs, websites and municipal/city profiles.

To standardize the methodology, the team participated in a series of workshops and trainings as shown in Table 3. The standardization of the methods and data presentation allows for cross-regional analysis for CRVA and CRA, which are crucial inputs for national-level targeting and prioritization in responding to the impacts of climate change in the agriculture sector.

Table 3. Workshops and trainings participated by the CMU team for CRVA and CRA

Activity	Venue	Date	Participants
Training/Workshop on Climate Risk Vulnerability Assessment (CRVA)	Quezon City	June 6-8, 2016	Angela Grace Toledo-Bruno, Raquel O. Salingay, Thea Arbie S. Rivera and Joseph C. Paquit
Cost-Benefit Analysis of Climate-Resilient Agriculture Technologies and Practices	Quezon City	August 4-6, 2016	Thea Arbie S. Rivera
Participatory Workshop for Mapping Crop Occurrences in Bukidnon	CMU, Musuan, Bukidnon	August 11, 2016	Mapping and Crop experts, Agri. Tech, DA personnel, AMIA Team
Training/Meeting for GIS focal persons	Manila	August 21-24, 2016	Joseph C. Paquit
GIS National Working Group Workshop/Meeting	Lake Hotel, Tagaytay City	Sept. 22 & 23, 2016	Joseph C. Paquit
Progress Review and Assessment of on-going Projects under the AMIA 2 program	DA-BAR, Quezon City	Sept. 27-28, 2016	Angela Grace Toledo-Bruno
Meeting for CMU AMIA 2 research team to orient local partners about the project and to initially identify participants for the FGD and respondents for interviews	Malaybalay City Agriculture Office	September 30, 2016	Angela Grace Toledo-Bruno, Raquel O. Salingay and Thea Arbie S. Rivera
Focus Group Discussion on the Climate Resilient Agriculture Practices	Brgy. San Jose, Malaybalay City	October 21, 2016	Corn farmers
Workshop/meeting on Climate-Risk Vulnerability Assessment (CRVA)	Los Baños, Laguna	January 10-12, 2017	Angela Grace Toledo-Bruno, Thea Arbie S. Rivera and Keven Patrivell J.Tañara
The AMIA2-CIAT Project Results Sharing and Validation Workshop	Parklane International Hotel, Cebu City	February 6-7, 2017	Angela Grace Toledo-Bruno, Joseph C. Paquit, Thea Arbie S. Rivera and Jedilyn M. Tandog
National Review and Planning Workshop of BAR Funded Climate Change Projects	DA-BAR, Quezon City	March 6-10, 2017	Angela Grace Toledo-Bruno
Workshop on finalizing results of CRA prioritization, CRVA, and Extended CBA	B Hotel, Quezon City	March 1-3, 2017	Thea Arbie S. Rivera and Raquel O. Salingay

Activity	Venue	Date	Participants
Local Stakeholders Validation Workshop	Veranda, Malaybalay City, Bukidnon	May 25-26, 2017	Local and Regional stakeholders
Completion Review	Partido State University in GOA Camarines Sur	May 31- June 2, 2017	Kevin Patrivel Tañara
National Review and Planning Workshop	DA-BAR office, Quezon City	April 3-7, 2017	Angela Grace Toledo-Bruno and Joseph C. Paquit
Climate-Resilience Monitoring and Evaluation.	Sequoia Hotel, Quezon City	June 21-22, 2017	Angela Grace Toledo-Bruno
Validation and Writeshop	CMU, Musuan, Bukidnon	June 30, 2017	Local and Regional stakeholders

It should, however, be noted that based on the agreed crops per region, conducted during CRA prioritization, Region 10 was tasked to work on corn, rice, cacao, coffee and tomato for CRVA, specifically in the province of Bukidnon. Documentation and economic analysis of CRA practices focus on corn being the major crop in Malaybalay and Bukidnon. Inland fishery was excluded since the fishing is not dominant in Bukidnon being a landlocked province.

2.3.3. Data Collection and Analysis

2.3.3.1. Climate risk vulnerability assessment (CRVA)

Species Occurrence Points (SOP)

Species occurrence points (SOPs) were gathered from local experts through a participatory mapping workshop entitled "Participatory Workshop for Mapping Crop Occurrences in Bukidnon" conducted last August 11, 2016, at CMU. This was participated by personnel from city and municipal agricultural offices in Bukidnon as well as the report officers of the Provincial

Figure 5. Local agriculture personnel and report officers during the mapping of SOPs

Agriculture Office. The Report Officers represent specific crop, i.e. rice, corn, rubber/coconut, coffee/cacao and vegetables. The distribution of the crops was also validated with the presence of city/municipal extension or agriculture office personnel. The main purpose of the workshop is to locate existing crop presence in the municipalities. The mapping exercise was designed to rapidly collect data instead of actual field collection. During the feedback and validation of data conducted on May 2017, farmers from the different cities/municipalities validated the map on the distribution of crops. Table 4 summarizes the number of SOPs per municipality/city

The team did not solely rely on topographic maps but also on digital maps. The map provided by CIAT was enhanced by integrating the use of Google Earth. The map depicts grids representing the resolution of the environmental variable that also contains features such as road network, river network, digital elevation model, municipal and barangay political boundaries (from Philgis.org) to validate the occurrence of crops. These data were exported to Google Earth. This enabled the team to validate the information drawn by the local experts.

The participants of the mapping workshop on crop occurrences located the different crops for each grid based on personal knowledge and from technical reports. The local experts also provided data on crop yield based, which were then compared to the national yield averages reported by the Philippine Statistics Authority (PSA). This was used to classify yield as high, moderate and low.

Figure 6. Farmers validating crop occurrence points

Table 4. Number of Species Occurrence Points per Municipality

Location	Corn	Rice	Cacao	Coffee	Tomato
Baungon	0	6	0	0	0
Cabanglasan	0	18	0	0	0
Damulog	17	12	7	6	0
Dangcagan	14	11	3	1	0
Don Carlos	27	18	7	9	0
Impasug-ong	0	12	4	7	5
Kadingilan	19	5	9	5	0
Kalilangan	0	9	7	0	0
Kibawe	28	13	3	8	0
Kitaotao	36	10	0	0	0
Lantapan	1	1	1	2	0
Libona	0	15	11	11	0
Malaybalay City	100	67	21	34	30
Malitbog	0	7	0	0	0
Manolo Fortich	0	5	7	0	0
Maramag	160	57	0	21	0
Pangantucan	0	13	4	7	0
Quezon	33	25	0	0	0
San Fernando	49	11	0	4	0
Sumilao	0	10	6	6	0
Talakag	36	13	0	11	2
Valencia	228	227	62	7	21
Total	748	555	152	139	58

Local experts seemingly have more knowledge on the occurrences of corn and rice than on cacao, coffee and tomato. This resulted to a variation in terms of the total number of occurrence points per crop. SOP data generated from the mapping workshop were largely in analog format. Hence, the team initiated the digitization of the data using ArcMap ver. 10.1 (license was obtained from LiDAR project implemented by CMU). Eventually, the digital data was stored in the database and forwarded to CIAT for cross-regional analysis. The integrity of the data was ensured by repeatedly undertaking Google Earth-based validation.

Climatic Variables

Twenty baseline and projected climate variables sourced out from CIAT were used in Maxent modelling. These variables were derived from the monthly temperature and rainfall values that are biologically relevant. These variables represent annual, quarterly, monthly and even daily ranges in climate as shown in Table 5.

Table 5. Bioclimatic variables

Code	Variable
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3	Isothermality (BIO2/BIO7) (* 100)
BIO4	Temperature Seasonality (standard deviation *100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter

Model Building using Maxent

Maxent modelling (see Philips et.al 2005) was used to model the climatic suitability of the five selected crops, i.e. corn, rice, cacao, coffee and tomato. Most of the data pre-processing were done in GIS. A .csv file was prepared containing all needed information regarding the species occurrence points. The coordinate reference system for all environmental variables was set to WGS 1984. All environmental raster layers were formatted to American Standard Code for Information Interchange (ASCII) format. ASCII is the common file format in modeling. For model accuracy evaluation, the AUC-ROC was produced as one of the Maxent outputs was used. The percent influence of each environmental variable on the distribution of the species was determined using the Jackknife test. The result of the test was automatically produced by Maxent. Figure 7 illustrates the conceptual summary of the modelling method.

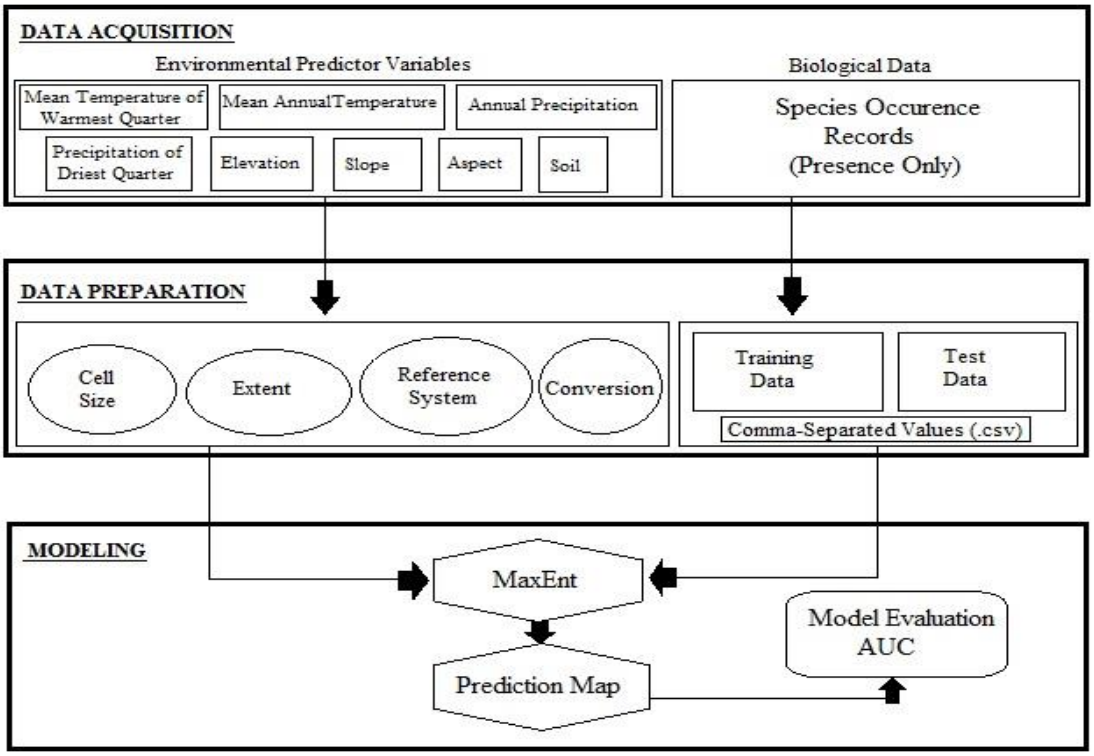


Figure 7. Maxent modeling framework (Phillips, et al, 2005)

Sensitivity Analysis

Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change (Läderach et.al 2011). Crop sensitivity was assessed by analyzing changes in climatic suitability of crops by the year 2050 in comparison with the baseline crop suitability. The change in climatic suitability of crops between baseline and future predictions was analyzed in ArcMap using a step-by-step process that involved the use of tools such as the raster calculation, reclassification and zonal analysis. Using this protocol, the potential effect of climate change to crop suitability was analyzed. The team's hypothesis was centered on the idea that the five crops have different baseline climatic suitability and, therefore, would have varied response to climate change. For instance, coffee is known to thrive in cooler areas of the province while rice is more adapted to a warmer climate. Thus, these crops will have different suitability models for both baseline and projected climate scenarios.

CIAT formulated a sensitivity index based on percent change as depicted in Table _. An index of 1.0 means a very high loss in suitability while an index of -1.0 means very high gain. The index equal to 0 means there is no change in suitability detected from baseline to projected climate scenarios.

Table 6. Sensitivity index based on percent change in crop suitability from baseline to future climate scenarios

Percent Change in Suitability (Range in %)	Index	Description
<= -50 (Very high loss)	1.0	Loss
>-50 & <= -25 (High loss)	0.5	
> -25 & <= -5 (Moderate loss)	0.25	
> -5 & <= 5 (No change)	0	No Change
> 5 & <= 25 (Moderate gain)	-0.25	Gain
> 25 & <= 50 (High gain)	-0.5	
> 50 (Very high gain)	-1.0	

Analysis of Exposure to Hazards

Exposure is the character, magnitude and rate of climate change and variation (Läderach et.al 2011). Several biophysical indicators of exposure to climate change were factored-in as summarized in Table 7 as hazards.

Table 7. Percent score of hazards in Bukidnon Province

Hazard	Percent Score (Mindanao)
Typhoon	16.95
Flood	15.25
Drought	16.95
Erosion	12.71
Landslide	14.41

Note: Hazards such as storm surge (8.47%), sea level rise (5.08%) and saltwater intrusion were considered irrelevant for Bukidnon.

All hazard data were sourced-out from CIAT who managed the pooling of datasets from different sources for distribution to different SUC partners and standardization of cross-regional outputs. Flood and drought data were extracted from the AMIA 1 dataset. The factors were weighted based on its impact on agriculture on the national scale and downscaled to the provincial level. The weighting process involved the analysis of the impact of these hazards to the economy, food security, household income and crop productivity for each municipality in Bukidnon. For each municipality, the mean value of aggregate weight was computed. Normalization was employed to generate index from 0 to 1. Five equal breaks were used to establish the thresholds for the following classes: 0-0.20 (Very Low), 0.20-0.40 (Low), 0.40-0.60

(Moderate), 0.60-0.80 (High), and 0.80-1.00 (Very High).

Analysis of Adaptive Capacity

Adaptive capacity is the ability of a system to adjust to climate change (Läderach et.al 2011). It is one the three components of the vulnerability assessment, in addition to exposure and sensitivity. Adaptive capacity is directly correlated with resilience. Measured on a municipal/city scale in the context of climate change effects to agriculture, the adaptive capacity index provides information on how resilient an area is to climate change. The adaptive capacity parameters used are those that are relevant to the agricultural sector in the province. The indicators are summarized in Table 8.

Table 8. Adaptive capacity Indicators

Indicator	Sub-indicators	Weight
Economic capital	Income level, water and sanitation, electricity, banks and financial institutions, commodity prices, farm income, agricultural insurance, employment in agriculture.	14.29
Natural capital	Forest cover, groundwater availability, irrigation system	14.29
Social capital	Farmer unions, farmer cooperatives	14.29
Human capital	School enrolment, student teacher ratio, number of class rooms, number of schoolbuilidngs, health services, nutrition sufficiency	14.29
Physical capital	Land tenure, farm size, farm equipment, value of livestock, irrigated area, access to quality seeds, roads, market access	14.29
Institutional capital	Civil society organization (CSO) programs, government response to calamities	14.29
Anticipatory capital	Presence of MDRRMC, early warning systems, radio/TV stations, telecommunications	14.29

As previously mentioned, the analysis of adaptive capacity in this study was contextualized for the agricultural sector. Several socioeconomic information from each municipality that is relevant to agriculture were gathered from sources at the local (Provincial Planning and Development Office and municipal/city agriculture offices of Bukidnon) and national levels (competitiveness.org). The data were analyzed to generate a measure of adaptive capacity per municipality/city in the form of an index. The formulation of index involved the process of data standardization to bring the values of the different adaptive capacity parameters to a common range that is 0-1. Five equal breaks were used to establish the thresholds for the following classes: 0-0.20 (Very Low), 0.20-0.40 (Low), 0.40-0.60 (Moderate), 0.60-0.80 (High), and 0.80-1.00 (Very High).

Climate Risk Vulnerability Assessment (CRVA)

Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001). Based on the definition, vulnerability is a function of sensitivity, exposure and adaptive capacity. A national workshop led by national experts was conducted with the objective of coming up with final weight of each factor. The CRV equation adopted in this study is presented below.

$$(Haz, Sens, AC) = \sum_{n=i} ((Haz_{(w_h)} + Sens_{(w_s)}) + 1 - AC_{(w_a)})$$

where: Haz is the hazard index; Sens is the sensitivity index; AC is the adaptive capacity index; i refers to crop; W_h is the given weight for hazard; W_s is the given weight for sensitivity; and W_a is the weight given for adaptive capacity. Figure 8 illustrates the conceptual framework of the CRVA model.

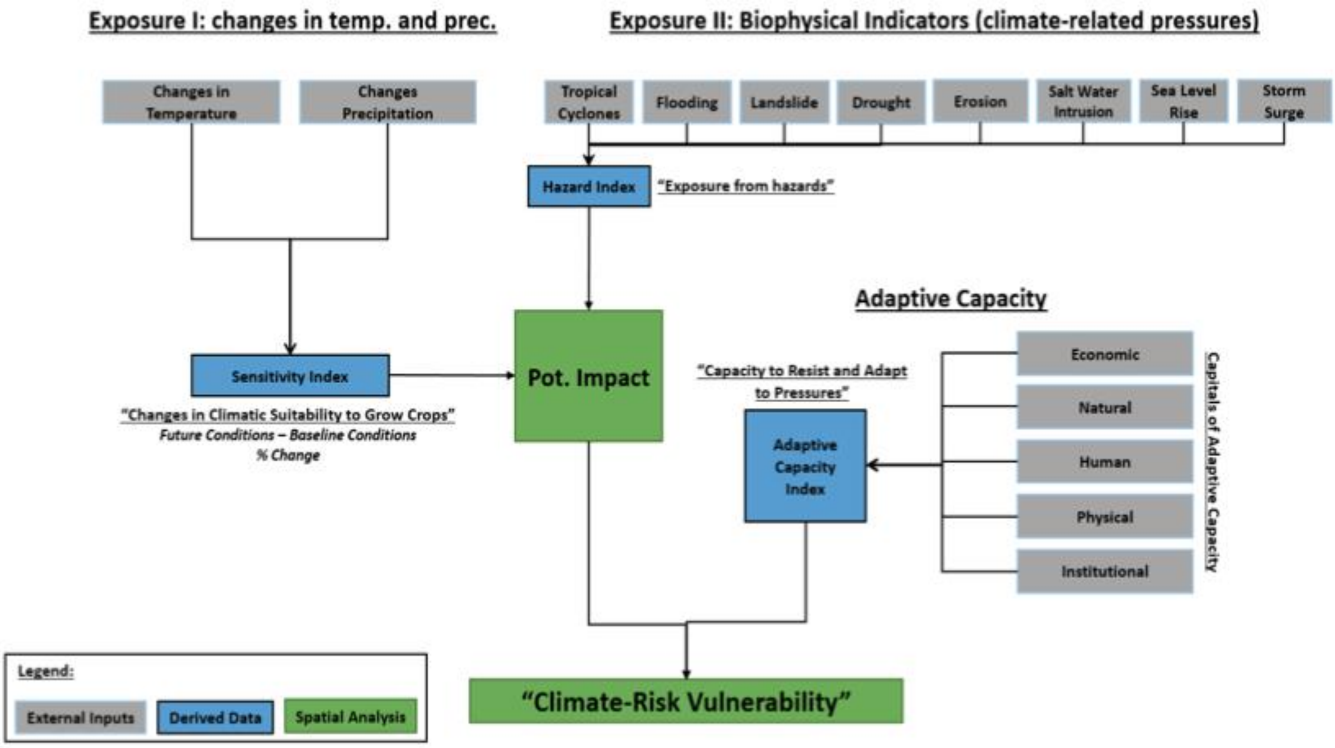


Figure 8. Framework for CRVA (CIAT, 2017)

The analysis of weights for each component of vulnerability was discussed by a group of national experts. The weights have been a contentious issue as many have questioned how the experts have come up with such, especially the version that had AC at 70%. It was obvious from the beginning that such process of assigning weights by experts is subjective. To remedy the problem, CIAT did a sensitivity analysis undertaken in one province per island group to explore the impact of varying proportions of weights to the overall vulnerability. This involved the use of other weight proportions that are based on scientific literatures. CIAT, however, cautioned that when comparing weights, variations in spatial scale, resolution, and type of vulnerability being assessed must be considered. The results of the sensitivity analysis revealed a consistent detection of vulnerable municipalities/cities since majority of the versions consider AC as the factor with the highest weight.

The team relied on the output of CIAT since a national scale analysis had to be generated, which incorporated all the data from AMIA 2 implementing partners from state universities and colleges (SUCs). The different weight proportions used are shown in Table 9.

Table 9. Weights used to assess CRVA

Version	Sensitivity (%)	Exposure (%)	Adaptive Capacity (%)
1	15	15	70
2	33	33	33
3	25	25	50
4	20	20	60
5	30	30	40

2.3.3.2. Local stakeholders' perceptions, knowledge and strategies

One of the main objectives of the project is to determine the local stakeholders' perceptions, knowledge and strategies for adapting to climate risks. In the few months of the start of the project implementation, secondary data related to the stakeholders' perception were taken from different offices while conducting focus group discussions (FDG) and key informant interviews (KII). During the conduct of FGD, biodynamic farming and crop diversification were documented as strategies in adapting climate risk. On the other hand, the perceptions and knowledge of the stakeholders on climate change were measured through a pre-test and a post-test questionnaire method.

Since the focus of the CRA is on corn, a total of 16 corn farmer respondents were evaluated. Five questions per component i.e. climate change, vulnerable areas and CRA practices, were administered to the respondents before the intervention and same set of questions were also administered after the intervention. Paired T-test was used to analyse change of the knowledge and awareness of the participants on the areas evaluated.

2.3.3 3. Climate-resilient agriculture (CRA)

CRA Practices for Corn

In documenting CRA practices, the study employed a series of selection criteria: identification of focus crop, pilot area, and two (2) locally existing CRA practices. With the assistance of the personnel from DA-RFO 10 and the local agriculture offices, the identified focus commodity was corn. Corn is one of the major commodities produced in the Northern Mindanao region. The selection of study area considered the following:

- suitability map for corn, i.e. area with high distribution or occurrence of corn
- responsiveness of the local government unit (LGU) and agriculture extension workers
- geographic accessibility;
- contact with local farmer organizations; and
- availability of secondary data.

The participatory mapping conducted on August 2016 among agriculture extension and record officers of the Municipal/City and Provincial Agriculture offices generated map on the distribution of corn farms in the province. On the other hand, the Malaybalay City Corn Growers' Association was instrumental in the identification of specific pilot barangay. A subsequent Focus Group Discussion (FGD) with local corn producers provided the venue for listing various CRA practices in the area. FGD drew out farming practices for corn production. Participants shared and selected biodynamic and corn-banana crop diversification as CRA practices for corn. They also identified the farmers who are adopting the selected CRA practices.

Figure 9. Presentation of the AMIA 2 project during the assembly meeting of Malaybalay City Corn Growers Association on September 29, 2016

Figure 10. FGD among corn growers in San Jose, Malaybalay City on October 2016

Respondents of the CRA component of this study were the corn growers in Brgy. San Jose, Malaybalay City. Primary data were gathered from the selected corn farmers through Key Informant Interviews (KII) and from the extension workers of the Malaybalay City Agriculture Office through expert consultation. The study utilized pre-structured interview questionnaires, which contained questions on socio-demographic data as well as the production and marketing activities. Additional questions on perceived costs and benefits were included for those informants adopting the identified CRA practices. Supplemental secondary data were derived from literature review, statistical trends and reports.

Primary data collection ran from October 2016 to May 2017. Purposive sampling technique, with collaborative consultation of local agriculture extension worker, determines the 12 key informants. These informants represent three groups of farmers, with four farmers in each group, to represent the three selected corn farming practices – conventional; corn-banana crop diversification and biodynamic. The former serves as counterfactual or baseline scenario in the cost-benefit analysis (CBA). In other words, the analysis compares the costs incurred and benefits gained by farmers "with" the CRA practice (corn-banana crop diversification and biodynamic) and farmers "without" the practice (conventional). The "with-without" analysis minimizes error in recalling the production information by farmers especially that keeping farm records is not a common activity for them. This is in contrast to the "before-after" method that asks the same farmer-respondent of his/her farming activities before and after adoption of the technology, in this case, the CRA practice. By using the "with-without" analysis, the present study assumes both groups of informants have the same socio-economic and agroecosystem background.

Figure 11. **Key informant interviews with farmers on CRA practices for corn production on October to November 2016**

Cost-Benefit Analysis

To test the financial feasibility of identified CRAs, collected data were subjected to the Cost-Benefit Analysis (CBA) tool prescribed by CIAT. CIAT provided both the online and offline Microsoft Excel version of the CBA tool. Access of the online version is at http://cbatool.ciat.cigar.org. Given this, the study limits the analysis of costs and benefits of identified CRAs to the parameters and calculations specified in the CBA tool.

In the context of the present study, CBA measures the incremental (additional) costs and benefits of adopting climate-resilient agriculture practices, including the externalities. Externalities, economic or environmental, are impacts of the CRA to third parties (European Commission, 2015). Either positive or negative, externalities are spill over of the practice to unintended audience and usually have no existing monetary value. Externalities of adopting the CRA practices such as improved soil fertility and reduced energy emission account as benefits to society. The present study uses secondary data from experimental researches that attempts to value ecosystem services. In addition, the CBA employed is both an ex-ante and ex-post analysis. Ex-post since the informants are already practicing the CRA and ex-ante since benefits from ecosystem services resulting from the practice may still be realized. Further, the adoption rates employed in the analysis is an estimated likelihood of adoption at the immediate community level. The likelihood of CRA adoption was derived from the acceptability rating of sampled local corn growers using a Dart Board evaluation tool supplemented with literature review.

In the CBA analysis, the cost of adopting the CRAs are categorized into installation costs, maintenance costs and operation costs. These costs are specifically associated with the introduction of the CRA in the farming system. The analysis focuses on an annual and per hectare production costs and benefits accrued from the adoption of CRA. Ng'ang'a et al. (2017) describes all costs incurred at the beginning of the adoption process as Installation Costs. This refers to the initial costs necessary to implement the CRA such as the purchase of planting materials, tools and farm equipment. Maintenance costs are periodic expenses incurred throughout the adoption of the CRA. For instance, manual weeding and composting are regular activities in organic farming. Operation costs, on the other hand, relates to farm outputs produced from the adoption of CRA. These are expenses incurred in performing activities connected to the output of the CRA including, but not limited to, harvesting.

Crucial terms in CBA are the Discount Rate, Net Present Value (NPV), and Internal Rate of Return (IRR). The cost of capital is the discount rate. This is the cost for borrowing money or the amount of interest due per period. The discount rate represents the percentage of risk investors are willing to accept for an investment. As Ng'ang'a et al. (2017) described, the main purpose of the discount rate in CBA is to account for the loss of economic efficiency due to risk. In this study, the discount rate equals to the existing interest rate in the area, a buffer from possibilities of failure in choosing to adopt the CRA.

Since the realization of benefits from present investment happens at a future time, there is a need to translate these benefits to its present value for comparison among CRAs. The present value is the expected present worth of an investment from a flow of income over time. In theory, the present value of money is always less than or equal to its future value due to the amount of interest. Consequently, the Net Present Value of an investment is the difference in the expected present value of cash inflows (incremental benefits) and present value of cash outflows (incremental costs) over a period. The present study compares the initial investment of farmers on the CRA with the calculated NPV. The higher the NPV, the more profitable is the CRA. Mathematically, computation of NPV follows the equation:

$$\mathrm{NPV}_j^{\mathrm{CRA-Conv.}} = \sum_{t=1}^{T} \frac{1}{(1+r)^t} \left[\sum_{j}^{j} \mathrm{P}_{jt} * \Delta \mathrm{Y}_{jt}^{\mathrm{CRA-Conv.}} - \sum_{j=1}^{j} * \Delta \mathrm{C}_{jt}^{\mathrm{CRA-Conv.}} \right]$$

Where $\mathbf{P_{jt}}$ represents the price of commodity "**j**" in time "**t**"; $\mathbf{\Delta Y}^{\mathbf{CRA\text{-}Conv}}$. is the annual change in yield with the CRA and the conventional system; $\mathbf{\Delta C}^{\mathbf{CRA\text{-}Conv}}$. represents the annual change in cost; **r** is the discount rate; and **T** represents the life cycle of the CRA or the financial period used in the analysis.

The Internal Rate of Return, on the other hand, expresses profit over time as a proportion of the initial investment. As an annual measurement, IRR is the discount rate that sets the NPV to zero, that is, the present value of all benefits equals the present value of all costs. In other words, the higher the IRR of the CRA, the more worthwhile is the investment since the proportion of expected profit from the initial investment is higher. Analysis of the IRR closely takes into account the NPV value together with the payback period. The latter refers to the number of years to recompense the initial investment.

The CBA result in the succeeding section held prices of inputs and farm outputs constant throughout the period of analysis. Prices used are in nominal values. A supporting sensitivity analysis, however, tests the effect of changes in yield and farm gate prices to NPV and IRR values. For the sensitivity analysis, the study employed the 10-year statistical trend in corn price and production in the province of Bukidnon (Philippine Statistics Authority, 2017). Data used include the average, minimum and maximum farm gate prices of corn and the average and minimum yield in kilogram per hectare (2006-2015). The maximum yield value was set above the reported yield of one informant, having a production value higher than the provincial data.

2.4. Results and Discussion

2.4.1. Climate Risk Vulnerability Assessment (CRVA)

2.4.1.1. Existing Occurrences of Crops

Figure 12 depicts the distribution of occurrence points of the five crops under study. Corn has the highest number of occurrence points as shown in Table 10 wherein majority are found in Valencia City. Valencia also had the highest number of occurrence points for rice and cacao. In contrast, Malaybalay City tops in the coffee and tomato occurrences.

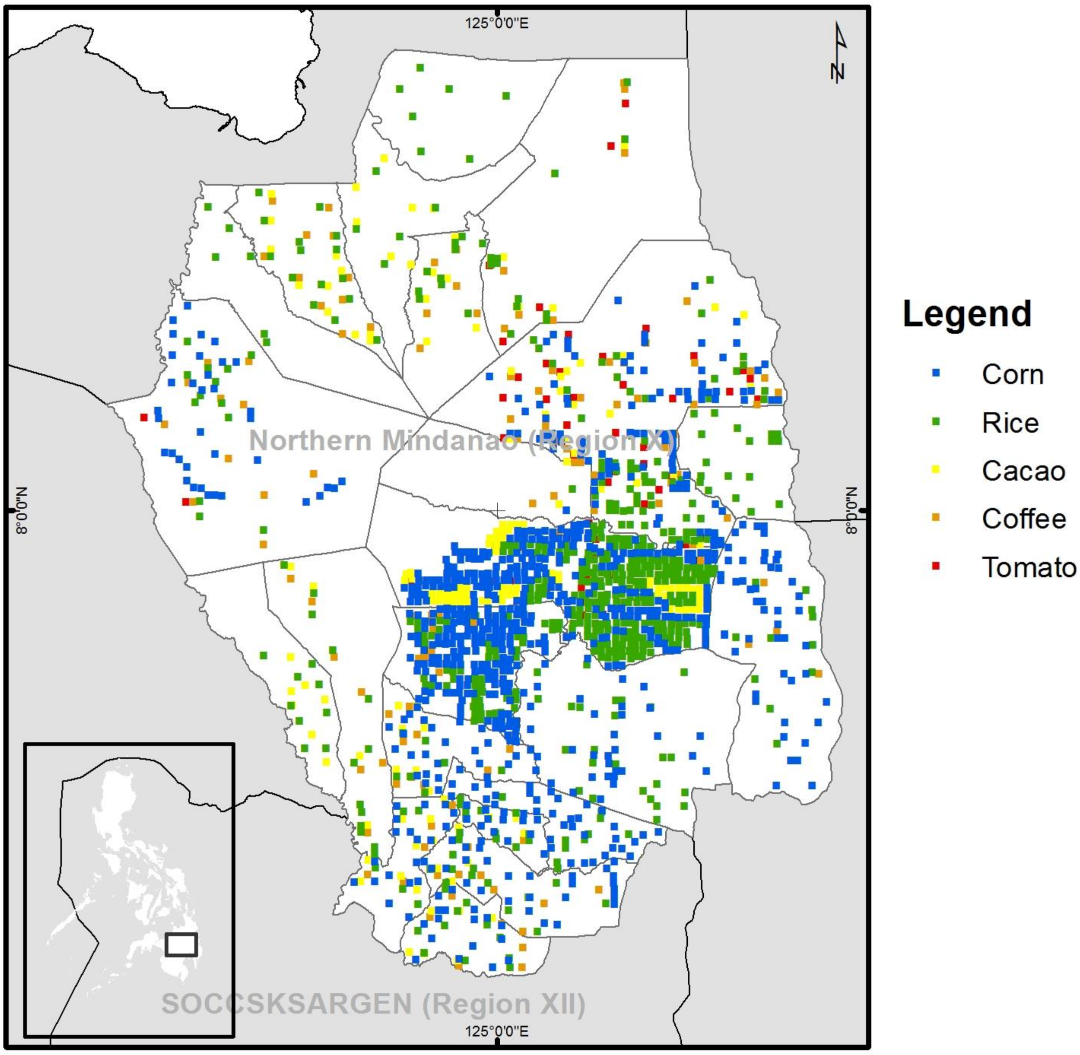


Figure 12. Map of the occurrence points of the five crops

The generation of occurrence points relied mainly on the knowledge of local experts during the participatory mapping. As part of digitization, the team ran some validation tests to filter the data. Originally, there were about 900 occurrences for corn that were later trimmed to its current number. This proved the significance of the validation procedure. The distribution of occurrence points per municipality/city is shown in Table 10.

Table 10. Number of species occurrence points per municipality/city

Location	Corn	Rice	Cacao	Coffee	Tomato
Baungon	0	6	0	0	0
Cabanglasan	0	18	0	0	0
Damulog	17	12	7	6	0
Dangcagan	14	11	3	1	0
Don Carlos	27	18	7	9	0
Impasug-ong	0	12	4	7	5
Kadingilan	19	5	9	5	0
Kalilangan	0	9	7	0	0
Kibawe	28	13	3	8	0
Kitaotao	36	10	0	0	0
Lantapan	1	1	1	2	0
Libona	0	15	11	11	0
Malaybalay city	100	67	21	34*	30*
Malitbog	0	7	0	0	0
Manolo Fortich	0	5	7	0	0
Maramag	160	57	0	21	0
Pangantucan	0	13	4	7	0
Quezon	33	25	0	0	0
San Fernando	49	11	0	4	0
Sumilao	0	10	6	6	0
Talakag	36	13	0	11	2
Valencia	228*	227*	62*	7	21
Total	748	555	152	139	58

Note: * means highest occurrence value per crop/ municipality

2.4.1.2. Crop Suitability

The mean test AUCs for the five crops is shown in Table 11. The values are all greater than random (0.5) which implies that the resulting suitability models gained an acceptable accuracy. An AUC value of 0.50 and below indicates the model does not perform better than random whereas a value of 1.0 indicates perfect discrimination (Khanum et al. 2013).

Table 11. Mean test AUC of the crops

Crop	Mean test AUC	Standard deviation
Corn	0.772	0.008
Rice	0.767	0.015
Cacao	0.748	0.017
Coffee	0.694	0.034
Tomato	0.801	0.044

The bioclimatic variables that contributed best to the model differ across the five crops. As depicted in Table 12, the variables with the greatest percent contribution were:

- Bio2 - Mean Diurnal Range (Mean of monthly (max temp – min temp): 30.3% for corn
- Bio9 - Mean Temperature of Driest Quarter: 22% for rice
- Bio7- Temperature Annual Range (BIO5-BIO6): 30.2% for cacao
- Bio7: 38.4% for coffee
- Bio4 - Temperature Seasonality (standard deviation *100): 35% for tomato

These values are means over 10 replicate runs.

Table 12.

Variable	Percent Contribution				
	Corn	**Rice**	**Cacao**	**Coffee**	**Tomato**
Bio1	1.1	3.2	0.1	1.3	0.3
Bio2	30.3*	0.7	1.6	0.9	0.3
Bio3	0.5	0.4	0.7	0.6	0.6
Bio4	0.7	5.4	1.3	16.3	35*
Bio5	9.1	9.6	0.7	1.1	0
Bio6	0.3	1.1	0.2	1.3	0
Bio7	1.4	1.5	30.2*	38.4*	0.9
Bio8	1.3	10	1.8	1.9	0.1
Bio9	3	22*	7.6	2.6	1.7
Bio10	1.2	0.5	1.3	0.6	0
Bio11	0.6	1.8	0.3	0.1	0
Bio12	8.9	7.7	7.7	6.1	6.6
Bio13	1.7	9.4	7.7	1	7.9
Bio14	0.1	0.8	8.1	1.4	0.4
Bio15	5.5	2.2	12.5	11.5	2.6
Bio16	5	7.5	1.7	3.9	13.7
Bio17	0.8	2.2	2.5	2	0.7
Bio18	23.7	7	5.1	3.5	3.5
Bio19	4.8	7.2	8.9	4.9	25.6

Note: * means the value of the variable with highest mean percent contribution to the Maxent model

Percent contributions are a result of Jackknife test, which rely mainly on how the occurrence points relate to the spatial pattern of bioclimatic variables. Since this study made use of all bioclimatic variables without prior testing the multicolinearity, caution is required in the interpretation of percent contribution.

As modelled, there is a gain in suitable areas for corn, rice, cacao and tomato but decrease for coffee Previously unsuitable areas that are located at higher elevations are predicted to change because of shifts in temperature and precipitation levels.

Climate suitability of corn is high in the 2050 projection. Corn is an upland crop that is predicted to benefit from increasing temperature that could potentially turn cooler areas across the mountains into much warmer areas. However, expansion of corn plantations is not encouraged in the mountains, as it would involve conversion of available forests and grassland ecosystems into agricultural use, which could have impact to soil and water.

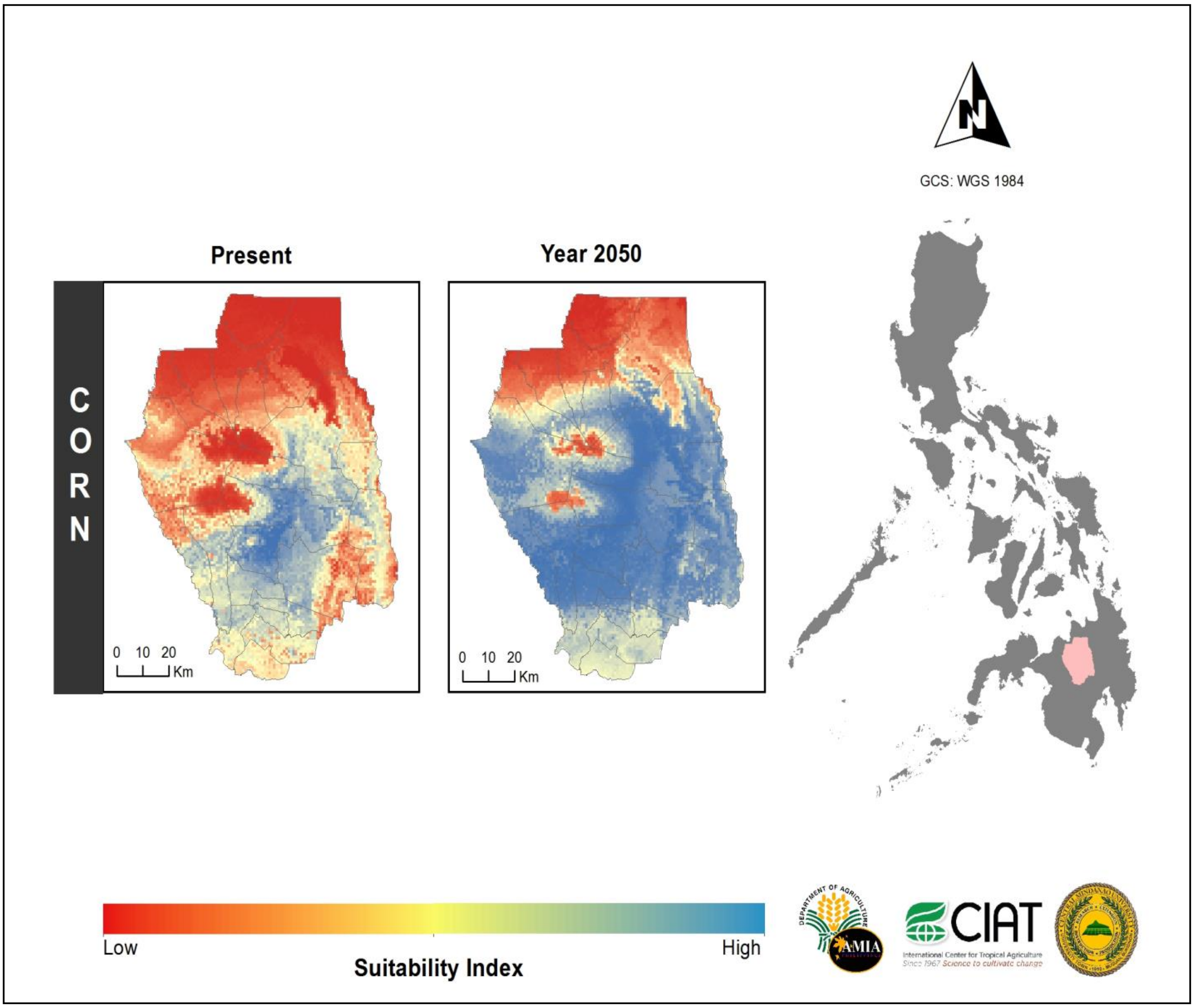


Figure 13. Baseline and projected climate suitability of corn in Bukidnon

Meanwhile, even though rice gained more suitable areas as shown in Figure 14, recommendations for expansion of rice farms into the identified suitable areas should be subjected to further research. In the case of lowland rice, the main considerations are slope and available irrigation. These considerations must always be factored-in in decision making for rice farm expansion.

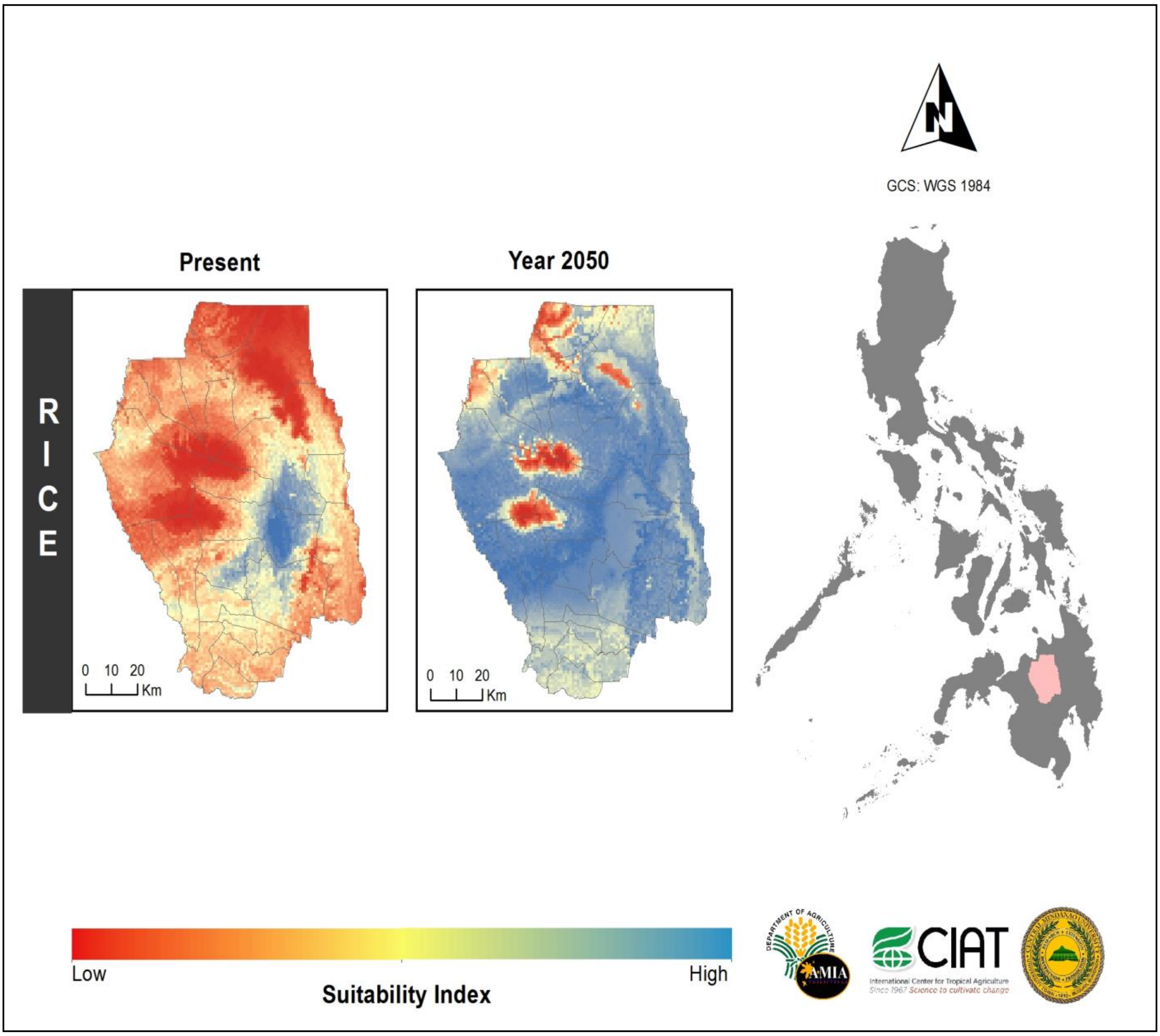


Figure 14. Baseline and projected climate suitability of rice in Bukidnon

There is also an increasing suitability in the case of cacao as shown in Figure 15. This crop is one of the commodities that are promoted by the Department of Agriculture as well as some government agencies such as LGUs and DENR for NGP. The crop is ideal for climate change adaptation and mitigation since it is a perennial crop that could potentially sequester large amounts of carbon.

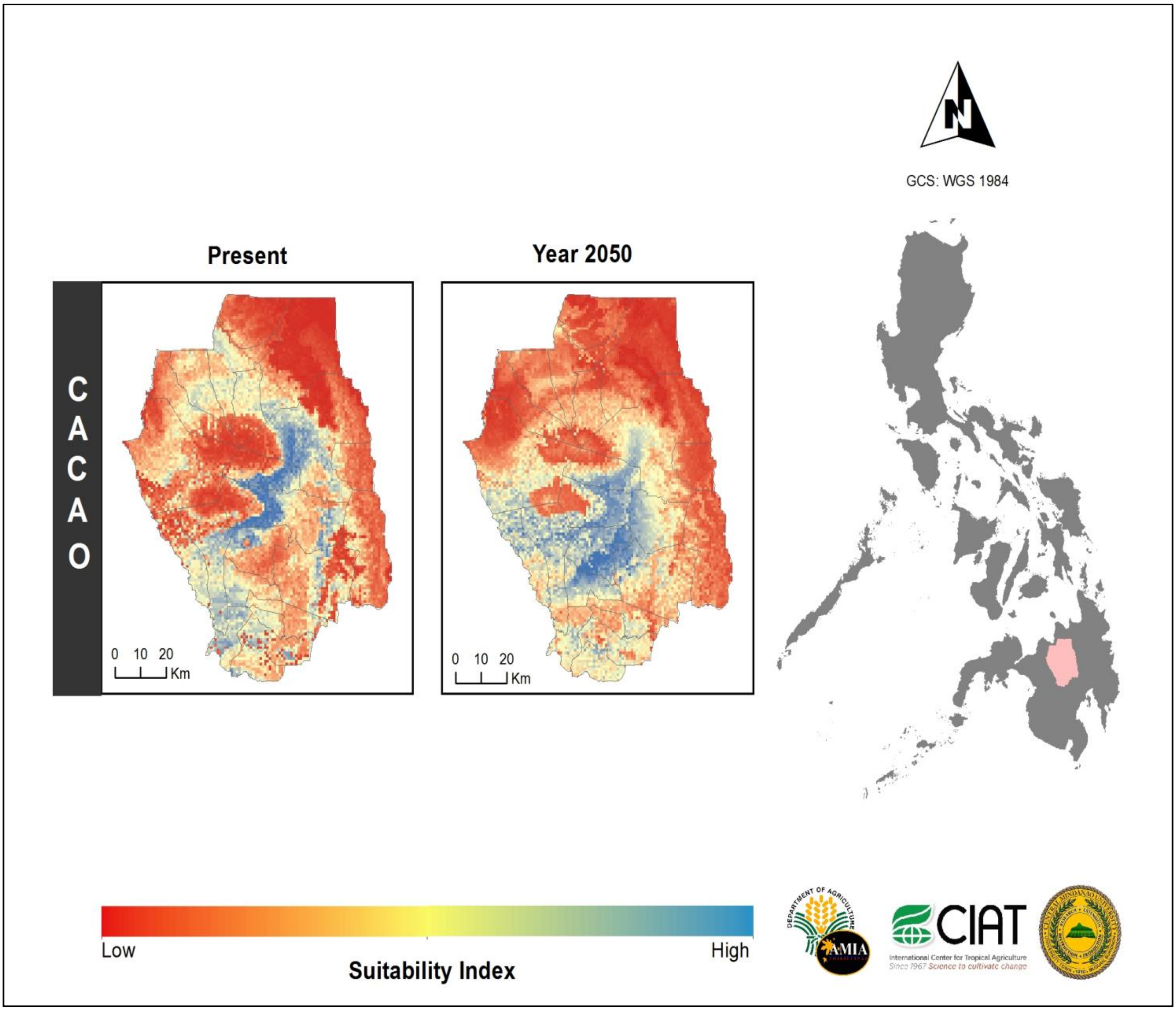


Figure15. Baseline and projected climate suitability of cacao in Bukidnon

For tomato, the projected suitable areas would increase and are concentrated along the Eastern, Central and Southern part of Bukidnon province (see Figure 16). Tomato is known to thrive in areas with cool climate but intolerant to extremely cool weather. Mountainous regions along the eastern part are modelled to get warmer in the future, hence, becoming suitable for vegetables such as tomato.

A different result has been observed for coffee since its climatic suitability is projected to decrease as shown in Figure 17. Model outputs have shown that coffee would likely be impacted negatively by climate change. This is an alarming finding since many areas in the province have coffee plantations, which are apparently thriving at present. In fact, coffee is one of the high value crops in the province cultivated for commercial purposes.

It should be emphasized that the suitability being referred to is measured using climatic parameters only. The model did not factor-in other parameters such as soil, aspect, and slope, which are deemed essential for plant growth and survival at the local scale. Therefore, it is recommended that the term climatic suitability be adapted when referring to the suitability information generated from this project.

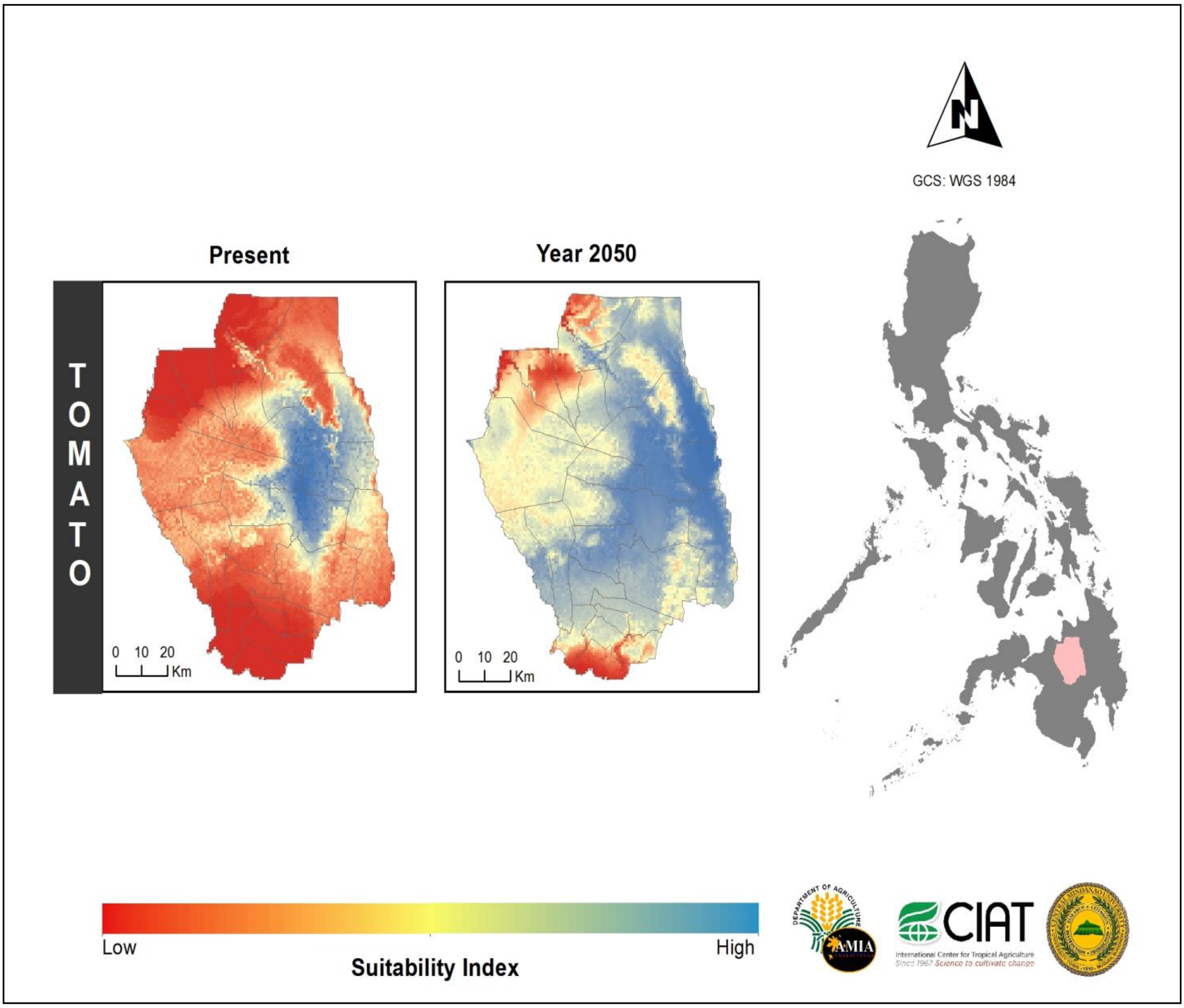


Figure 16. Baseline and projected climate suitability of tomato in Bukidnon

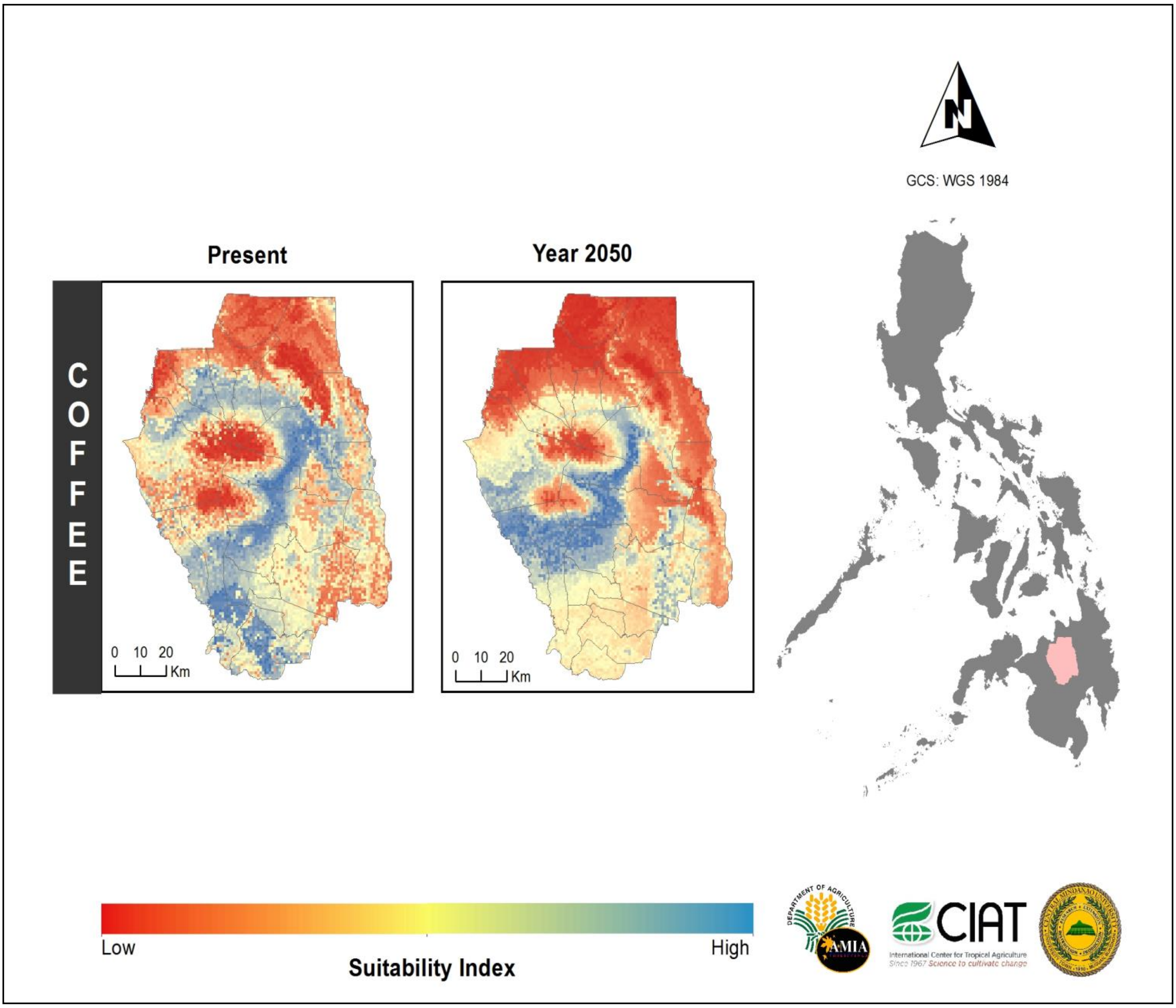


Figure 17. Baseline and projected climate suitability of coffee in Bukidnon

2.4.1.3. Sensitivity

Thorough analysis of the results, however, revealed that all crops considered in the study are sensitive to climate change, either positively or negatively sensitive. Corn, rice, cacao and tomato are found to be negatively sensitive to climate change. The negative indices of the four mentioned crops means that they have gained more suitable areas as already shown in the maps of climate suitability of crops. However, with a projected decrease in suitability, coffee has a positive sensitivity, i.e. loss of suitable areas in the future climate scenario. Sensitivity maps of individual crops across municipalities are shown in Figures 18, 19, 20, 21 & 22.

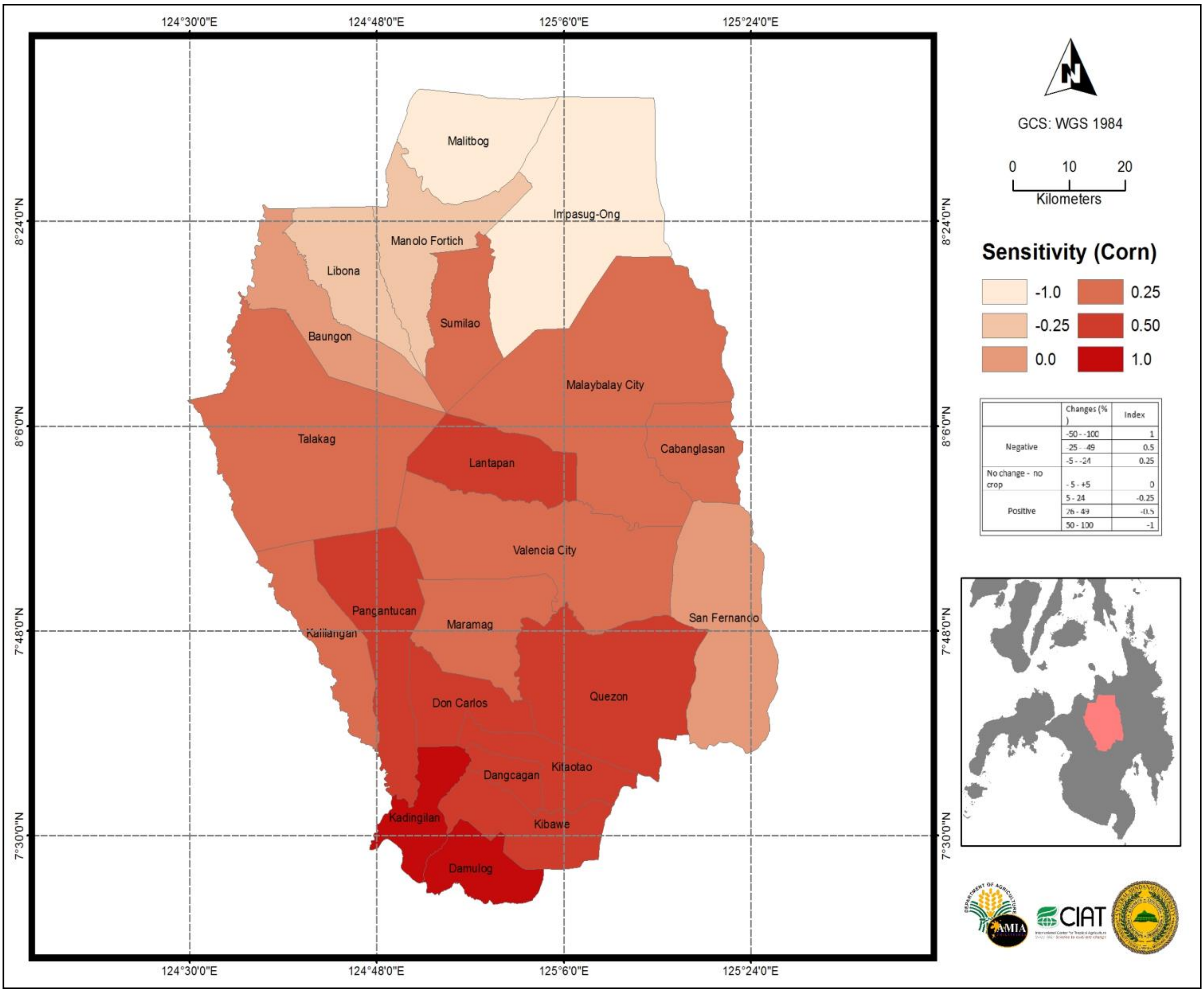


Figure 18. Climate sensitivity of corn in Bukidnon

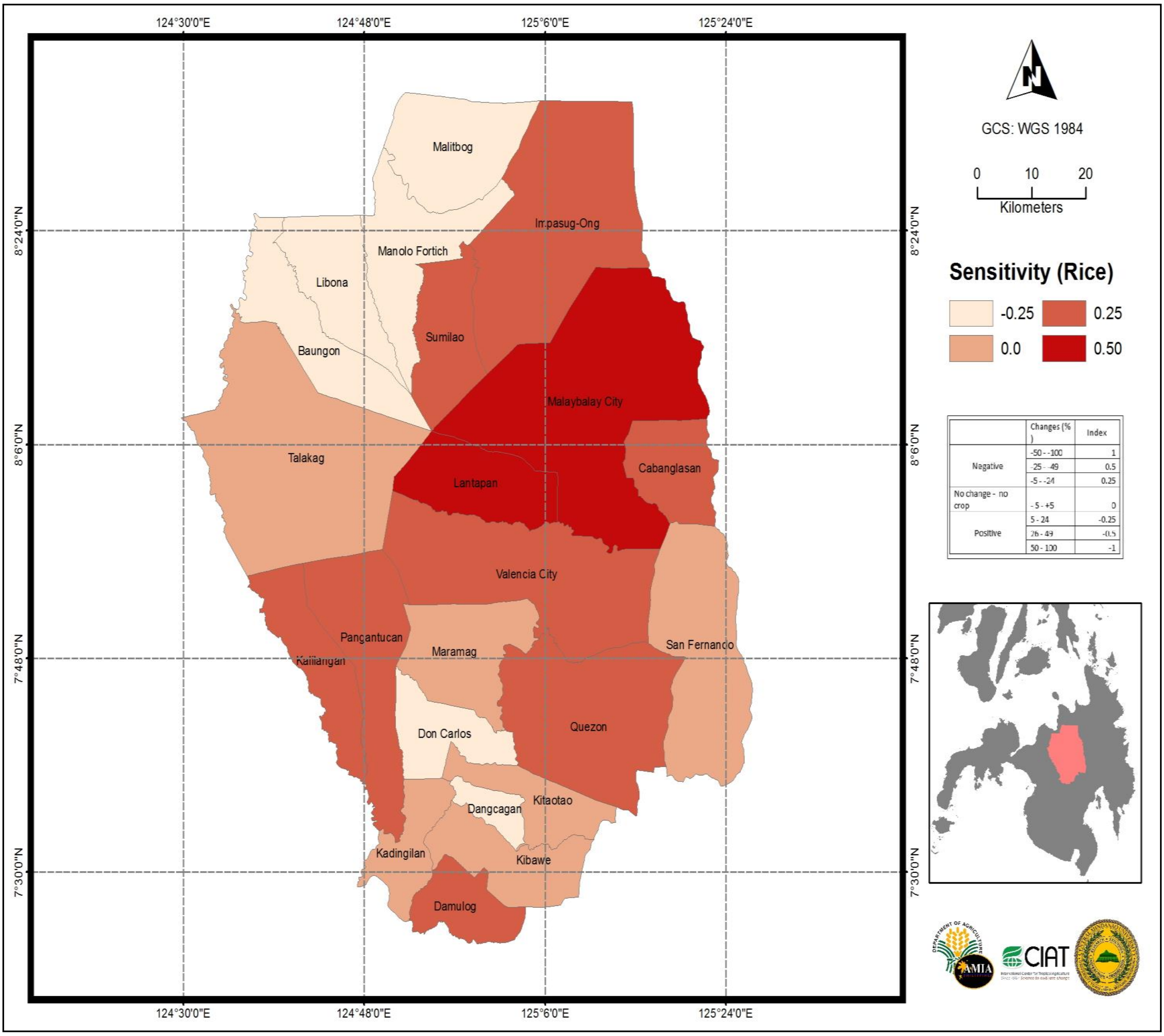


Figure 19. Climate sensitivity of rice in Bukidnon

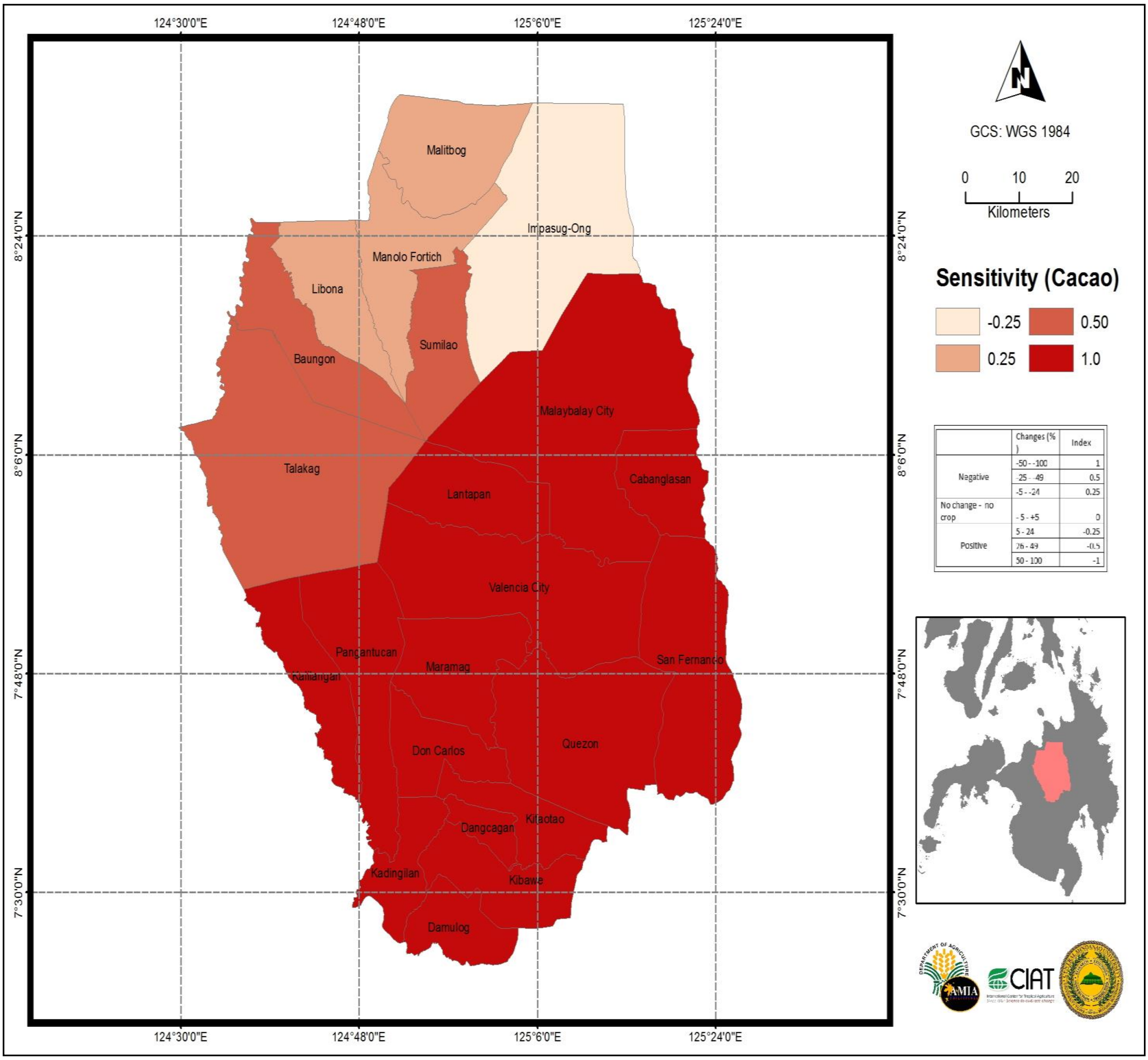


Figure 20. Climate sensitivity of cacao in Bukidnon

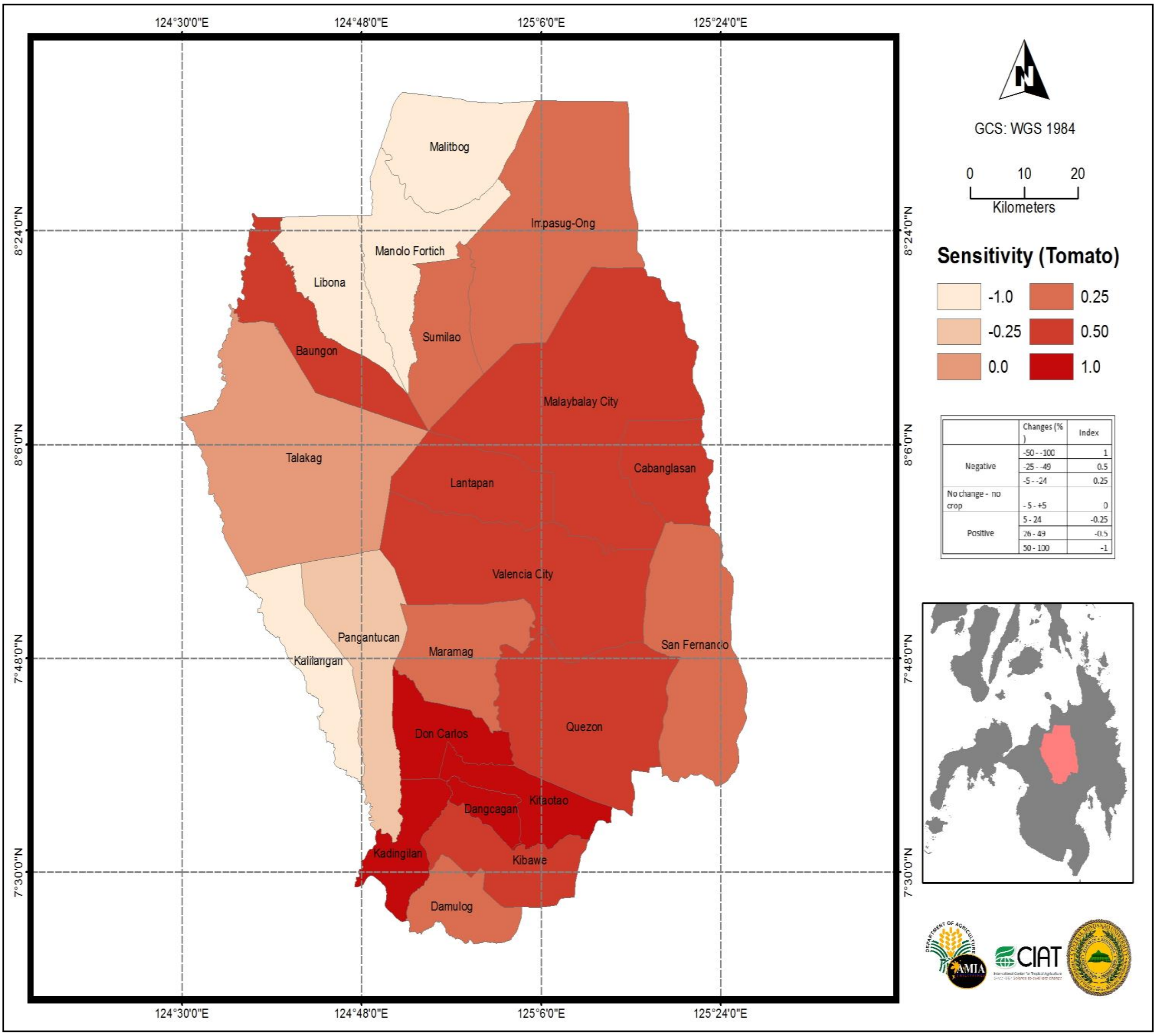


Figure 21. Climate sensitivity of tomato in Bukidnon

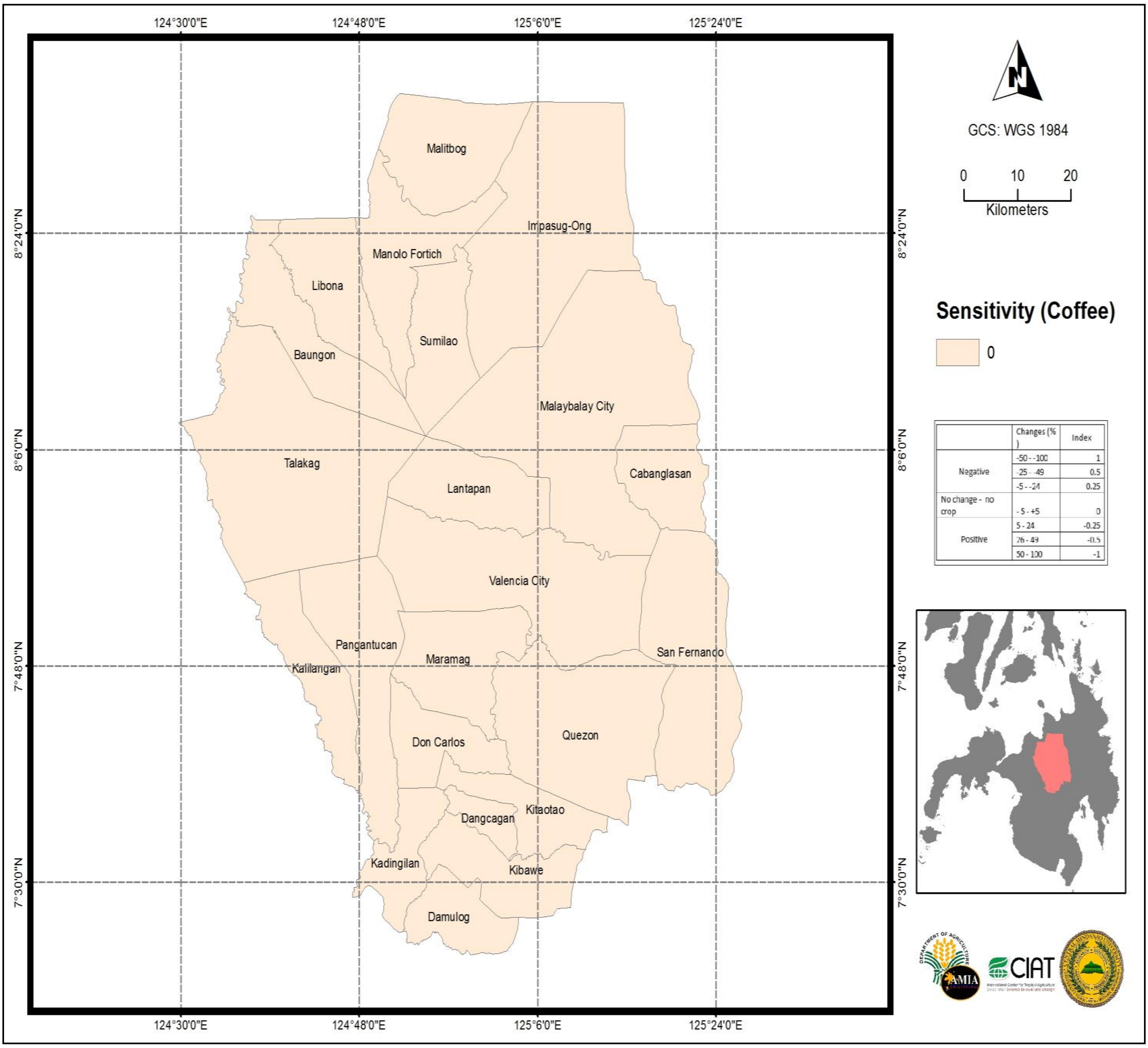


Figure 22. Climate sensitivity of coffee in Bukidnon

Results on the sensitivity of all crops at the municipal/city level shown in Figure 23 revealed that five municipalities are highly sensitive, i.e. with diminishing climate suitability for crops. These are, Kitaotao and Damulog in the south, Kalilangan in the west, and Baungon and Malitbog in the North. In contrast, the neighboring cities of Valencia and Malaybalay as well as the municipalities of Sumilao and Manolo Fortich are the least sensitive among the 22 areas.

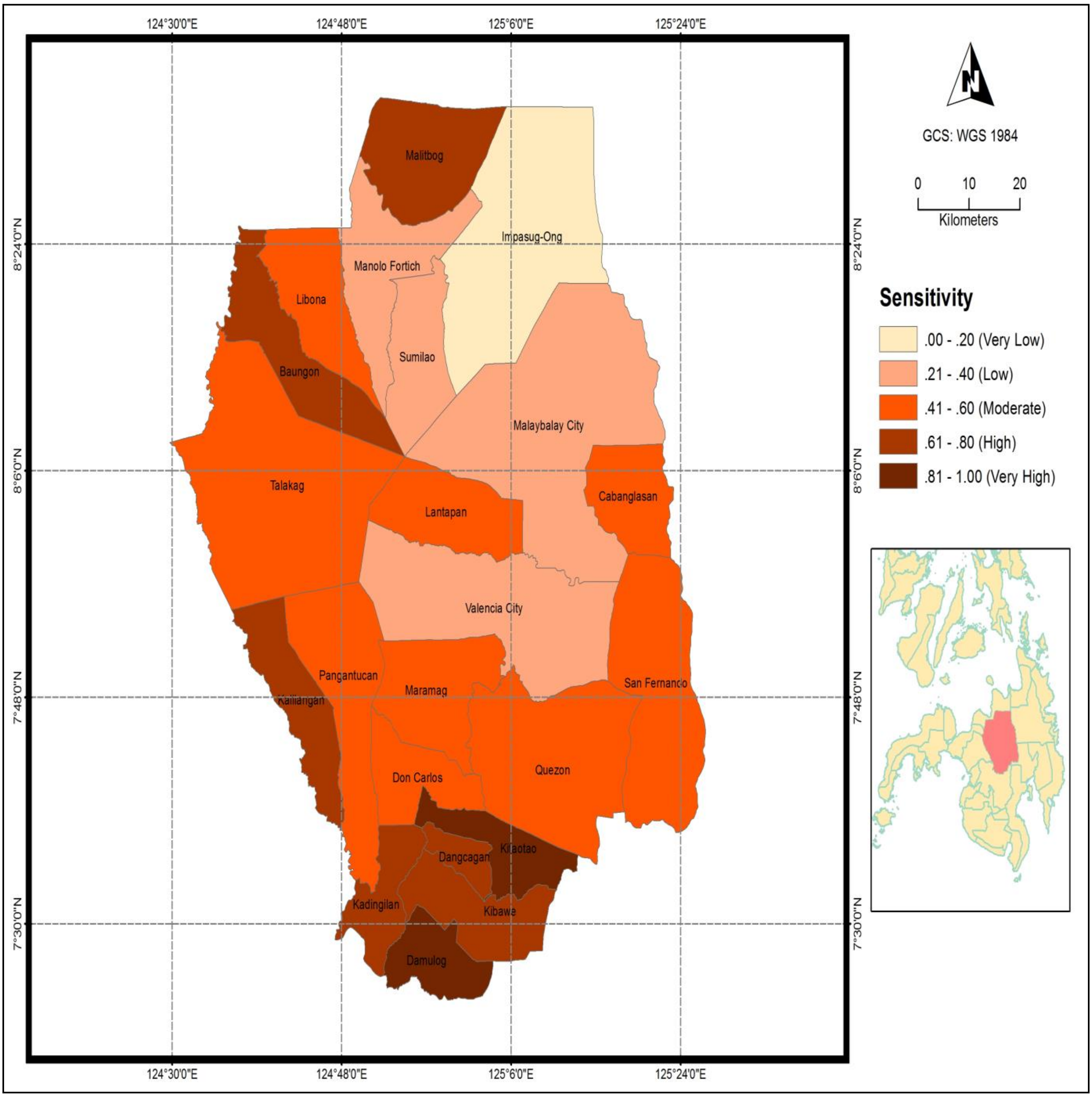


Figure 23. Level of sensitivity of municipalities/cities in Bukidnon

2.4.1.4. Exposure to Hazards

Hazards such as typhoon, flood, drought, erosion and landslide put higher pressure to the agricultural sector as these results to damaging consequences. In general, typhoons can be very destructive to agricultural crops. When it comes to typhoon, the Philippines ranks second to China as the most exposed country in the world (NOAA, 2010). However, the frequency of typhoons in the island of Mindanao is lesser compared to that of Visayas and Luzon. Meanwhile, in the context of agriculture, flooding caused by overflowing of rivers and irrigation canals is commonly reported in the province. This problem is a close consequence of the degrading health of the watersheds in the province. The sloping topography and poor vegetation cover of the mountains in Bukidnon also cause varying levels of erosion thereby affecting soil fertility. Landslides are also reported especially in areas near Kitaotao. Map in Figure 24 revealed that the most exposed municipalities to climate change- induced hazards are Kitaotao, Damulog, Kibawe and Kadingilan.

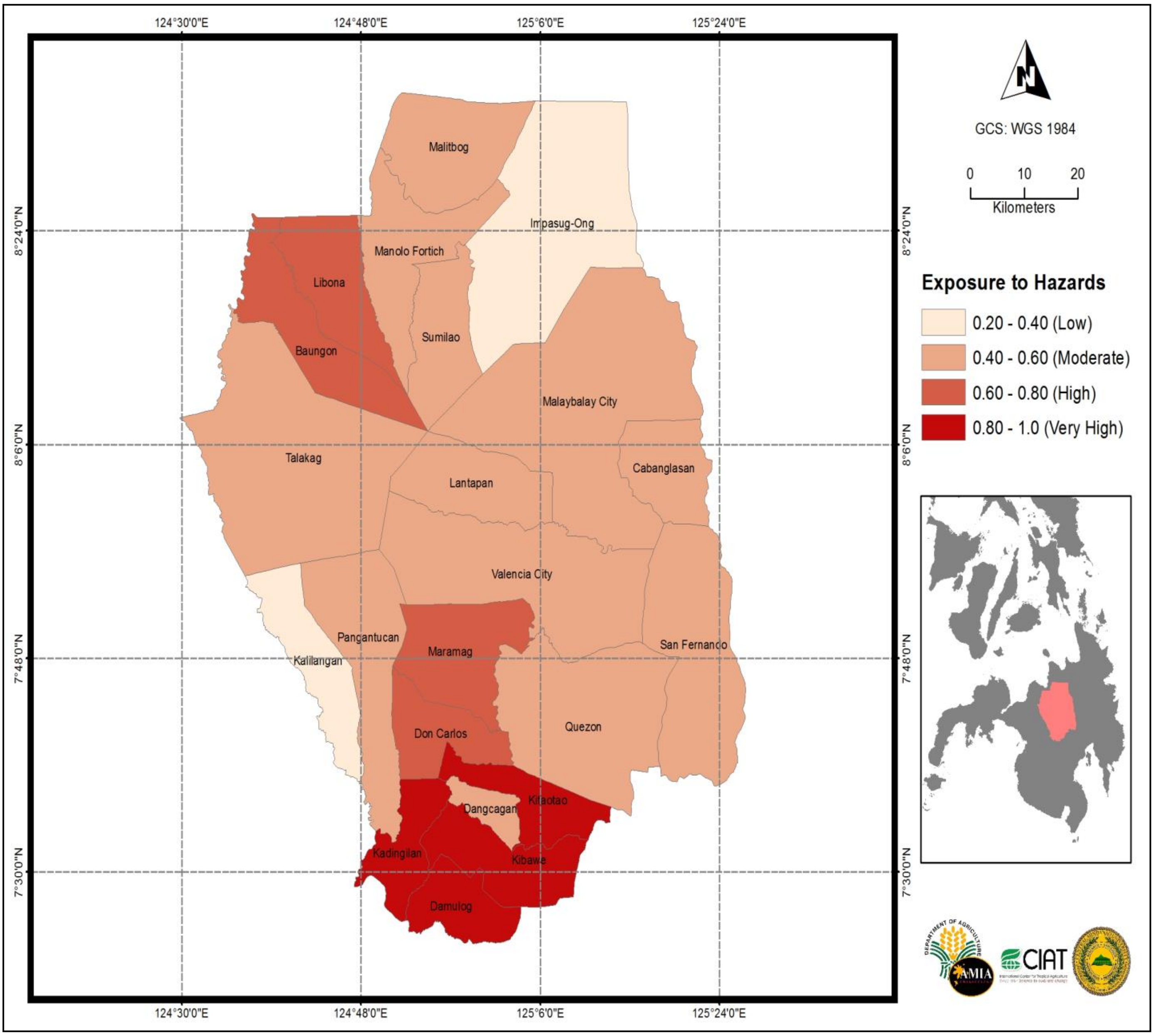


Figure 24. Level of exposure to hazards of municipalities/cities in Bukidnon

2.4.1.6. Adaptive Capacity

As depicted in Figure 25, the municipalities of Damulog and Kitaotao obtained very low adaptive capacity ratings. A close examination of the adaptive capacity parameters revealed that one of the prime reasons of the low adaptive capacity is income. As observed, Damulog and Kitaotao have lower income compared to other municipalities. These two municipalities are among those with the least number of banks and financial institutions that are crucial components of economic capital. In addition, these municipalities are among the lowest in terms of farmer membership to cooperatives, a critical parameter in the social capital. Although these two municipalities are almost consistently lower in all parameters, both obtained a higher rating for natural capital. In contrast, Valencia City, Malaybalay City and the municipality of Impasug-ong are rated very high in adaptive capacity. These areas are on top in terms of economic, human, social and institutional capital. This implies that they can better adapt to climate change pressures, particularly in the agricultural sector. Figure 25 presents the adaptive capacity of the municipalities/cities in Bukidnon.

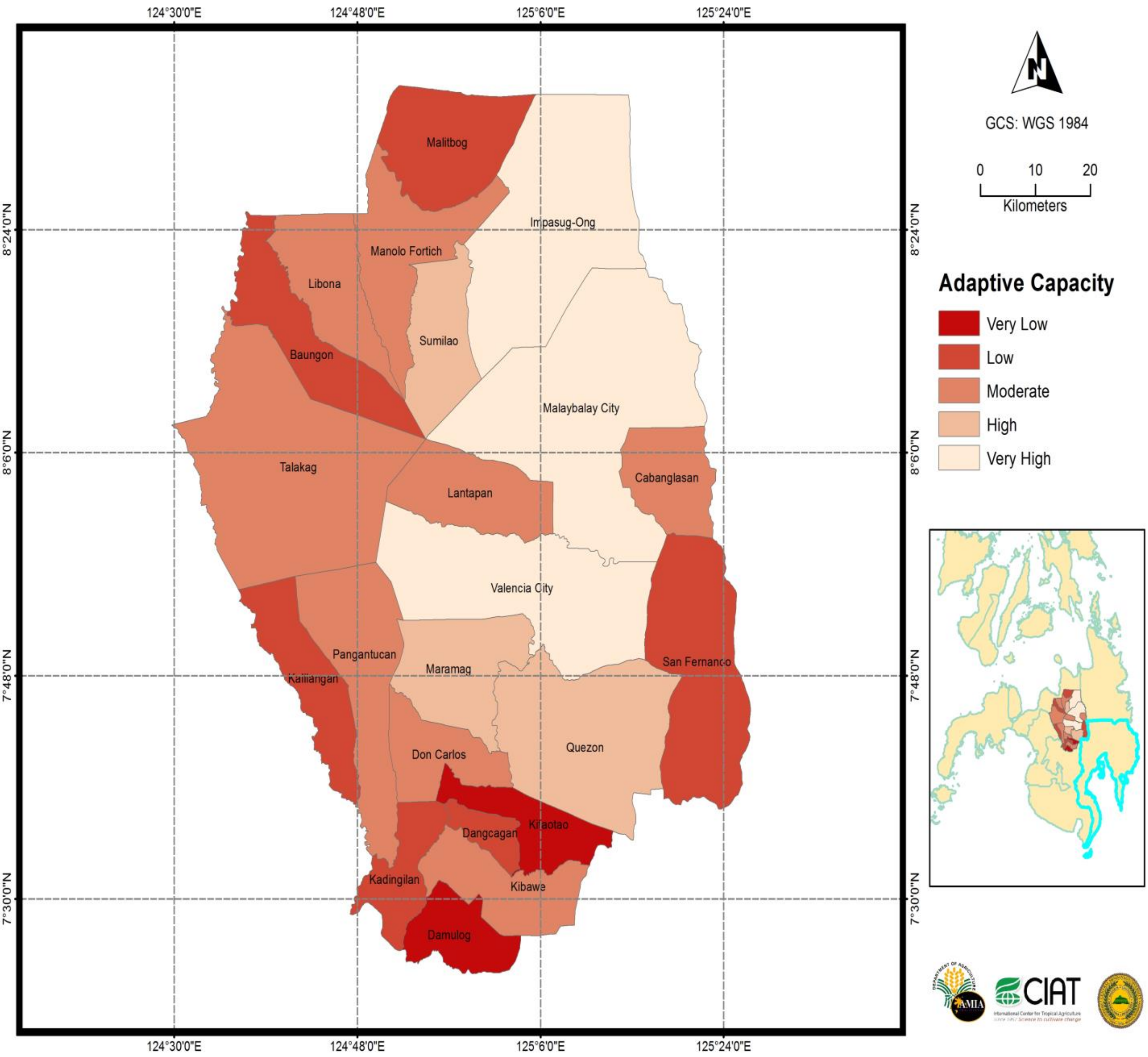


Figure 25. Levels of adaptive capacity of the municipalities/cities in Bukidnon

2.4.1.7. Climate Risk Vulnerability (CRV)

The final Climate Risk Vulnerability (CRV) map for 2050 is an integration of the exposure, sensitivity and adaptive capacity components. The weights used in coming up with the CRV map were 15% for Exposure, 15% for Sensitivity and 70% for Adaptive Capacity.

With 70% coming from adaptive capacity parameters, the final CRV map shown in Figure 26 is closely correlated with the levels of adaptive capacity of municipalities/cities. The current CRV map provides information on a municipal/city scale that is useful for provincial level planning and prioritization. As the results have indicated, the prioritization of Kitaotao and Damulog is imperative when it comes to climate change adaptation and mitigation initiatives and projects of the Department of Agriculture, LGUs and other national agencies and international organizations. Aside from being highly exposed to climate-related hazards, the adaptive capacities of these two municipalities are very low. As such, interventions should focus on improving or enhancing their adaptive capacity.

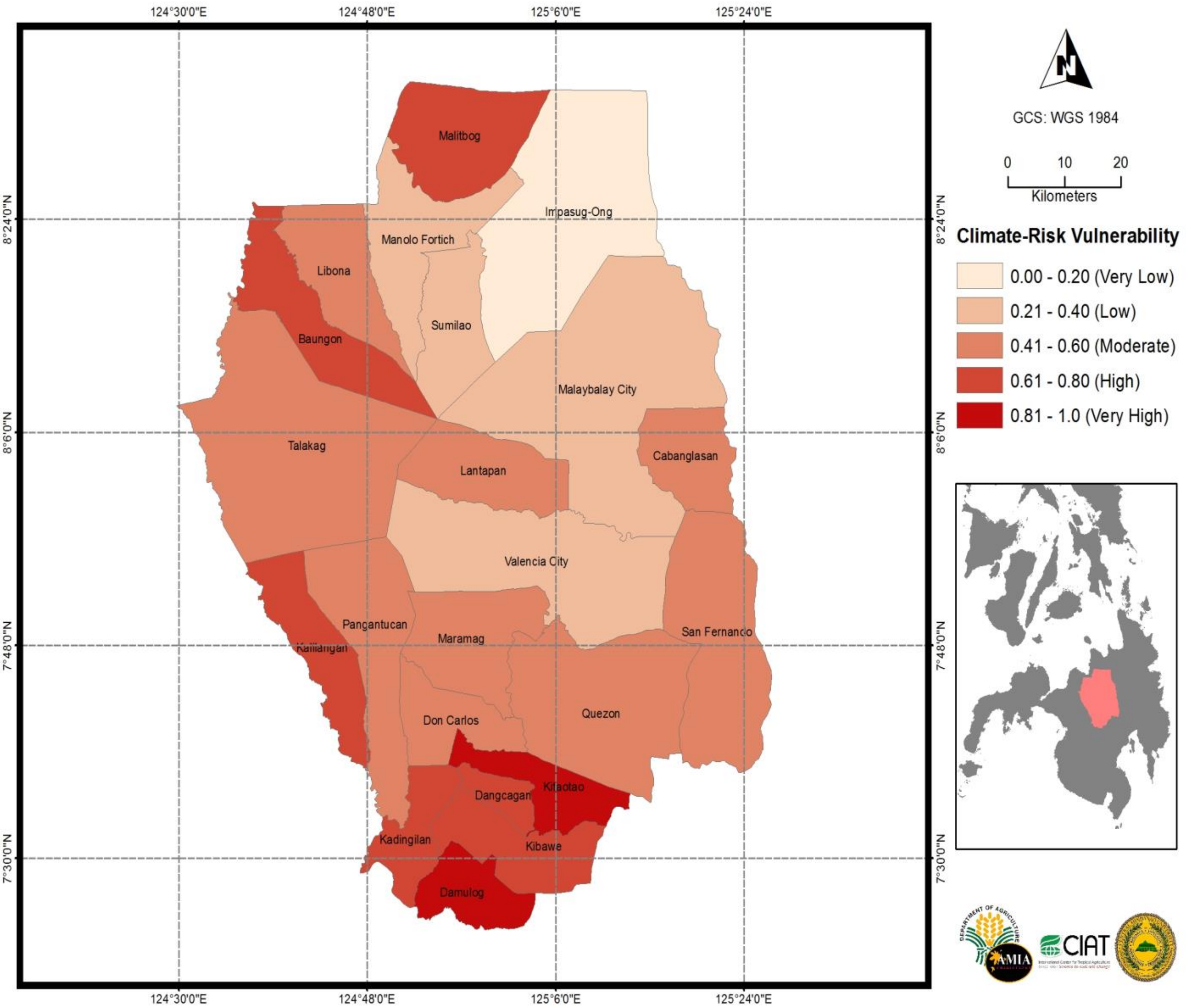


Figure 26. Climate risk vulnerability (CRV) map of Bukidnon

2.4.2. Local stakeholders' perceptions, knowledge and strategies for adapting to climate risks

Prior to the selection of CRAs, a focus group discussion (FGD) was conducted among 17 farmers of Barangay San Jose in Malaybalay City. This was the venue to inform the farmers about the project and discuss the concepts of climate change and vulnerability assessment. The team explained that the purpose of the FGD was to share experiences in corn farming considering climate change risks. Part of the discussion output was to draw out and identify climate-resilient agriculture practices, specifically for corn.

FGD participants ranges from 25 to 78 years old, 59% are male and 95% are married. Farmers revealed that changing climatic condition, drought (El Nino), flood and occasional landslide were the climate hazards they experienced. All these hazards cause significant yield reduction. Floods brought damage to farms and properties including death of farm animals and lodging of crops. In contrast, farmers also experience long dry spell, particularly in the recent El Niño. In response, farmers shifted their cropping calendar. Currently they can no longer plant on April and October due to unavailability of rain, which is the major source of water. One farmer attested that the start of cropping season is no longer predictable since the onset of rain is also unpredictable. Some farmers opt to plant for only one cropping season since there is no assurance of a better or higher yield in the second cropping. This farmer hoped for a climate suitable corn seed variety.

Although farmers are using the conventional methods, few of the corn farmers have adopted other technologies. Farmers try intercropping corn with banana or peanut. Some have diversified their farms by planting cassava, sweet potato and vegetables. Soil fertility is enhanced by applying manure, vermicast or the common commercial fertilizers. However, some have also adopted other practices such as the use of Bio-N, goat urine and fermented plant juice. Still others adopt a combination of conventional and organic agriculture practices.

Majority of the corn farmers use conventional methods. Common production concerns raised were:

- High prices of farm inputs
- Lack of financing
- Unstable price of the produce
- Low price of produce during harvest season
- Lack of transportation in remote farm areas

Farm inputs are necessary due to weeds and pest infestation. Herbicides are used in steep and rolling farms since plowing can result to erosion. One farmer shared that few of the corn farmers are practicing the bio-dynamics that advocates specific planting schedule for specific crop to avoid pest and diseases. This is actually what they referred as the old, traditional farming system, which relies on the "forces of nature". Farmer Olivo attested using the biodynamic calendar to schedule planting which, accordingly, follows the lunar cycle.

During the local stakeholders' validation, the CMU team was able to discuss again the topics on climate change, climate risk vulnerability and cost benefit analysis of climate resilient agriculture practice. The generated information and outputs were shared for validation and the opportunity to learn from the project results. Part of the activity was also to measure the level of awareness of the farmers with regards to the outputs and learnings of the project through the use of pre-test and post-test questionnaire in the vernacular. Figure 27 presents the results.

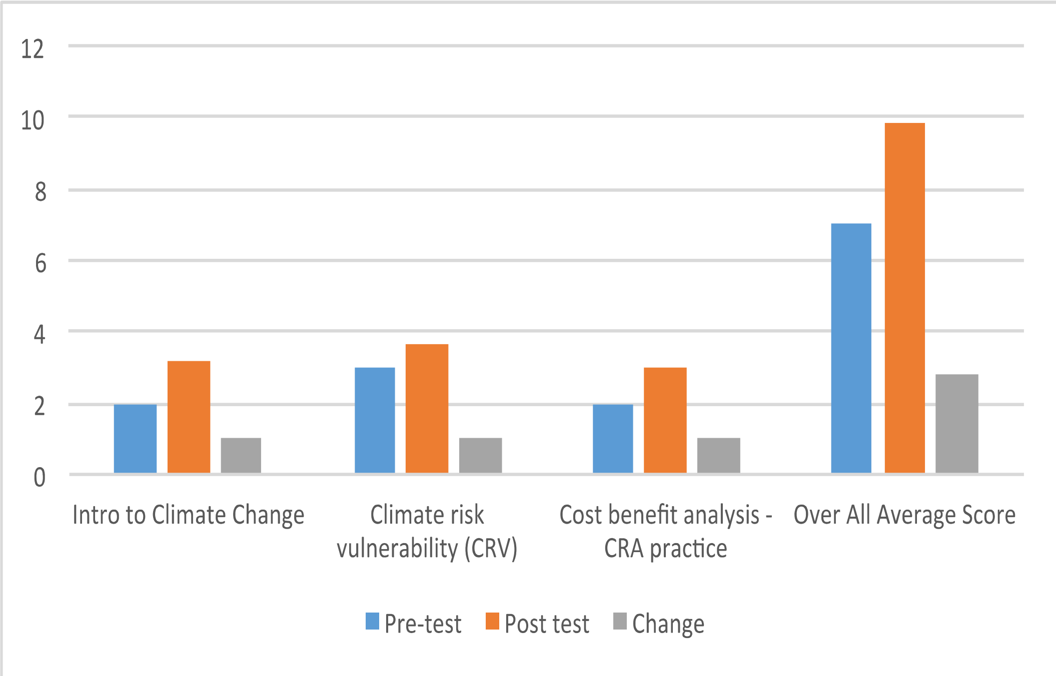


Figure 27. Level of awareness of farmer respondents

Table 13 shows that the result of the post-test on the causes and effects of climate change is significantly higher (P>0.01) compared to the pre-test. This implied that the farmers gained more knowledge and the level of their awareness increased after the discussion and sharing of the outputs of the project.

Table 13. Comparison of the evaluation results before and after the conduct the seminar

Variables	Mean scores	SD	t-value	df	Prob
Climate change		1.36015	-4.779	15	.000**
Pre test	1.7				
Post test	3.3				
Climate Change vulnerable areas		1.51520	-2.145	15	.049*
Pre test	2.9				
Post test	3.7				
Climate Resilient Agriculture practices		1.34164	-2.236	15	.041*
Pre test	2.5				
Post test	3.3				

Similarly, the result of the post-test on the knowledge of climate risk vulnerability and vulnerable areas is significantly higher (P> 0.05) than in pre-test. On the aspect of CRA practices, the knowledge level of the stakeholders significantly increased (P>0.05) as manifested by the result of their post-test. The results imply that FGD and validation activities can be venues of stakeholders to gain knowledge and awareness. Hopefully, these would be translated into actual practices to cope with the climate-related risks in farming.

2.4.3. Local CRA Practices

Key informants and participants of FGD provided information to characterize the conventional corn production practices in Brgy. San Jose. Mainly produced in two cropping per year, planting of corn starts in the months of May to June and harvested in August to September for the first cropping. The second cropping starts in October and ends in January to February the following year. Corn farms are rain fed and manually operated. Farmer-informants in the study have been into corn production for more than five years. Land cultivated is owned and is less than three hectares on the average. Other crops planted include root crops, vegetables, banana, rubber and falcata.

Typical corn production activities comprise land clearing, burning, herbicide spraying (except for those into pure biodynamic), furrowing, planting, fertilizer application, manual weeding, harvesting, shelling, and drying. Although involved in all of the farm activities, farmer-informants hire farm laborers during clearing, planting, harvesting and shelling. Payment for man-labor ranges from PhP150 to PhP200 per day. The latter excludes provision of snacks or meal, depending on the time of the day.

Figure 28. A typical corn farm in San Jose, Malaybalay City

In terms of direct inputs, "*sige-sige*" is a commonly utilized corn variety. This vernacular term is translated as "plant and plant" or plant "again and again" because farmers can continually set aside seed grains from the last harvest and use it in the next cropping. Hence, farmers rarely purchase the "sige-sige" seeds but exchange payment is valued at PhP25.00 per kilo. On the other hand, the informants were unable to provide a formal name of the variety since they just exchanged it with other corn farmers. A farmer-led network of people organization, *Magsasaka at Siyentipiko Para sa Pag-unlad ng Agrikultura* (MASIPAG), however, describes the *sige-sige* corn as a contaminated variety of genetically-modified (GM) corn seeds.

Utilization of synthetic fertilizer includes two to four bags of 14-14-14, 21-0-0, 46-0-0 and 16-20-0. Weed control through spraying takes place twice, at land preparation and a week after planting. Average yield per hectare among the informants is 2.1 metric ton with maximum and minimum yield at 2.8 and 1.3 metric tons, respectively. Majority of the produce are marketed with a fourth of the total harvest set aside for home consumption. Market outlet is the nearest barangay at Aglayan, Malaybalay City, located 7.6 kilometers along the national road. In-field transportation utilizes draft animals especially in the sloping areas.

Farmers have adopted alternative practices in corn production due to the various assistance and subsidy from the local government as well as the support of cooperative and active attendance to trainings. Trainings include, among others, crop diversification with vegetables, fruit and root crops. Knowledge of farmers on the focused CRA practices are offshoots of farmers' trainings conducted in the area.

Diversified farming system includes the planting or growing of different types of crops together with corn in the same parcel of land. During the FGD with corn farmers in Barangay San Jose, Malaybalay City, farmers are growing banana, coffee and vegetable with corn. Specific CRA practices in different corn production operations were identified as follows:

1. Varietal selection and planting
    a. Some farmers plant corn and other crops following the dates suggested by the biodynamic calendar, preferably three days before and after the new moon for fruiting crops like corn
    b. Seed treatment before planting using amount of salt and fertilizer
    c. Seeds treated with Bio-N (biofertilizer) before planting
2. Land preparation.
    a. Most farmers do not plow their land since farms are located in rolling and hilly terrains. This practice is perceived to prevent soil erosion.
3. Weed management
    a. Only brushing and mulching is done as weed control practice since most of the cultivated area is rolling to hilly. The weed biomass gathered after brushing are placed between furrows to prevent weed growth, conserve water and as source of organic fertilizers.
4. Soil fertility Management
    a. Farmers apply animal manure such as swine manure and chicken dung in their farms
    b. Farmes practice the utilization of composts from vermiculture
    c. Goat urine is applied as foliar fertilizer
    d. Fermented plant biomass like sunflower leaves and other natural/plant sources
5. Pest infestation and management practices
    a. Planting on the date prescribed by the biodynamic calendar to reduce pest infestation and disease infection

FGD with corn farmers drew out two local CRA practices, i.e. biodynamic and crop diversification, specifically corn-banana divesification. Biodynamic agriculture is a farming method that treats the farm as a living system. The farm and the farmer interact with the environment in building healthy soil and farm products (Proctor, 2007). This practice makes use of an annual biodynamic cropping calendar, which guides decision of farmers on crop selection and appropriate days of conducting farm activities (e.g. planting, farm visits and harvesting). Biodynamic farming system follows the principle of the harmony of the forces in nature such that there are specific dates and time suggested to plant a certain crop to increase yield and to avoid pest occurrence. More importantly, this is done to ensure availability of water and favourable environmental condition during the cropping cycle. The practice hopes to minimize pest occurrence by considering the life cycle of common crop pests in the planting schedule. Biodynamic agriculture also embraces the formulation of organic fertilizers and pesticides. It utilizes waste materials in the farm combined with available cheap ingredients. Recent study of Setboonsarng (2015) finds biodynamic practice to lessen cost of farm inputs. In addition, Maeder et al (2002) provided evidences of its positive effects to the environment.

Corn farmers in San Jose adopt biodynamic by primarily using the biodynamic-cropping calendar. The farmers learned of the calendar in 2015 during a Farmer Field School. An organic farming advocate who is also a member of an organization promoting organic products introduced the use and benefits of biodynamic farming. Farmers purchase the calendar annually at 50 pesos each. Others photocopy the material at a cheaper cost.

Farmers experienced better yield than before by following the biodynamic-cropping calendar. The observance of specific planting dates enables them to align their production with the rainy season and harvesting on the dry season. Farm yield is also higher with less occurrence of pests and plant diseases. Aside from using biodynamic-cropping calendar, some farmers adopted other components of the technology. This includes preparation and utilization of natural pesticide and fertilizers such as fermented plant juices, bio-pesticides, oriental herbal nutrients, chicken dung, vermicasts and farm composts instead of the synthetic counterparts. Further, weeding is manual without the use of herbicides.

Farmers practicing the organic farming component of biodynamic said they observed enhanced soil fertility and reduced soil acidity after two years of adoption. Moreover, their production cost is lower from eliminating the use of synthetic fertilizers and pesticides. Hence, they experienced higher farm profit.

Crop diversification, on the other hand, is a practice of planting two or more crops in the same land at the same time. The practice provides alternate on-farm income and maximizes use of resources. In this CRA, banana is planted together with corn at the peripheries, as hedge grow or contour crop in slight to moderately sloping areas. Corn is planted as the main crop for commercial and family consumption while banana augments farm income before harvest of corn or during low production season.

Figure 29. Farms practicing crop diversification using intercropping of corn and banana

As a secondary crop, less labor and material input is allocated for banana. Production inputs comprise few bags of fertilizers (depending on soil quality) and planting materials. These planting materials are available in neighboring farms or as subsidy from the Department of Agriculture. Crop maintenance such as under brushing (manual weeding) and sucker management are done every two months. Bunch management happens monthly or every other month. Harvesting is either once or twice per month.

Cardaba (or Cardava) is the common banana cultivar produced with corn. This cultivar is part of the diet of the local community prepared either as snack or as substitute to the staple corn and rice. Local demand utilization include processing Cardaba into chips and banana paste and sauce by medium-scale processors.

Outputs of the CRVA provide scientific and geospatial-based information on the suitability and sensitivity of crops to projected scenarios due to climate change. Hence, future investments in the agriculture sector should prioritize climate resilient agriculture (CRA) practices with its goals focused on mitigation, adaptation and productivity. The selection of CRAs takes into account criteria such as weather smartness, soil conservation, efficiency in energy and water utilization, and value chains in ranking CRAs for potential investments. Based from the FGD and expert consultations with local agriculture office personnel, existing local practices mentioned above were considered for prioritization and subject to profitability analysis.

2.4.4. Cost-Benefit Analysis of CRAs

Cost-benefit analysis in the study considered only farm activities of farmer-informants as affected by the adoption of CRA practices. Data in the "without" scenario comes from farmer-informants solely engaged in corn production. The "with CRA" scenario comprises corn production activities plus the CRA practice, that is, the use of biodynamic and crop diversification. This is to capture the change in costs and farm output due to CRA adoption. Costs for installation, maintenance and operations of the CRA are captured in a typical one-hectare land. Although the informants may engage in other on-farm enterprises in separate parcels of land or may have less than a hectare of land, the analysis limits on the CRA implementation and translates costs and production activities to a per hectare measure.

In the analysis, the discount rate is at 12% from the average annual interest charged by lenders in the area. The figure also falls in the acceptable discount rate for developing countries used by ADB (Asian Development Bank, 2013). Average exchange rate at the time of analysis is 48.73 pesos per US dollar (http://www.bsp.gov.ph/statistics/spei_ new/tab12_pus.htm). The analysis covers a span of ten (10) years corresponding to the estimated life cycle of the CRAs. Considering the average age of the informants, which is 50 years old, adoption of the CRAs will continue for the next 10 years. Given the labor intensiveness of biodynamic and other possible options of crops to cultivate with corn aside from banana, the period of analysis is a conservative assumption.

Cost-benefit analysis shows both CRAs having positive private NPV and with IRR values higher than the 12% discount rate shown in Table 14. Crop diversification, however, proves a promising investment than the use of biodynamic reflecting a much higher NPV. Despite this, there is a lag period of six (6) years before fully recovering the initial investment. The initial investment in the analysis refers to the additional costs incurred with the CRA practice. A longer payback period is observed in biodynamic. This means the incremental investment of PhP18,656 with the adoption of biodynamic in corn production will be fully repaid on the ninth year of operation.

Table 14. Private NPV and IRR of CRA practices, San Jose, Malaybalay City, October 2016 – May 2017.

Particulars	Corn Production with Biodynamic	Corn-Banana Diversification
Private Net Present Value (NPV)	PhP3,776	PhP 37,809
Private Internal Rate of Return (IRR)	17%	30%
Initial Investment	PhP18,656	PhP32,219
Payback Period	9 years	6 years

Further computation reveals expenditures on farm equipment, tools and draft animals comprising bulk of the installation cost for both of the CRAs (see Table _). Compared to conventional production, use of biodynamic requires additional tools on composting and preparation of organic inputs. In the same situation, crop diversification employ additional tools for banana cultivation especially with the purchase of draft animal.

Table15. Incremental adoption costs of CRA practices, San Jose, Malaybalay City, October 2016 – May 2017.

Costs	Corn Production with Biodynamic (PhP)	Corn-Banana Diversification (PhP)
Machinery/Equipment/ Tools	28,890	28,890
Material Inputs	(17,130)	1,300
Services	(400)	(600)
Labor	5,600	(300)
Transfer Cost (10%)	1,696	2,929
TOTAL ANNUAL ADOPTION COST	18,656	32,219

Note: Total annual adoption cost comprises installation costs of CRAs; Transfer cost of 10% is already determined in the CBA tool.

Observed incremental benefits in biodynamic include lesser costs in material inputs and farm services. This results from exclusion of synthetic fertilizers and consequent service cost in transporting it to the farm area. Labor cost, on the other hand, increases with the practice particularly in land preparation, manual weeding, and formulation of organic fertilizer and pesticides.

In crop diversification, cultivation in one hectare comprises both corn and banana. Increase in material inputs is due to additional cost in buying planting materials and fertilizers for banana. In contrast, the practice shows reduced costs in services and labor. The slight reduction in expense reflects the trade-off between decreased labor use in corn and minimal increment of labor management in banana as secondary crop. Though banana suckers are additional inputs, transport cost is minimal since farmers obtain the suckers from neighboring farms.

In terms of cost category, installation costs comprises more than half of the total costs in implementing the CRAs (see Table 16). Practice of biodynamic relatively incurs higher maintenance cost than crop diversification due to additional labor spent in composting and weeding. In contrast, operation cost in crop diversification exceeds that of biodynamic owing to labor utilized in harvesting banana per month. Operation costs also include expenses in transporting farm produce to market outlets. In the case of farmers in Brgy. San Jose, this implies significant cash expense given that the location of most farms are at a distance from road systems.

Table16. Estimated installation, maintenance, and operation costs of CRA practices, San Jose, Malaybalay City, October 2016 – May 2017

Costs	Corn Production with Biodynamic (PhP)	Corn-Banana Diversification (PhP)
Installation	48,380	61,870
Maintenance	14,530	10,470
Operation	14,900	24,620
TOTAL	77,810	96,960

At the point of view of society, the analysis incorporates benefits the society gains with the adoption of CRA practices. While the CRAs may contribute social externalities as increased labor employment and participation of women, the analysis only include environmental externalities, that is, improvement in ecosystem services. Limitations in the conduct of actual field experiments and household survey, however, are countered through the use secondary data from published scientific studies.

Reviewed literatures of experimental researches on organic agriculture, wherein practice of biodynamic is closely related, environmental gains include increased soil carbon stock (Gattinger, et al., 2012; Lal, 2014), increased top soil formation (Mader, et al., 2002; Sandhu, et al 2007), and reduced emission from fossil energy inputs (Mader, et al., 2002). Reganold (n.d.) conducted and reviewed various studies comparing biodynamic and conventional farms in terms of soil quality effects in New Zealand. There was a significant difference of topsoil depth between the two farms with biodynamic farming system having an average of 2.2 cm of deeper topsoil structure. Meta-anlaysis of datasets gathered from studies comparing organic and non-organic farming systems concluded better soil carbon stock in organic farms. Gattinger, et al. (2012) valued this increase around 3.50 ± 1.08 Mg C/ha (converted as 1,080 kg C/ha). Interestingly, the study of Mader, et al. (2002) observed lower crop yields in organic farming systems. Data used was from a 21-year study of agronomic and ecological performance of biodynamic, bioorganic, and conventional farming systems in Central Europe. However, decreased utilization of synthetic fertilizer and pesticides recorded a significant reduction in energy emission by 53 to 97%, respectively. Quantitative value of saved fossil energy was 0.25 mt/ha/yr.

Various studies, on the other hand, found crop diversification to increase rainfall infiltration (Rusinamhodzi, et al 2012; Sandhu, Wratten, Cullen, and Case, 2007) and decrease soil erosion (Kariaga, 2004; Sandhu, et al, 2007). In terms of reduced incidence of soil erosion, Kariaga (2004) calculated 12.6 tons ha/yr of soil retained due to intercropping maize with another crop like legume. Rainfall infiltration, attributed to number of planted crops with maize, increases by 16 mm/ha as calculated in the study of Rusinamhodzi, et al (2012). Also from existing literatures are the shadow prices attached to the quantitative benefits of environemntal services resulting from the CRAs. Studies of Lal (2014) and Sandhu, et al (2007) are sources of these prices (see Table 17).

Table 17. Value of externalities used in the Cost-Benefit Analysis

CRA	Externalities	Physical Value	Shadow Price	Source
Corn Production with Biodynamic	Increase in soil carbon stock	1,080 kgC/ha	0.133 USD per kilogram	Gattinger et al, 2012; Lal, 2014
	Increase in top soil formation	0.25 mt/ha/year	23.6 USD per ton	Mader et al. 2002; Sandhu et al. 2008
	Reduction in emission from fossil energy inputs	0.6 CO_2e/ ha/year	11 USD per ton	Mader et al 2002; unitjuggler.com 2017; earthontheedge.com 2017; USEPA 2017
Corn-Banana Crop Diversification	Increase rainfall infiltration	16 mm/ha	0.44 USD per mm/ha	Rusinamhodzi et al, 2012; Rusinamhodzi, 2015; Sandhu et al 2008
	Decrease soil erosion	12.6 ton/ha/year	23.6 USD per ton	Kariaga 2004; Sandhu et al 2008

Incorporating the above values in the CBA shows positive social NPV and IRR for both CRAs. Between the two, crop diversification reveals higher NPV and IRR. The NPV reflects the incremental present value of benefits per hectare that the society gains from implementing the CRA.

An important question to ask is how much would be the likely social NPV considering the adoption behavior of farmers to the identified CRAs? In attempting to answer this question and in the absence of an adoption study specific for the CRAs, the project conducted a validation workshop to participating farmers from various municipalities in the province. The workshop includes simplified presentation of the concept and effect of climate change, results of the climate-risk and vulnerability assessment of the region and the cost-benefit analysis of the identified CRAs. To gauge the likely adoption of the CRAs, a Dart Board technique measures the acceptance of participants for each of the CRAs. The percentage of participants indicating 80 to 100 percent acceptance rating are assumed as potential adoptors of the CRAs. The same percentage assumes the value of the estimated diffusion ceiling of adoption.

Proportion of adoption at the starting point for biodynamic comes from perceptions of key informants on percentage of current local adoptors of biodynamic in Barangay San Jose relative to total population of corn farmers. Similarly, reported adoption rate of organic agriculture in the Philippines for 2016 is at 0.9 percent (Willer and Lernoud, 2016). In crop diversification, starting point of adoption is the ratio of existing area cultivated with banana to that of total corn area in Barangay San Jose. Unit of analysis in the aggregation is the total area cultivated for corn in 2016 (855 ha). The assumption is that the existing corn production areas are potential location for CRA practices specific for corn. Given the likely value of adoption parameters, investing in biodynamic results to aggregate social NPV of 25 million pesos. Aggregate benefit for crop diversification is higher than biodynamic at 103 million pesos.

Table 18. Aggregate social NPV and IRR of CRA practices, San Jose, Malaybalay City, October 2016 – May 2017.

Particulars	Corn Production with Biodynamic	Corn-Banana Diversification
Social Net Present Value (NPV)	PhP37,524	PhP116,845
Social Internal Rate of Return (IRR)	48%	65%
Estimated diffusion ceiling (k)	28%	57%
Proportion of adoption at starting point	1%	7%
Proportion of adoption at mid-point	15%	25%
Number of unit in analysis	855 ha	855 ha
Aggregate Social NPV	PhP24,951,041	PhP103,174,716

The main purpose of the analysis is to prioritize investment options for the pilot area in terms of existing CRA practices. This is to guide policy makers on the worthiness of investing on the CRAs specifically looking at the value of benefits, private and social, arising from implementation. Alternatively, if whether the potential benefits outweighs the estimated costs.

The CRAs investigated in the study have potentials and drawbacks. Integrating biodynamic in corn production qualifies to the dimensions of a climate-resilient agriculture. With its similarity to organic farming system, the practice promotes soil and water conservation, reduces use of fossil energy and has potentials for value-adding benefits. Although the resulting NPV and IRR are comparatively lower than crop diversification, initial investment necessary to implement the practice is lower (PhP18,656). Organic farming related activities of biodynamic as composting and formulation of organic inputs are shared knowledge among local farmers. However, drawbacks come from additional labor requirement on the part of the farmer, which may discourage adoption. In addition, repayment of initial investment happens after nine (9) years. The longer payback period is a result of various factors as corn yield and output prices. For instance, a possible premium price for organically produced corn at 15 pesos per kilo moves the payback period to five years. A price sensitivity analysis shows farm gate price below 11 pesos per kilo, cet.par., turns NPV negative. Likewise, changes in yield, cet.par., below 5,600 kilograms per hectare results to negative private NPV (see Tables 19, 20 & 21).

Table 19. Sensitivity analysis of CRA practices – change in farm gate price of corn

Farm Gate Prices in Bukidnon 2006-2015 (PhP/kg)	Corn Production with Biodynamic			Corn-Banana Crop Diversification		
	Private NPV	Private IRR	Payback period	Private NPV	Private IRR	Payback period
Average farm gate price (PhP10.81)	(1,312)	10%	10	38,309	30%	6
Lowest farm gate price (PhP9.01)	(14,586)	(16%)	10	39,613	30%	6
Highest farm gate price (PhP12.12)	8,348	23%	8	37,360	29%	6

Table20. Sensitivity analysis on corn production with biodynamic – change in yield

Yield (kilogram)	Private NPV	Social NPV	Private IRR	Social IRR
Current value	3,776	37,524	17%	48%
3,348	(134,215)	(100,467)	#NUM!	#NUM!
3,643	(116,139)	(82,391)	#NUM!	#NUM!
3,938	(98,063)	(64,315)	#NUM!	#NUM!
4,233	(79,987)	(46,239)	#NUM!	#NUM!
4,528	(61,911)	(28,163)	#NUM!	#NUM!
4,823	(43,835)	(10,087)	#NUM!	0%
5,118	(25,759)	7,989	#NUM!	20%
5,413	(7,682)	26,065	0%	38%
5,708	10,394	44,141	25%	54%
6,003	28,470	62,217	46%	71%

Table 21. Sensitivity analysis of corn-banana crop diversification – change in yield

Yield (kilogram)	Private NPV	Social NPV	Private IRR	Social IRR
Current value	37,814	116,845	30%	65%
3,348	(7,044)	71,992	8%	45%
3,643	11,032	90,068	17%	53%
3,938	29,108	108,144	26%	61%
4,233	47,184	126,220	34%	69%
4,528	65,260	144,296	42%	77%
4,823	83,336	162,372	50%	85%
5,118	101,412	180,448	58%	94%
5,413	119,488	198,525	66%	102%
5,708	137,564	216,601	74%	111%
6,003	155,641	234,677	82%	120%

As an alternate CRA investment, CBA on crop diversification shows better NPV and IRR values. Given its attractiveness of additional income stream, farmers may likely adopt this CRA. Moreover, price and yield sensitivity analysis shows better NPV values even at price per kilogram below the minimum price of nine (9) pesos and yield per hectare below average provincial yield at 4,053 kilogram. Although payback period is earlier than with biodynamic, six (6) years is still a long time for initial investment to recover.

Given the longer payback periods for both practices, decisions to prioritize any of the CRAs will have to include mechanisms of supporting farmers in the initial phase of implementation. Strategies to lessen labor in formulating organic inputs in biodynamic, for instance, may compensate opportunity costs of labor. For crop diversification, input subsidies as planting materials and fertilizers may help lessen installation costs. Moreover, ownership of farm equipment and tools, especially on draft animal, comprises bulk of adoption cost. The necessity of owning draft animals for individual farmers lessens labor cost not only in land cultivation but more so in transporting produce to the nearest accessible road. Supporting policy on this direction may lessen adoption cost.

2.5. Summary and Conclusion

The "new climate normal" declared by PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) is an offshoot of climate change, which correspondingly impacts the agricultural sector. Spearheaded by the DA System-wide Climate Change Office (DA SWCCO), DA responds through the implementation of the AMIA project. AMIA hopes to strengthen the institutional capacity as well as resiliency in agriculture, particularly in vulnerable areas. The strategies outlined in the AMIA seek to support local communities in managing climate risks – from extreme weather events to long-term climatic shifts.

AMIA Phase 2 is an integrated and multi-stakeholder effort to operationalize CRVA and CRA in the target regions. AMIA2 provides the need for science-based data on crop vulnerabilities and suitability to respond to the threats of climate change and natural disasters. In addition, it aims to select and document CRA practices for target crop per region and subject such practices to a cost-benefit analysis.

Central Mindanao University is the implementing SUC for the AMIA2 in Northern Mindanao. The focus of the study is Bukidnon Province and targeting five major crops, i.e. rice, corn, cacao, tomato and coffee. The methodology of the project is standardized using the protocols of CIAT to allow cross-regional analysis of the data. The protocols are operationalized through participatory approach and partnership with regional (DA RFO 10) and local (City/Municipal and Provincial) agriculture offices in Bukidnon. In the case of CRA, CMU partnered with the Malaybalay City Agriculture Office, the Malaybalay City Corn Growers' Association and the farmers of Barangay San Jose.

CRVA outputs draw out the following major conclusions:

1) Bioclimatic variables with greatest percent contribution are Bio2 (30.3%), Bio9 (22%), Bio7 (30.2%), Bio7 (38.4%), Bio4 (35%) for corn, rice, cacao, coffee and tomato, respectively.
2) Results of crop suitability model indicate that there is a gain in suitable areas for corn, rice, cacao and tomato but decreasing for coffee in the projected 2050 climate scenario.
3) Corn, rice, cacao and tomato are found to be negatively sensitive to climate change while coffee is positive, which is consistent with the crop suitability results.
4) Results on the sensitivity at the municipal/city level considering all crops revealed that the municipalities of Kitaotao, Damulog, Kalilangan, Baungon and Malitbog are highly sensitive (i.e. decreasing crop suitability area) while the cities of Valencia and Malaybalay and the municipalities of Sumilao and Manolo fortich are the least sensitive.
5) The most exposed municipalities to climate change induced hazards, such as typhoon, flood, drought, erosion and landslide, are Kitaotao, Damulog, Kibawe and Kadingilan.
6) The municipalities of Damulog and Kitaotao obtained a very low adaptive capacity rating. These municipalities consistently rank low in all capitals components except for the natural capital.
7) Valencia City, Malaybalay City and Impasug-ong rated very high in adaptive capacity topping in terms of economic, human, social and

institutional capital.
8) The municipalities of Kitaotao and Damulog have very high climate risk vulnerability due to low adaptive capacity.

Farmers indicated changing climatic condition such as longer dry months, heavy rains, floods and occasional landslides as climate hazards experienced in the recent years. Documentation of corn farming practices reveal that majority of the farmers are adopting the conventional method although other farmers also practice alternative technologies. The selection of CRA practices takes into account weather smartness, soil conservation, efficiency in energy and water utilization. Outputs of FGDs and expert consultations drew out two existing local practices to be considered for prioritization and profitability analysis The two CRA practices are biodynamic agriculture and the crop diversification, specifically of corn and banana.

Results of the CBA draw out the following major conclusions:

1) Cost-benefit analysis shows both CRAs having positive private NPV and with IRR values higher than the 12% discount rate.
2) Crop diversification proves a promising investment with a much higher NPV and lag period of six (6) years before fully recovering the initial investment.
3) Biodynamic has a longer payback period and incremental investment will be fully repaid on the ninth year of operation.
4) Incremental adoption cost is higher for corn-banana crop diversification (PhP 32,219) compared to biodynamic (PhP 18,656).
5) Estimated installation, maintenance, and operation costs is higher for corn-banana crop diversification (PhP 96,960) compared to biodynamic (PhP 77,810).
6) Social NPV and Aggregate Social NPV is consistently higher for corn-banana crop diversification compared to biodynamic.

The CRVA and CRA outputs provide critical inputs to planning, prioritizing, decision-making and institutionalizing climate-resilient agriculture in Bukidnon. Crucial to these is increasing or enhancing the adaptive capacity of farmers and LGUs particularly in the physical, economic and social capitals. On the other hand, the adoption of CRA practices requires assistance and subsidy for farm inputs, labor and transportation costs. Crucial in all these is providing enabling institutional policies to ensure a climate-resilient agriculture sector in Bukidnon.

2.6. Bibliography

(2015). *AEW Annual Assessment Report CY 2015.* San Jose, Malaybalay City.

Andrieu, N., Sogoba, B., Zougmore, R., Howland, F., Samake, O., Bonilla-Findji, O., Corner-Dolloff, C. (2017). Prioritizing investments for climate-smart agriculture: Lessons leaarned from Mali. *Agricultural Systems*, 13-24. doi:http://dx.doi.org/10.1016/j.agsy.2017.02.008

Asian Development Bank. (2013). *Cost-benefit analysis for development: A practical guide.* Mandaluyong City, Philippines: Asian Development Bank.

Bangko Sentral ng Pilipinas. (2017, March 2). Retrieved from Pesos per UD Dollar Rate: http://www.bsp.gov.ph/statistics/spei_new/tab12_pus.htm

Espino, R. C., & Atienza, C. S. (2001). Crop diversification in the Philippines. In F. a. Organization, M. K. Papademetriou, & F. J. Dent (Eds.), *Crop Diversification in the Asia-Pacific Region* (pp. 95-111). Bangkok, Thailand: Food and Agriculture Organization.

European Commission. (2015). *Guide to cost-benefit analysis of investment projects.* Luxembourg: European Union.

Food and Agriculture Organization. (2001). *Crop diversification in the Asia-Pacific region.* (M. K. Papademetriou, & F. J. Dent, Eds.) Bangkok, Thailand: Food and Agriculture Organization.

Gattinger, A., Muller, A., Haeni, M., Skinner, C., Fliessbach, A., Buchmann, N., Niggli, U. (2012). Enhanced top soil carbon stocks under organic farming. *Sustainability Science* (pp. 18226–18231). New York: National Academy of Sciences of the United States of America.

Gunjal, K. (2016). *Agricultural risks management tools: Capacity development module 3.* Platform for Agricultural Risk Management.

Hijmans, R., Cameron, S., Parra J., Jones P., Jarvis, A. 2005. Very high resolution interpolated climate surfaces for global land areas. Inter. J. Climatology.

IPCC. 2001. Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group {II} to the third assessment report of the Intergovernmental Panel on Climate Change. Ed. James McCarthy. Cambridge, UK; New York, USA: Cambridge University Press.

Kariaga, B. (2004, July). Intercropping maize with cowpeas and beans for soil and water management in Western Kenya. *ISCO 2004 - 13th International Soil Conservation Organization Conference.* Retrieved June 21, 2017, from http://www.tucson.ars.ag.gov/ isco/isco13/PAPERS%20F-L/KARIAGA .pdf

KIT Royal Tropical Institute. (n.d.). *KIT Royal Tropical Institute.* Retrieved July 21, 2017, from KIT Sustainable Economic Development: http://www.kit.nl/sed/wp-content/uploads/ publications/748_Module%2010.doc.

Khanum, R., Mumtaz, A., Kumar, S. 2013. Predicting impacts of climate change on medicinal asclepiads of Pakistan using Maxent modeling. Acta Oecologica, 49, 23–31. doi:10.1016/j.actao.2013.02.007

Läderach, P., Eitzinger, A., Bunn, C., Benedikter, A., Quiroga, A., Pantoja, A., Rizo, L. 2011. Adaptation by agricultural communities to climate change through participatory & supply chain inclusive management. International Center for Tropical Agriculture (CIAT), Managua, Nicaragua and Cali, Colombia Cali, Colombia.

Lal, R. (2014). Societal value of soil carbon. *Journal of Soil and Water Conservation,* 69(6), 186A-192A. doi:doi:10.2489/jswc.69.6.186A

Mader, P., Fliessbach, A., Dubois, D., Gunst, L., Fried, P., & Niggli, U. (2002). Soil fertility and biodiversity in organic farming. *Science*, 1694-1697. doi:doi: 10.1126/science.1071148

Ng'ang'a, S. K., Notenbaert, A., Mwungu, C. M., Mwongera, C., & Girvetz, E. (2017). *Cost and benefit for climate-smart soil practices in Western Kenya.* Kampala, Uganda: International Center for Tropical Agriculture.

Palao, L.K.M., Guerten, N., Martinez, A., Parker, L., Balanza, J.G.C., Leyte, J., Dikitanan, R.C. and Burra, D.D. 2017. A climate risk vulnerability assessment for the adaptation and mitigation initiative in agriculture program in the Philippines. DA, DA-AMIA and CIAT.

Paquit J., Pampolina N., Tiburan C Jr., Manalo MM. 2017. Maxent modeling of the habitat distribution of the critically endangered *Pterocarpus indicus* Willd. forma indicus In Mindanao, Philippines. J. Bio. Env. Sci. 10(3), p. 112-122

Philips, S., Anderson, R., Schapire R. 2005. Maximum entropy modeling of species geographic distributions. Ecological Modelling 190, 231–259.

PhilGIS. (2017). Retrieved from http://philgis.org/city-and-capital-page/malaybalay-city

Philippine Statistics Authority. (2017). *Philippine Statistics Authority.* Retrieved July 21, 2017, from CountrySTAT Philippines: http://countrystat.psa.gov.ph/ selection.asp

Proctor, P. (2007). *Biodynamic farming and gardening.* Mudra India: India Press.

Rahman, S. (n.d.). Determinants of crop choices by Bangladeshi farmers: A bivariate probit analysis. *Asian Journal of Agriculture and Development, 5*(1), 29-41.

Reganold, J. (nd). Effects of biodynamic and conventional farming on soil quality in New Zealand. Department of Crop and Soil Sciences Washington State University,Pullman, Washington, USA. Retrieved June 21, 2017, from http://infrc.or.jp/english/KNF_Data_Base_Web/PDF%20KNF%20Conf%20Data/ C3-3-071.pdf

Rudinas, J. S., Godilano, E. C., & Ilaga, A. G. (n.d.). Retrieved July 5, 2017, from http://www.pdf.ph/downloads/Rural%20Development/Highlights%20of%20Meeting/23%20May%202013/attachments/03_Implementing%20Climate%20Smart%20Agriculture.pdf

Rusinamhodzi, L. (2015). Crop rotations and residue management in conservation agriculture. In M. Farooq, & K. Siddique (Eds.), *Conservation Agriculture* (pp. 21-37). Switzerland: Springer International Publishing. doi:10.1007/978-3-319-11620-4

Rusinamhodzi, L., Corbeels, M., Nyamangara, J., & Giller, K. E. (2012). Maize–grain legume intercropping is an attractive option for ecological intensification that reduces climatic risk for smallholder farmers in central Mozambique. *Field Crops Research, 136*, 12-22. doi:https://doi.org/10.1016/j.fcr.2012.07.014

Sandhu, H. S., Wratten, S. D., Cullen, R., & Case, B. (2007). The future of farming: The value of ecosystem services in conventional and organic arable land. An experimental approach. *Ecological Economics*, 835-847. doi:doi:10.1016/j.ecolecon.2007.05.007

Setboonsarng, S. (2015). Organic agriculture, poverty reduction, climate change, and the millennium develop-ment goals. In S. Setboonsarng, & A. Markandya (Eds.), *Organic Agriculture and Post-2015 Development Goals Building on the Comparative Advantage of Poor Farmers* (pp. pp.3-48). Metro Manila, Philippines: Asian Development Bank.

The World Bank. (2010). *Cost-benefit analysis in World Bank projects.* Washington, D.C.: The World Bank.

Unit Juggler. (2017, March 24). Retrieved from Conversion: https://www.unitjuggler.com/index.html

Willer, H., & Lernoud, J. (Eds.). (2016). *The world of organic agriculture. Statistics and emerging trends 2016.* Frick, Switzerland: Research Institute of Organic Agriculture (FiBL), Frick, and IFOAM-Organics International, Bonn.

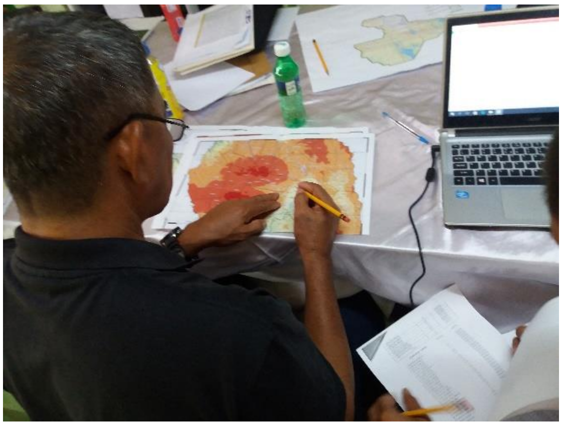
2.7. Appendices

A. Project Activities Documentation (photos and attendance sheets)

A.1. Mapping of crop occurrence








Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting and Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province

PARTICIPATORY WORKSHOP for MAPPING CROP OCCURRENCES IN BUKIDNON

August 11, 2015
CEC Board Room, UFLS Building
Central Mindanao University, Musuan, Bukidnon

No.	NAME	DESIGNATION	INSTITUTION	CONTACT NO. & EMAIL ADDRESS	SIGNATURE
1	THELMA F. NOMBRADO	Supervising Agrif.	LGU-DA - Val.	cogovi@e.com [illegible] 09058976249	
2	VICENTE S. RAMIREZ	AGRI. II	Pgro DA. Buk	09353976504	
3	ROLAND D. LANDUAY	Agri. Tech.	MAO - Maramag	mao_maramag@yahoo.com 0926 375 1374	
4	JIM C. VALOR	AA - I	PAO-BUKIDNON	09169796390	
5	Richard B. Leon	Div. Chief Supervising Agriculturist	LGU- Malaybalay City	09178154656	
6	Ethel Zean B. Micabalo	Instructor - 1	CMU	methelzean@cmu.edu.ph	
7	THEO ARBIE B. RIVERA	AMIA 2	CMU	0916 7478459	
8	MERLITA D. MOLINA	Agri II	PLGU- Bukidnon	merlita.molina@yahoo.com 09068778941	
9	JOSEPH C. PAGUIT	Proj. staff	CMU	09296960696	
10	Angela Grace T. Bruno	Proj. staff	CMU	09175794056	

Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting and Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province

PARTICIPATORY WORKSHOP for MAPPING CROP OCCURRENCES IN BUKIDNON

August 11, 2015
CEC Board Room, UFLS Building
Central Mindanao University, Musuan, Bukidnon

No.	NAME	DESIGNATION	INSTITUTION	CONTACT NO. & EMAIL ADDRESS	SIGNATURE
11	Jedilyn M. Tandoy	Research Assistant	CMU- CFES	0936-309-9658	
12	Tanara, Keven Patrivell J.	R.A	CMU- CFES	0935-982-3301	
13	ENGR DOMINCIO ELESEO	PEO/AMIA	DA-RFO10	0995-640-2443	
14	LEO FRILL M. PALAO	SRA - CIAT	CIAT	0932 847 6644	
15	Maria Lilith Turan	Agri II - PRRD	PAgO Buk	princesleily@gmail.	
16					
17					
18					
19					
20					

A.2. Focus group discussion (FGD)

CIAT

Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting and Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province

FOCUS GROUP DISCUSSION ON THE CLIMATE RESILIENT AGRICULTURE PRACTICES
Among Corn Farmers

October 21, 2016 @ Brgy. San Jose, Malaybalay City, Bukidnon

	NAME (pangalan)	ADDRESS (pinuy-anan)	Occupation	Age	Gender	Other sources of income	Contact number	Religious affiliation (relihiyon)	Highest educ. Attainment (edikasyon)	AREA(ha) of land cultivated for corn farming (gidak-on sa luna nga gitikad)	Major Crops grown (mga nag-unang pananom)	No. of years in corn farming experience (gidugayaon sa pag-uma)	Climate hazards experiences in the area (mga nasinating kalamidad sa kasamtangang lugar
1.	Roberto A. Caballe	P-9	Ret. Govt Emp.	68	M	Farming	09051136815	RC	MAED.	1-5	corn / cassava	20	Soil Erosion
2.	Olivo A. Caballes	P-7	Farmer	63	M	Farming	09364146990	RC	2nd. College.	3 ha	saging/binggala, mais	35	drought
3.	Bienvenido Linan	P7	Farmer	62	M	"		RC	2nd yr. HS	4 ha	mais / saging	30	drought
4.	Vilma G. Binayao	7	"	62	F	"		RC	Elem. Grad	2.5	Mais, rubber, lubi	1980	drought
5.	Artemio U. Turas	8	"	61	M	"	09357437849	RC	Grade 4	4	Rubber, cacao, mais	43	Firming, drought
6.	Denna A. Duarte	9	"	49	F	"		SDA	3rd yr HS	10	Rubber, Saging, cape.-	26	flooding, Landslide
7.	Cetchie C. Bacoy.	9	"	49	F	"		RC	Elem. Grad.	5	mais, Falcata	30	bagyo, landslide
8.	Gladyl G. Indapan	10	housekeeper	47	F	Farm		Fundamental Baptist	1st yr. HS	3	Saging, Mais, Kalabasa	28	drought, ilaga
9.	Maria Ruth B. Alpas	7	Farmer	1965	F	Farm	09350359373	RC	HS Grad.	1-5	Binggala, mais	30	ilaga, Kusog nga
10.	Mariam L. Oro	12	Farmer / BHW	40	F	Farm / Fishing	09068991802	SDA	3rd yr. College	2.5	Balanghoy, lubi, kapayas	5	hangin, uwan
11.	Dante M. Oro	"	Farmer	46	M	"	09263776041	SDA	2nd yr. HS	2.5	"	20	"
12.	Vicente R. Cabucon	9	"	45	M	"	09363203073	RC	3rd yr. HS	2	mais, Falcata	12	hangin
13.	Romeo B. Romagos Sr.	8	"	49	M	Binding Machine of Rice	09061289790	RC	HS Grad	3	Mais, Saging binggala	30	bagyo, landslide
14.	Camilo Cua, Sr.	"	"	78	M	Farm		Baptish	Elem. Grad	5	Rubber, cape, Mais	40 na nagdaot.	El niño
15.	Bienvenido Linan	8	..	60	M	Farming	09260841750	SDA	Grade 5	1	Corn, cassava,		
16.	Alpas, Alderes	7	farmer	25	M	Farming/Labor	09350359373	RC	2nd yr. SH	2	banana, Rubber	20	Init, rodents
17.	Alpas, Roberto	7	"	66	M	Farming / Labor		RC	HS Grad.	2	binggala, Mais, Cacao	5	Peste, Kusog hangin
											Mais, saging	30	Climate change,

CIAT

Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting and Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province

FOCUS GROUP DISCUSSION ON THE CLIMATE RESILIENT AGRICULTURE PRACTICES
Among Corn Farmers
October 21, 2016

@ Brgy. San Jose, Malaybalay City, Bukidnon

No.	NAME	DESIGNATION	INSTITUTION	CONTACT NO.	SIGNATURE
1	Vilma G. Binayao	Farmer	Brgy. San Jose, MC		
2	Denna A. Duarte	Farmer	Brgy. San Jose		
3	artemio U. Turas	Farmer	Brgy. San Jose		
4	Cetchie C. Bacoy	Farmer	Brgy. San Jose		
5	Gladyl G. Indapan	Farmer	Brgy. San Jose		
6	Olivo A. Caballes	Farmer	Brgy. San Jose		
7	Maria Ruth B. Alpas	Farmer	Brgy. San Jose		
8	Mariam L. Oro	Farmer	Brgy. San Jose		
9	Dante M. Oro	Farmer	Brgy. San Jose		
10	Vicente R. (Robby) Cabucon	Farmer	Brgy. San Jose		
11	Romeo B. ~~Romagos~~, Romagos, Sr.	Farmer	Brgy. San Jose		
12	Beinvenido S. Liñan	Farmer	Brgy. San Jose		
13	Camilo Cua, Sr.	Farmer	Brgy. San Jose		

	Romualdo U. Rondina	Farmer	Brgy. San Jose		
15	Ardenes B. Alpas	Farmer	"		
16	Roberto B. Alpas	Farmer	"		
17	Roberto A. Caballes	Farmer	Brgy. San Jose		
18	Ma. Jorgen P. Soriano	Farmer	"		
19	Myna S. [illegible]	Farmer	"		
20	Salapang, Cherry	Farmer	"		
21	LABITA, JOERIL C.	Farmer	"		
22	My jane C. Indapan	Farmer	Brgy. San Jose		
23	May Grace P. Manguiran	Farmer	"		
24	Janilyn G. Canuyan	Farmer	"		
25	RYAN A OLBENDE	Farmer	Brgy. San Jose		
26	Lorna P. Rosaroso	Farmer	Brgy. San Jose		
27					
28					
29					
30					
31					
32					
33					
34					
34					

A.3. Key informant interview (KII)

A.4. Feedback and validation

Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting and Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA)

Phase 2: Focus on Bukidnon Province

"LOCAL STAKEHOLDERS VALIDATION WORKSHOP"

May 25-26, 2017

@ Veranda, Malaybalay City, Bukidnon

No.	NAME	DESIGNATION	INSTITUTION/ Address.	CONTACT NO.	SIGNATURE
1	Eva O. Gamutan	bussiness women & Farmers	Brgy. San Jose	09273351815	[signature]
2	Mariam L. Oro	Farmer	"	09068491802	[signature]
3	Owen T. Sageud	Farmer	"	09058341147	[signature]
4	Noli S. Lonte	Farmer	"	/	[signature]
5	Dante M. Oro	Farmer	"	09263776041	[signature]
6	Venjan S. Salinday	Farmer	"	/	[signature]
7	Rolando Quiret	Bussiness men Farmer	"	09278153336	[signature]
8	Delmenia B. Sayson	Farmer	"	09107198770	[signature]
9	Aurea B. Hilario	Farmer	"	/	[signature]
10	Glady G. Indapan	Farmer	"	/	[signature]

No.	NAME	DESIGNATION	INSTITUTION	CONTACT NO.	SIGNATURE
	Constantino Lozano	Farmer	Panalsalan, Mal	09366645802	[signature]
	12. Dionesio Jimenez SR.	Farmer	" "	/	[signature]
13	13, Pagint, Joseph C.	Facilitator	CMU		[signature]
14	Jedilyn M. Tandog	RA	CMU	0936-309-9658	[signature]
15	Sol mae Z. Valdehueza	LGU-Libona - clerk		09102214180	[signature]
16	JUNSPIE T. LUMANDAS	FARMER	KADINGILAN POVL	09976834637	[signature]
17	Abundio E. Iwayan	Farmer	Valencia	09977726164	[signature]
18	Angela Grace Toledo-Bruno	Project Staff	CMU	0917 714 1787	[signature]
19	DAN B. BACARRO	MAFC	BAUNGON	09216642817	[signature]
20	MERCADO JUNNI	FARMER	BAUNGON	/	[signature]
21	Beginah M. Luna	Farmer	San Jose	09169004981	[signature]
22	Alvarez, Michael Peri		CMU		[signature]
23	Barraga, Michelle F.		Dalwangan	09076888705	[signature]
24	Ara, Alexander. Jr. S.		Valencia		[signature]
25	Jedilyn M. Tandog	RA	CMU	09363099658	[signature]
26	Thea Arbie S. Rinera	Project staff	CMU	09174478414	[signature]

	Raquel O. Salingay	Project staff	CMU		[signature]
	Rosalyn Quinte	Farmer	Maramag	09168668837	[signature]
29	Jacosalem Quinte	Farmer	Maramag		[signature]
30	Julieta L. Suello	Farmer	Maramag	09066148782	[signature]
31	Ma. Perla L. Manzo	Farmer	Maramag	09261328601	Manzo
32	ARTEMIO U. TUROS	FARMER			[signature]
33	Roneil L. Suello	Farmer		09551897795	[signature]
34	SALIM ABANTU	FARMER	MARAMAG		[signature]
35	Romualdo Andina			09268417501	[signature]
36	Richie S. Lopoz	farmer	Maramag	09366198871	[signature]
37	Olivo A. Caballes	farmer		09364146990	[signature]
38	Alpos, Ardenes	Farmer		09350354373	[signature]
39	Rowena Duarte	Farmer	San Jose		[signature]
40	Lotchie C. Bacoy	Farmer			[signature]
41	Tamara Keren Patrivell	RA	CMU		[signature]

Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting and Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA)
Phase 2: Focus on Bukidnon Province

"LOCAL STAKEHOLDERS VALIDATION WORKSHOP"

May 26, 2017
@ Veranda, Malaybalay City, Bukidnon

No.	NAME	DESIGNATION	INSTITUTION/ ADDRESS	CONTACT NO./EMAIL ADD.	SIGNATURE
1	Ronald C. Montejo	A.T.	LGU – Baungon	0935-192-4359 ronald34@gmail.com	[signature]
2	REYMON A. CAPUNO	AT	LGU – MARAMAG	09058860381 reymoncapuno@yahoo.com	[signature]
3	Sol Mae Z. Valdehueza	Clerk	LGU – Libona	09162216183	[signature]
4	JOEL J. GABO	SPSII	DMACPC	09771185420	[signature]
5	THELMA B. NOMBRADO	S.A.	LGU – Val.	09058976269	[signature]
6	AUDY G. MAGAD	Sup. Agri	DA – 10	09174110143	[signature]
7	Genaro O. Lesure Jr.	PDIV	PPDO – Buk	goleso@gmail.com	[signature]
8	Gay Alenia		DA – 10		[signature]
9	MYRA S. ABEJUELA	AgrI-II	LGU – Mlybly	09351148421	[signature]
10	MA. JINGEN P. SORIANO	AgrA-II	LGU – Mlyblay	0917-968-3913	[signature]

11	SUSAN I. CALIZON	PEO II	PPDO-BUK	09163003337	
12	Maria Lilith Turan	PRC	PAGO-BUK	09173089190	
13	Casanes, Noli Jhon	JO - AT	Kadingilan Buk	09261435967 nolijhon.casanes@gmail.com	
14	DOMINICIO A. ELESEO	PEO III	DA-RFO X	tadeseo@gmail.com	
15	Roxana H. Hojas	Director III	DA-RFO-10	09184437493	
16	Rhane Marie Pabillaran	AT	Baungon	09551848347	
17	Richard B. Llona	Supervising Agriculturist	Malaybalay City	09175154656	
18	Norberto T. Baltazar Jr.	PEO III	PPDO-BUK.	09173262555	
19	Alvarez, Michael Peri C.				
20	Panaga, Michelle F.		ROLOGON	09976887705	
21	Ara, Alexander J. S.		Valencia		
22	Vadilyn M. Tandog	RA	CMU	09363099658	
23	Angela Grace Toledo - Bruno	Project staff		0917-719-1787	
24	Joseph C. Pagnit	Project staff		0929-696-0696	
25	Then Arble S. Rivera	Project staff		0915-797-8459	
26	Raquel O. Salingay	Project staff		0926 887 0817	
27	Kevin Patrinell S. Tanam				
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					

A.5. Turn-over of outputs

ACKNOWLEDGMENT SHEET

This is to acknowledge receipt of research output from Central Mindanao University-AMIA2 Project entitled, **"Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province"**.

Date and Time	June 24, 2017, 11:38 A.M.
Receiving Agency	APCO - Bukidnon
Agency Address	Capitol Compound, Malaybalay City
Receiving Individual	Norberto T. Baltazar Jr.
Position/Designation	Project Evaluation Officer - IV
Signature	[signature]
Item(s) Received	1 CD containing electronic files of the following:
	Investment Brief- Corn Production with Biodynamics
	Investment Brief- Corn and Banana Crop Diversification
	CIAT Cost and Benefit Analysis Template
	Maps: Adaptive Capacity, Suitability
	Hazard, Sensitivity & Vulnerability

Witness/Delivering Individual:

JOSEPH [illegible]. [illegible]

Signature above printed name

Designation/Positon:
GIS focal person

ACKNOWLEDGMENT SHEET

This is to acknowledge receipt of research output from Central Mindanao University-AMIA2 Project entitled, **"Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province"**.

Date and Time	JUNE 29, 2017 - 11:08 AM
Receiving Agency	CITY AGRICULTURE OFFICE
Agency Address	CASISANG, MALAYBALAY CITY
Receiving Individual	DAISY JANE B. SUMBONGAN
Position/Designation	ADMINISTRATIVE STAFF
Signature	
Item(s) Received	1 CD containing electronic files of the following:
	Investment Brief- Corn Production with Biodynamics
	Investment Brief- Corn and Banana Crop Diversification
	CIAT Cost and Benefit Analysis Template
	Maps: Adaptive Capacity, Suitability
	Hazard, Sensitivity & Vulnerability

Witness/Delivering Individual:

JOSEPH C. PAQUIT

Signature above printed name

Designation/Positon:

GIS Focal person

ACKNOWLEDGMENT SHEET

This is to acknowledge receipt of research output from Central Mindanao University-AMIA2 Project entitled, **"Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province"**.

Date and Time	June 29, 2019
Receiving Agency	Prov'l Agriculture Office
Agency Address	Malaybalay City
Receiving Individual	Maria Lilith Tarca
Position/Designation	Sr. Agriculturist
Signature	
Item(s) Received	1 CD containing electronic files of the following:
	Investment Brief- Corn Production with Biodynamics
	Investment Brief- Corn and Banana Crop Diversification
	CIAT Cost and Benefit Analysis Template
	Maps: Adaptive capacity, Suitability
	Hazard, Sensitivity & Vulnerability

Witness/Delivering Individual:

Signature above printed name

Designation/Positon:
GIS focal person

ACKNOWLEDGMENT SHEET

This is to acknowledge receipt of research output from Central Mindanao University-AMIA2 Project entitled, **"Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province"**.

Date and Time	JUNE 30, 2017 ; 9:20 AM
Receiving Agency	Dept of Agricultural Economics, College of Agriculture, CMU
Agency Address	CMU, Musuan, 8710 Bukidnon
Receiving Individual	THEA ARIANE S. ONEDA
Position/Designation	Faculty
Signature	
Item(s) Received	1 CD containing electronic files of the following:
	Investment Brief- Corn Production with Biodynamics
	Investment Brief- Corn and Banana Crop Diversification
	CIAT Cost and Benefit Analysis Template
	Maps: Adaptive Capacity, Suitability
	Hazard, Sensitivity & Vulnerability

Witness/Delivering Individual:

Tañara Keven Balivell J.

Signature above printed name

Designation/Positon:

Lab Aide

ACKNOWLEDGMENT SHEET

This is to acknowledge receipt of research output from Central Mindanao University-AMIA2 Project entitled, **"Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province"**.

Date and Time	June 29, 2017
Receiving Agency	Department of Agriculture, RFO-10
Agency Address	Antonio Luna St., Cagayan de Oro City
Receiving Individual	Roxana H. Hojas
Position/Designation	Director III / Asst. Regional Director
Signature	
Item(s) Received	1 CD containing electronic files of the following:
	Investment Brief- Corn Production with Biodynamics
	Investment Brief- Corn and Banana Crop Diversification
	CIAT Cost and Benefit Analysis Template
	Maps: Adaptive Capacity, Suitability
	Hazard, Sensitivity & Vulnerability

Witness/Delivering Individual:

JOSEPH C. PAOUT

Signature above printed name

Designation/Positon:

GIS focal person

Appendix B. Respondents/Participants of KII and FGD

B.1. Key informants and respective geographic coordinates.

Particular	CRA Practice	Latitude	Longitude
Barangay San Jose, Malaybalay City		8.103563	125.128604
Sitio Mabuhay, Brgy. San Jose, Malaybalay City		8.101789	125.159676
KII-1	Conventional corn production	8.092229	125.178886
KII-2	Conventional corn production	8.102512	125.167299
KII-3	Conventional corn production	8.099308	125.165381
KII-4	Conventional corn production	8.090667	125.175949
KII-5	Corn production with Biodynamic	8.099764	125.152236
KII-6	Corn production with Biodynamic	8.106872	125.177566
KII-7	Corn production with Biodynamic	8.099312	125.177928
KII-8	Corn production with Biodynamic	8.093934	125.161083
KII-9	Corn-Banana crop diversification	8.102685	125.173258
KII-10	Corn-Banana crop diversification	8.107656	125.152648
KII-11	Corn-Banana crop diversification	8.106798	125.158464
KII-12	Corn-Banana crop diversification	8.118657	125.172493

B.2. FGD Participants' Profile
CRA Practices of Corn Farmers San Jose, Malaybalay City, Bukidnon
October 21, 2016

Name	Add -ress	Occu- pation	Age	Gen- der	Sources of Income	Contact number	Religious Affiliation	Highest Educ. Attainment	Size of land cultivated for corn	Major crops grown	No. of years in corn farming	Climate hazards
1. Roberto A. Caballe	P-9	Retired gov't. employee	68	M	Farming	09051136815	Roman Catholic	M.A. Education	1.5 has	Corn, cassava	20	Soil erosion
2. Olivo A. Caballes	P-7	Farmer	63	M	Farming	09364146990	Roman Catholic	2nd year college	3 has	Banana, cassava, corn	35	Drought
3. Beinvenido S. Liñan	P-7	Farmer	62	M	Farming		Roman Catholic	2nd year high school	4 has	Corn, banana	30	Drought
4. Vilma G. Binayao	P-7	Farmer	62	F	Farming		Roman Catholic	Elementary graduate	2.5 has	Corn, rubber, coconut	36	Drought
5. Artemio V. Turos	P-8	Farmer	61	M	Farming	09357437849	Roman Catholic	Grade 4	4 has	Rubber, cacao, corn	43	Drought
6. Denna A. Duarte	P-9	Farmer	44	F	Farming		Seventh Day Adventist	3rd year high school	10 has	Rubber, banana, coffee, cassava, corn	26	Landslide due to storm
7. Lotchie C. Bacoy	P-9	Farmer	49	F	Farming		Roman Catholic	Elementary graduate	5 has	Corn, squash	30	Landslide, strong wind
8. Gladly G. Indapan	P-10	House keeper	47	F	Farming		Fundamental Baptist	1st year high school	3 has	Banana, corn, squash	28	Drought, pest infestation

Name	Add -ress	Occu-pation	Age	Gen-der	Sources of Income	Contact number	Religious Affiliation	Highest Educ. Attainment	Size of land cultivated for corn	Major crops grown	No. of years in corn farming	Climate hazards
												(rodents)
9. Maria Ruth B. Alpas	P-7	Farmer	51	F	Farming	09350354373	Roman Catholic	High school grad.	1.5 has	cassava, corn	30	Pest infestation (rodents), strong wind
10. Mariam L. Oro	P-12	Farmer/ BHW	40	F	Farming/fishing	09068491802	SDA	3rd year college	2.5 has	Cassava, coconut, corn, coffee	5	Heavy rainfall, strong wind
11. Dante M. Oro	P-11	Farmer	46	M	Farming	09263776041	SDA	2nd year high school	2.5 has	Cassava, coconut, corn, coffee	20	Heavy rainfall, strong wind
12. Vicente R. Cahucom	P-9	Farmer	45	F	Farming	09363203193	Roman Catholic	3rd year high school	2 has	Corn, falcatta	12	Kusog hangin
13. Romeo B. Romagos, Sn.	P-8	Farmer	49	M	Farming,construct-ion	09061289790	Roman Catholic	High school grad.	3 has	Corn, banana, cassava	30	Storm, landslide, pest infestation (rodents)
14. Camilo Cua Sn.	P-11	Farmer	78	M	Farming		Baptist	Elem. Grad.	5 has	Rubber, coffee, corn	36	El Nino
15. Romualdo V. Rondina	P-8	Farmer	60	M	Farming	09268417501	SDA	Grade 5	1 has	Coffee, cassava	20	High temperature, pest infestation (rodents)
16. Ardenes B. Alpas	P-7	Farmer	25	M	Farming,labor	09350354373	Roman Catholic	2nd year high school	2 has	Banana, rubber	5	Pest infestation,

Name	Add -ress	Occu-pation	Age	Gen-der	Sources of Income	Contact number	Religious Affiliation	Highest Educ. Attainment	Size of land cultivated for corn	Major crops grown	No. of years in corn farming	Climate hazards
17. Roberto A. Alpas	P-7	Farmer	66	M	Farming,labor		Roman Catholic	High school grad	2 has	Cassava, corn, ginger, peanuts, banana	30	strong wind Climate change resulting to reduced harvest

Appendix C

C.1. CBA Dataset- Biodynamic Agriculture

GENERAL INFORMATION	
Practice name	Biodynamic in Corn Production
Description of practice	Corn production with the use of Biodynamic cropping calendar, bio fertilizers and bio pesticides.
Discount rate (%)	12
Exchange rate (Local currency/USD)	48.73
Number of financial periods in the analysis	10
OUTPUTS/ACTIVITIES AFFECTED BY THE PRACTICE	
Name of output/activity 1	Corn grain

GROSS BENEFIT FLOW	
SHAPE OF THE RESPONSE INCREMENTAL PHYSICAL RESPONSE	
Output 1- CORN GRAIN	
Period when output physical response starts	1 year
Period when output physical reaches maximum	2 years
ESTIMATED CHANGES IN PRODUCTIVITY	
Output 1- Corn	
Current yield of output	4216
Change rate of yield under conventional practice	0
More likely yield output of CSA	5600
Annual change CSA output	
OUTPUT PRICES AT FARM LEVEL	
Output 1- CORN GRAIN	
Unit	Peso
Farm price output	11.50
Change rate of farm price output (%)	0

ADOPTION COST FLOW					
Item	**Unit**	**Price of Unit**	**Annual trend of price**	**Conventional practice**	**CSA practice**
IMPLEMENTATION PERIOD					
Machinery and Equipment					
Sprayer	piece	1200	-	1	1

ADOPTION COST FLOW					
Item	**Unit**	**Price of Unit**	**Annual trend of price**	**Conventional practice**	**CSA practice**
Plough	piece	2000	-	0	1
Carabao	head	26390	-	0	1
Scythe	piece	250	-	2	4
Inputs					
Seeds	kg	25	-	24	22
Chicken dung	sack	105	-	0	8
Vermicompost	sack	200	-	0	8
Chemical herbicide at clearing	gallon	1000	-	2	0
21-0-0	sack	480	-	12	0
46-0-0	sack	980	-	12	0
Services					
Input trucking	Sacks	30	-	24	16
Animal hauling of inputs	sacks	20	-	24	16
Labor					
Clearing	md	200	-	20	54
Land preparation	mad	300	-	4	0
Herbicide application at land preparation	md	200	-	4	0
Planting	md	200	-	6	8
Fertilizer application	md	200	-	6	8
MAINTENANCE PERIOD					
Machinery and Equipment					
Bolo	Piece	150	-	6	8
Pick mattock	piece	450	-	0	2
Shovel	Piece	200	-	0	6
Rake	Piece	400	-	0	2
Hoe	Piece	150	-	0	2
Inputs					
Herbicide	gallon	1000	-	2	0
Fermented plant juice	liter	70	-	0	8
Farm compost	Sack	5	-	0	10
Services					
Labor					

ADOPTION COST FLOW					
Item	**Unit**	**Price of Unit**	**Annual trend of price**	**Conventional practice**	**CSA practice**
Manual weeding	md	170	-	6	40
Composting	md	170	-	0	16
Herbicide application at weeding	md	170	-	2	0

OPERATIONS PERIOD					
Period when operation cost initiate			2		
Period when operation cost ends			10		
Item	Unit	Price of Unit	Annual trend of price	Conventional practice	CSA practice
Machinery and Equipment					
Inputs					
Sacks	pieces	8	-	124	160
Services					
Shelling fee	Bushels	5	-	248	320
Animal hauling of produce	Sacks	20	-	124	160
Trucking of produce	Sacks	30	-	124	160
Drying	Sacks	3	-	124	160
Labor					
Harvesting	md	200	-	18	16
Shelling	md	170	-	6	2

VALUE OF EXTERNAL EFFECTS		
Name of external effect 1	Increase in soil carbon stock	
Name of external effect 2	Increase top soil formation	
Name of external effect 3	Reduction in emissions from fossil energy inputs	
SHAPE OF EXTERNAL EFFECTS		
Response Parameters of EE 1	Value	Unit
Practice lifecycle. Period of analysis (T)	10	Year
Period physical response starts EE 1	3	year
Response Parameters of EE 2	Value	Unit
Practice lifecycle. Period of analysis (T)	10	Year

VALUE OF EXTERNAL EFFECTS		
Period physical response starts EE 2	3	year
Response Parameters of EE 3	Value	Unit
Practice lifecycle. Period of analysis (T)	10	
Period physical response starts EE 3	3	
PHYSICAL PRODUCTION	Values	Unit
Physical response EE1	1080	kgC/ha
Physical response EE2	0.25	tsoilha/year
Physical response EE3	0.6	CO2e/ha/year
SHADOW PRICE OF EXTERNAL EFFECTS	Values in USD	Units
Shadow price of EE1	0.133	kilogram
Shadow price of EE2	23.6	ton
Shadow price of EE3	11	ton

ESTIMATION OF THE AGGREGATE ECONOMIC VALUE	
Date when diffusion starts	2018
Length of the prediction period	10
Estimated diffusion ceiling (K)	0.28
Proportion of adoption at starting point (po)	0.01
Proportion of adoption at mid point (p1)	0.15
Number of unit of analysis in the Region (N)	855ha

Appendix C

C.2. CBA Dataset- Crop Diversification

GENERAL INFORMATION	
Practice name	Corn-Banana crop diversification
Description of practice	Producing corn and banana at the same time. Banana are planted at the peripheries, along contours or in adjacent area.
Discount rate (%)	12
Exchange rate (Local currency/USD)	48.73
Number of financial periods in the analysis	10
OUTPUTS/ACTIVITIES AFFECTED BY THE PRACTICE	2
Name of output/activity 1	Corn grain
Name of output/activity 2	Banana

GROSS BENEFIT FLOW	
SHAPE OF THE RESPONSE INCREMENTAL PHYSICAL RESPONSE	
Output 1- CORN GRAIN	
Period when output physical response starts	1 year
Period when output physical reaches maximum	2 years
Output 2- BANANA	
Period when output physical response starts	2 years
Period when output physical reaches maximum	3 years
ESTIMATED CHANGES IN PRODUCTIVITY	
Output 1- CORN GRAIN	
Current yield of output	4216 kilogram
Change rate of yield under conventional practice	0
More likely yield output of CSA	4080 kilogram
Annual change CSA output	
Output 2- BANANA	
Current yield of output	0
Change rate of yield under conventional practice	
More likely yield output of CSA	4800 kilogram
Annual change CSA output	
OUTPUT PRICES AT FARM LEVEL	
Output 1- CORN GRAIN	
Unit	Peso
Farm price output	11.50

GROSS BENEFIT FLOW	
Change rate of farm price output (%)	0
Output 2- BANANA	
Unit	Peso
Farm price output	7
Change rate of farm price output (%)	

ADOPTION COST FLOW (CORN GRAIN – BANANA)					
Item	**Unit**	**Price of Unit**	**Annual trend of price**	**Conventional practice**	**CSA practice**
IMPLEMENTATION PERIOD					
Machinery and Equipment					
Scythe	piece	250	-	2	3
Plough	piece	2000	-	0	1
Carabao	head	26390	-	0	1
Bara	piece	250	-	0	1
Sprayer	piece	1200	-	1	1
Inputs					
Corn seeds	kilogram	25	-	24	28
Round-up	gallon	980	-	2	2
21-0-0	sack	480	-	12	0
46-0-0	sack	980	-	12	4
14-14-14	sack	1080	-	0	12
Sucker	piece	10	-	0	100
Chicken dung	sack	80	-	0	8
Lime	sack	20	-	0	10
Services					
Input transport	sack	50	-	48	36
Labor					
Clearing	md	200	-	20	10
Land cultivation for corn	mad	200	-	0	4
Planting for corn	md	200	-	6	12
Fertilizer application for corn	md	200	-	6	4
Herbicide application for corn	md	200	-	4	2
Land preparation in banana	mad	300	-	4	0
Under brushing	md	170	-	0	2
Digging and staking	md	170	-	0	2
Gathering of suckers	md	170	-	0	2

ADOPTION COST FLOW (CORN GRAIN – BANANA)					
Item	**Unit**	**Price of Unit**	**Annual trend of price**	**Conventional practice**	**CSA practice**
Planting of suckers	md	170	-	0	2
Fertilizer application in banana	md	170	-	0	2
MAINTENANCE PERIOD- CORN GRAIN					
Machinery and Equipment					
Bolo	piece	150	-	6	2
Inputs					
Larvane for Banana	bottle	450	-	0	2
Roundup for Corn	gallon	980	-	2	2
Services					
Labor					
Manual weeding in corn	md	170	-	6	4
Herbicide application in corn	md	170	-	2	2
Bunch management	md	170	-	0	12
Leaf removal	md	170	-	0	12
Under brushing	md	170	-	0	4
Sucker management	md	170	-	0	9

OPERATIONS PERIOD- CORN GRAIN					
Period when operation cost initiate	2				
Period when operation cost ends	10				
Item	Unit	Price of Unit	Annual trend of price	Conventional practice	CSA practice
Machinery and Equipment					
Inputs					
Sacks for unshelled corn	piece	8	-	124	120
Services					
Shelling fee for corn	bushels	5	-	248	240
Transport of produce	sack	50	-	124	120
Drying	sack	3	-	124	120
Labor					
Harvesting corn	md	200	-	18	40
Shelling corn	md	170	-	6	6

OPERATIONS PERIOD- BANANA					
Period when operation cost initiate			2		
Period when operation cost ends			10		
Item	Unit	Price of Unit	Annual trend of price	Conventional practice	CSA practice
Machinery and Equipment					
Inputs					
Sack	piece	20	-	0	72
Services					
Output trucking	sack	50	-	0	72
Labor					
Harvesting	md	170	-	0	12

VALUE OF EXTERNAL EFFECTS		
Name of external effect 1	Increase rainfall infiltration	
Name of external effect 2	Decrease soil erosion	
SHAPE OF EXTERNAL EFFECTS		
Response Parameters of EE 1	Value	Unit
Practice lifecycle. Period of analysis (T)	10	Year
Period physical response starts EE 1	2	year
Response Parameters of EE 2	Value	Unit
Practice lifecycle. Period of analysis (T)	10	Year
Period physical response starts EE 2	2	year
PHYSICAL PRODUCTION	Values	Unit
Physical response EE1	16	mm/ha
Physical response EE2	12.6	tons/ha/year
SHADOW PRICE OF EXTERNAL EFFECTS	Values in USD	Units
Shadow price of EE1	0.44	mm/ha
Shadow price of EE2	23.6	ton

ESTIMATION OF THE AGGREGATE ECONOMIC VALUE	
Date when diffusion starts	2018
Length of the prediction period	10
Estimated diffusion ceiling (K)	0.57
Proportion of adoption at starting point (po)	0.07
Proportion of adoption at mid point (p1)	0.25
Number of unit of analysis in the Region (N)	855 ha

Appendix D. Investment briefs to guide CRA prioritization decisions

Climate-Resilient Agriculture Practices Investment Prioritization

Region 10: Corn Production with Biodynamics

Overview

Geologically a combination of plains, mountains, rolling hills and coastal areas, Northern Mindanao comprises the provinces of Bukidnon, Camiguin, Lanao del Norte, Misamis Occidental and Misamis Oriental.

The agriculture sector employs 40 percent of the region's labor force (Regional Economic Situationer, 2014). Climatic condition and natural resources of the region make possible the production of its major crops: pineapple, banana, and corn, ranking first, second and third, respectively in the country (PSA, 2015).

The province of Bukidnon tops in the production of most agricultural commodities in the region. It contributed 67 percent of regional supply for corn in 2014. Corn sufficiency level in the province, however, is still at 75 percent.

In the face of agricultural productivity, the region is vulnerable to climatic changes. Drought, flooding and land slides brought economic losses. Climate vulnerability is a function of exposure to climate hazards, sensitivity to risks and strength of adaptive capacity. Exposure and sensitivity are variables difficult to control but adaptive capacity is something that individuals and the community can develop.

In Bukidnon, the municipalities of Damulog and Kitaotao were found highly vulnerable to climate change mainly due to their high sensitivity to climate hazards and low adaptive capacity. The long dry spell from February to late May of 2016 brought the region in a state of calamity. Loss of agricultural investment was estimated at 793 million with losses in corn at 615 million, (Mascarinas, 2016). Rice production was significantly affected without enough water supply. These experiences reflect the growing vulnerability of the agriculture-dependent economy towards climate change.

Prioritized CRA Practice

Addressing regional demand for corn amidst changing climatic condition calls for production practices providing balance between economic sustainability and environmental resiliency. Climate-Resilient Agriculture (CRA) builds on the concept of making farms and the agriculture sector less vulnerable to climate change. CRA stands on its goal for adaptation, mitigation and productivity. One farming practice that meets this criteria is the use of biodynamics system in corn production.

Biodynamic Agriculture is a farming system that treats the farm as a living system, for the purpose of building healthy soil and farm products (Proctor, 2007). The biodynamics cropping calendar guides farmers in farm decisions as to crop selection and appropriate days of conducting farm activities. This CRA helps minimize pest occurrence because the calendar considers the life cycle of common crop pests.

Biodynamics also embraces the formulation of organic fertilizers and pesticides. It utilizes waste materials in the farm such as animal manure and composts. In this case, biodynamics lessen cost of farm inputs (Setboonsarng, 2015). Environmental benefits of biodynamics include increased soil carbon stock, top soil formation and reduced fossil energy emission from use of synthetic inputs (Maeder et al., 2002).

Is the adoption of biodynamics a worthy investment? Evidence on economic feasibility of biodynamics in corn production was gathered in the pilot area of San Jose, Malaybalay City, province of Bukidnon. Selection of the area considers the crop suitability map for corn production, responsiveness of the local government workers, and presence of functional farmer's organization. Focus Group Discussion (FGD) in the area revealed the practice of biodynamics among local farmers.

Data Gathering and Methodology

The Cost-Benefit Analysis (CBA) tool prescribed by the International Center for Tropical Agriculture (CIAT) was used to compare production performance with and without the CRA. CBA is an economic tool for assessing relative desirability of competing investment alternatives in terms on the present value of benefits gained from potential investment. Eight (8) Key Informant Interviews (KII) with local farmers verifies result of FGD. Data gathered was on the cropping year 2016 and calculated in per hectare analysis. Secondary data from statistical reports and scientific literatures completes data requirements. Analysis is limited in the estimations produced in the CBA tool.

Results

Adopting biodynamics in corn production requires private initial investment of PhP18,656 (383 USD) per hectare. Additional farm tools and utilization of man labor comprises most of the expenditures. Sloping land terrains necessitates investment on draft animal. Increase in labor requirement comes from manual weeding and preparation of organic inputs as composts and natural fertilizers and pesticides. Reduced cost from purchased synthetic fertilizers and chemicals compensates additional costs in labor and farm tools.

Given current prices, actual difference in yield, and 12 percent discount rate, present value of future net cash flows from investment in the CRA is positive at

Summary of Results

CBA Tool Summary Result (1 hectare)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Payback Period	Initial Invest-ment	Social NPV	Social IRR	Scenario in the Analysis	
Value/Unit	77 USD	17%	9 years	383 USD	770 USD	49%	WITH CRA Conventional Corn Production	WITHOUT CRA Corn Production with Biodynamics
Aggregate Analysis	Total corn area*	Current adoption rate	Adoption rate	Aggregate NPV			Period	
	856ha	1%	28%	512,026 USD			10 years	

NB: 856 hectares of cultivated corn area in San Jose (pilot area); Foreign exchange rate PhP48.73 to 1 USD

77 USD (PhP53,776). Private IRR is slightly higher from the discount rate making the CRA moderately risky. Without price premium for organic corn, initial investment is realized after nine (9) years.

Since biodynamics promotes soil and energy conservation, among others, society gains from its adoption. Incorporating the identified environmental benefits, the CRA practice seem more attractive with social NPV of 770 USD (PhP37,524) per hectare and cuasi-social IRR of 49%. Out scaling the analysis to total corn production areas in the community, at estimated 28 percent adoption rate, results to aggregate present value of benefits at 512,026 USD (PhP25 million).

Recommendations

Benefits of biodynamics in corn production exceeds it costs. Investment thereof is feasible. However, caution is advised on investing due to observed low adoption of farmers on organic farming systems despite its benefits.

Policy directions may focus on price premium of organic corn and institutional support in terms of road infrastructure. The longer payback period necessitates short-term financial support schemes to adopters. Further, in order to reduce the degree of uncertainty in the evaluation of CRA impacts, the authors recommend allocation of funds to finance further researches toward gaining more information on environmental externalities.

References

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Climate-Resilient Agriculture Practices Investment Prioritization

Region 10: Corn-Banana Crop Diversification

Overview

Geologically a combination of plains, mountains, rolling hills and coastal areas, Northern Mindanao comprises the provinces of Bukidnon, Camiguin, Lanao del Norte, Misamis Occidental and Misamis Oriental.

The agriculture sector employs 40 percent of the region's labor force (Regional Economic Situationer, 2014). Climatic condition and natural resources of the region make possible the production of its major crops: pineapple, banana, and corn, ranking first, second and third, respectively in the country (PSA, 2015).

The province of Bukidnon tops in the production of most agricultural commodities in the region. It contributed 67 percent of regional supply for corn in 2014. Corn sufficiency level in the province, however, is still at 75 percent.

In the face of agricultural productivity, the region is vulnerable to climatic changes. Drought, flooding and land slides brought economic losses. Climate vulnerability is a function of exposure to climate hazards, sensitivity to risks and strength of adaptive capacity. Exposure and sensitivity are variables difficult to control but adaptive capacity is something that individuals and the community can develop.

In Bukidnon, the municipalities of Damulog and Kitaotao were found highly vulnerable to climate change mainly due to their high sensitivity to climate hazards and low adaptive capacity. The long dry spell from February to late May of 2016 brought the region in a state of calamity. Loss of agricultural investment was estimated at 793 million with losses in corn at 615 million, (Mascarinas, 2016). Rice production was significantly affected without enough water supply. These experiences reflect the growing vulnerability of the agriculture-dependent economy towards climate change.

Prioritized CRA Practice

Addressing regional demand for corn amidst changing climatic condition calls for production practices providing balance between economic sustainability and environmental resiliency. Climate-Resilient Agriculture (CRA) builds on the concept of making farms and the agriculture sector less vulnerable to climate change. CRA stands on its goal for adaptation, mitigation and productivity. One farming practice that meets this criteria is crop diversification.

Crop diversification is a practice of planting two or more crops in the same area of land at the same time. The practice provides alternate on-farm income and maximizes use of resources. In this CRA, banana is planted together with corn at the peripheries, as hedge grow or contour crop in gentle to medium-sloped areas. Corn is planted as main crop for commercial and family consumption while banana is produced to augment farm income. Specifically, the Cardaba banana cultivar is part of the local diet prepared as snack or as substitute to the staple corn and rice. Local demand utilization include processing into snack foods, banana paste and sauce.

As a secondary crop, less labor and material input is allocated for banana. Production inputs comprise few bags of fertilizers. Planting materials are provided by neighboring banana farms or as government subsidy. Maintenance such as under brushing and sucker management is done every two months.

Is corn-banana production a worthy investment? Evidence on economic feasibility of the CRA was conducted in the pilot area of San Jose, Malaybalay City, province of Bukidnon. The selection of the area considers the crop suitability map for corn production, responsiveness of the local government workers, and presence of farmer's organization. Focus Group Discussion (FGD) revealed the practice of the CRA among local farmers.

Data Gathering and Methodology

The Cost-Benefit Analysis (CBA) tool prescribed by the International Center for Tropical Agriculture (CIAT) was used to compare production performance with and without the CRA. CBA is an economic tool for assessing relative desirability of competing investment alternatives in terms of the present value of benefits gained from potential investment. Eight (8) Key Informant Interviews (KII) with local farmers verifies result of FGD. Data gathered was on the cropping year 2016 and calculated in per hectare analysis. Secondary data from statistical reports and scientific literatures completes data requirements. Analysis is limited in the estimations produced in the CBA tool.

Results

Initial investment in diversifying from pure corn to corn-banana production is PhP32,219 (661 USD). **Majority of the investment is directed to additional** material inputs and farm equipment/tools during installation. Sloping land terrains necessitates investment on draft animal. Observed higher operation cost is associated with monthly labor and transport cost in harvesting and marketing banana. Higher farm cost is expected in the first year of implementation. Financial benefit, specifically with banana, starts after the second year and reaches maximum on the third year.

Given current prices, actual difference in yield, and 12 percent discount rate, present value of future net cash flows from investment is positive at PhP37,809 per hectare (776 USD). Estimated IRR is 30% making the CRA practice less risky for farmers to adopt. Full recovery of investment, however, takes six (6) years. Increasing farm yield and better management practices for banana may shorten the payback period.

Summary of Results

CBA Tool Summary Result (1 hectare)	Net Present Value (NPV)	Internal Rate of Return (IRR)	Payback Period	Initial Investment	Social NPV	Social IRR	Scenario in the Analysis	
Value	776 USD	30%	6 years	661 USD	2,398 USD	65%	WITH CRA Conventional Corn Production	WITHOUT CRA Corn-Banana Crop Diversification
Aggregate Analysis	Total corn area*	Current adoption rate	Adoption rate	Aggregate NPV			Period	
	855 ha	7%	57%	2,117,273 USD			10 years	

NB: 855 hectares of cultivated corn area in San Jose (pilot area); Foreign exchange rate PhP48.73 to 1 USD

Base from literature, diversified farming contributes positive impact ecologically through increased rainfall infiltration (Thierfelder, Matemba-Mutasa, & Rusinamhodzi, 2015) and decreased soil erosion (Kariaga, 2004). Incorporating the identified environmental benefits, this CRA practice seem more attractive with social NPV of around PhP116,845 (2,398 USD).

Out scaling the analysis to total corn production areas in the community, at estimated 57 percent adoption rate, results to aggregate present value of benefits at PhP103 million (2,117,273 USD).

Recommendations

Benefits from corn-banana production exceeds its costs, investment thereof is feasible. Investment is maximize when accompanied with improved farm management and institutional support in terms of road infrastructure. The longer payback period necessitates short-term financial support schemes to adopters. Further, in order to reduce the degree of uncertainty in the evaluation of CRA impacts, the authors recommend allocation of funds to finance further researches toward gaining more information on environmental externalities.

References

Kariaga, B.M. (2004, July). Intercropping maize with cowpeas and beans for soil and water management in Western Kenya. ISCO 2004 - 13th International Soil Conservation Organization Conference. Conserving Soil and Water for Society: Sharing Solutions. Retrieved from [illegible]

[illegible] (2016, February 26). Drought costs Northern Mindanao agriculture almost [illegible]. Interaksyon. Retrieved from [illegible]

Philippine Statistics Authority (2016). Selected statistics on Agriculture 2015. Retrieved from [illegible]

Regional Economic Situationer. Region X (2014). Retrieved from [illegible]

Thierfelder, C., Matemba-Mutasa, R., & Rusinamhodzi, L. (2015). Yield response of maize (Zea mays L.) to conservation agriculture cropping system in Southern Africa. Soil and Tillage Research, 146B, 230-242. [illegible]

This brief was authored by: [illegible]. Completed July 2017.

C. PROJECT MANAGEMENT

1. Summary of Yearly Comments of Evaluators and ctions Taken by Researcher

Objectives/Expected Outputs	Comments/Suggestions	Action Taken
Date of Review and Evaluation: September 27-28, 2016		
Objective/EO 1: To strengthen the capacities for CRA methodologies of key R and D organizations in the region	• This objective seems not appropriate since it is basically orientation/briefing of the SUC staff who will be involved in the project. In this activity, the standard procedure/protocol is presented/discussed and when necessary re-adjusted/refined by local participants to suit local conditions/requirements. As per presentation, training/orientation of RFO team members/other stakeholders has been completed	• After a series of orientation/workshops prior to AMIA 2 implementation, a proposal template was already formulated to come up with more or less uniform and standard proposal that participating SUCs/RFOs will conform. As such, the objectives were already agreed upon by all AMIA 2 SUC implementors. The difference though is on the selection of sites and crops/fishery resources Training on CRA methodologies was targeted to SUC and RFO teams to come up with standard protocols and methods, understandably, to come up with cross-regional and national analyses of the outputs
Objective/EO 2: To assess climate risks in the regions agri-fisheries sector through geospatial and climate modelling tools	• Major outputs lie on objectives 2,3 and 4. However, there were no further discussion as to how the data, particularly those GIS related, could be linked with the national team level joint analysis of cross-regional data considering standard map scale and base map • Please be clear on how each element in the vulnerability index is scored and this should be done through participatory	• This requires levelling-off and discussion with CIAT and all AMIA 2 SUC implementors to address the concerns on joint data analysis, vulnerability index and the use of vulnerability tool. This is to have common and standard analysis for all to allow national –level comparison and analysis. As such, the AMAI2 at CMU cannot individually respond to this comment. • During the workshop of the finalization of the proposal, it has already agreed that AMIA 2 at CMU will focus on Bukidnon Province, specifically on corn, rice, coffee, cacao and tomato as the major crops. These also coincide with the major crops of the region. This has been agreed after a series of consultations and discussions, including the RFO and the local agriculture office of Bukidnon and Malaybalay (for CRA practice). Inland fishery was

Objectives/Expected Outputs	Comments/Suggestions	Action Taken
	activities • The project is focused on agri-fisheries, hence the reports should highlight both agriculture and fisheries. • It is suggested for the proponent to familiarize with the BSWM's Vulnerability Assessment (VSA) Tool to avoid duplication of efforts and unnecessary use of resources	not included. The team may consider changing the title but this needs approval from CIAT and DA-BAR. • The team is following the standards set by CIAT for uniformity and to allow for cross-regional analysis.
Objective/EO 3: To determine local stakeholders' perceptions, knowledge and strategies for adapting climate risks	• It is important to consider the measurement indices for farmer's understanding , attitude and perception on climate change	• This concern needs levelling-off and discussion with CIAT and other SUC implementors. At this stage, CMU still has to level-off with CIAT since this needs primary data gathering, in cases where these are not available in local agriculture offices. • These data can be gathered if this questions will integrated in FGDs and KII for CRA practices.If this entails all cities/municipalities, then it will have a budget implication. As such, there has to be a common protocol on this objective
Objective/EO 4: To document and analyse local CRA practices to support AMIA 2 knowledge-sharing and investment planning	• Documentation of local practices through FGD may have to be done deeper (i.e. technical validation of these practices, how it works; related CBA and why it works; what makes it work; what are the institutional and social factors • Kindly attach the profile of FGD participants in the report. • Clarify the process and criteria for identifying CRA practices	• The corn farming practices enumerated during FGD allowed farmers to survive natural calamities. The data were then subjected to initial analysis and narrowed down to two (2) CRA practices considering the dimensions of climate resilient agriculture (weather, soil, energy, water, and value chain smart) as well as the number of potential adaptors and sustainability. The output of the analysis will still be validated to gather a deeper understanding of why such CRA practice will work and is appropriate to respond to the identified climate risks. • A profile of FGD participants was prepared as shown in Appendix B.2. of this report. This profile will also be presented to CIAT to conform with other SUC AMIA 2 implementers.

Objectives/Expected Outputs	Comments/Suggestions	Action Taken
	Please work out on how the regional and national profiles be complemented/harmonized to come up with a comprehensive output.	• The standard used in the selection of CRA are: "weather smartness, soil conservation, efficiency in energy and water utilization, and value chains in ranking CRAs for potential investments" as discussed in Section 2.4.3.
Objective/EO 5 To establish AMIA baseline for outcome monitoring and evaluation (M & E) of CRA communities and livelihoods	• This objective does not seem to be deliverable. The project is supposed to come up with recommended strategies to reduce impact of climate change • Please revise this objective. The SUC should instead provide inputs for M and E rather than to establish it	• AMIA 2 will provide the baseline data using the parameters applied in this project (e.g. crop occurrence, vulnerability indices, adaptive capacity indicators, etc). The baseline data generated in AMIA 2 become the basis for M and E. However, the M and E component protocol is still to be discussed through workshop as reflected in the Work Plan
Management	• The project started last August 2016 with an approved duration of 9 months	• Although project orientation/ trainings/workshops on AMIA 2 were conducted last May/June 2016, the project formally started in August 2016 due to some delay in the release of the budget.
Financial	• The total approved budget for the project is PhP999,993.00 with an initial release of PhP499,996.50	• The first tranche of the budget was released last August 15, 2016.
Others	• What was noticeable in the report was the project location which is Malaybalay City. It should be emphasized that project coverage for CRA is the whole province of Bukidnon. This is to be consistent with other RFOs/Provinces • Please arrange the legends in the maps in the chronological	• Comments on CRVA and vulnerability indicators will be addressed as one national project under AMIA 2, with CIAT leading the discussion. • AMIA 2 implemented by CMU is focused on Bukidnon, covering all the municipalities and 2 cities. However, CRA practices and CBA will focus on farming practices of corn growers in Brgy San Jose, Malaybalay City. This is following the criteria established as well as on the recommendation of the local agriculture offices. • Due to some data limitation and availability, the final CRVA output will still have to be refined. Hopefully, these will be available during the scheduled stakeholders' validation. The relevance and use of the generated data and maps could be discussed as well so both CMU and stakeholders will be able to assess how these can be useful in specific local or national

Objectives/Expected Outputs	Comments/Suggestions	Action Taken
	order • Please make sure that the CRVA (refined or not) should be taught to the stakeholders who will use the information • Kindly clarify how the CRVA will be deployed and delivered • There are concerns on international recommendations and its relevance to what is actually felt on the ground • Please emphasize the value of the vulnerability maps and how we will make use of it • The regional proponents should be aware and understand the assumptions on why the indicators are important. The models to be used may be specific/applicable only in a locality • Please be clear on the CRVA and its concepts and methodologies. This should be included and highlighted in future trainings. Also, about the use of VA-related words (e.g. adaptive capacity) • The project is expected to come up with refined CRVA tools and customized maps per region. Also, expected deliverables of the project (among others) include: standard framework/guidelines in the conduct of CRA; and	programs/projects implemented at the regional, provincial and/or local levels. Discussion on publications will be done once outputs and maps will be finalized. • (Note: these concerns were already addressed during the refinement of the methodology. These are capture in this terminal report)

Objectives/Expected Outputs	Comments/Suggestions	Action Taken
	revised/refined framework as the RFO counterparts see it fit for their area/location • The project will be refining existing CRVA tools rather than actually creating new ones. The improvements/modifications in the refined tools should be reported The evaluators hope to see publications and information sharing schemes under the project about the documented CRA activities	
Recommendation The project is good for continuation provided that comments and suggestions are taken into consideration. **Date of Review and Evaluation: April 10, 2017**		
Objective/EO 1 To strengthen capacities for CRA methodologies of key research and development organizations in the region	• Kindly specify the indicators for this objective	• Since this is a national project, protocols of the methodologies were standardized by CIAT. The GIS expert of CMU team is already knowledgeable of the Maxent model used in this project. Over-all, the specific members of the team have been capacitated, particularly on CRVA and CBA tool through the participation in the series of trainings and workshops conducted and facilitated by CIAT. As such , indicators for this is the number of trainings/worskhops participated by specific experts of the team, i.e. GIS, Socio-econ. The list of trainings/workshops participated are summarized in the Table3 of this report.
	• To what extent is the capacity of partners for CRA methods improved (from _% to _%	• Since the protocols and methodologies are developed by CIAT, skills of experts in the team has improved from 50-100% for both CRVA and CBA tool
Objective/EO 2 To assess climate risks in the region's agri-fisheries sector through geo-spatial	• Please coordinate with CIAT and other SUCs to standardize the map elements (e.g. color, legends, scale, etc) and validation of results	• The maps generated in this project followed the standards agreed during the series of workshops and discussions (see Table 3) at UPLB and PSU in Camarines Sur.

Objectives/Expected Outputs	Comments/Suggestions	Action Taken
and climate modelling tools	• The suitability of crops for 2050 will depend on the vulnerability. It is suggested that hazards are not aggregated in one map. The suitability map developed per crop should depend on the limiting factor	• CRVA methodology of CIAT (see Palao, et al, 2017) already aggregated the hazards. CMU follows this protocol for standardization of outputs and cross-regional analysis of CIAT
	• The project is agri-fisheries, kindly report why fisheries was not included in the assessment	• The title of this project has already been revised. It was changed from Agri-fisheries to Agriculture. It is also emphasized in the report that Bukidnon only focus on 5 crops: corn, rice, cacao, tomato and coffee
Objective/EO 3 To determine local stakeholders' perceptions, knowledge and strategies for adapting to climate risks	• Please report the level of perception of the stakeholders, e.g. LGU, farmers, before and after the project to measure level of improvement in knowledge on CC, VA and SA	• The project only deals with climate change, CRVA and CRA with CBA but no Sustainability Assessment was conducted. In terms of the level of perceptions, farmers level of knowledge was measured as discussed in Section 2.4.2. Local stakeholders' perceptions, knowledge and strategies for adapting to climate risks

Objectives/Expected Outputs	Comments/Suggestions	Action Taken
Objective/ EO 4 To document and analyse local CRA practices to support AMIA2 knowledge-sharing and investment planning	• Please clearly define/identify the standard criteria to classify a technology as "Climate Resilient Agri-fisheries" CRA practices	• The standard used in the selection of CRA are: "weather smartness, soil conservation, efficiency in energy and water utilization, and value chains in ranking CRAs for potential investments" as discussed in Section 2.4.3.
	• Cost returns analysis should make use of more data (sampling) sets	• The number of samples/respondents were increased from 4-12
	• Did you look into other CRA practices aside from biodynamic?	• The other CRA practice is crop diversification, specifically corn-banana as discussed in Section 2.4.4.
	• Specify whether the chosen CRA practices with investment briefs, were validated/pre-tested at level of intended users	• Results of the CBA and the investment briefs were presented during the feedback and validation. For farmers, it was presented in the vernacular, however, the actual investment brief is written in English (see Appendix D).
	• Learn the appropriate knowledge products (KP) for intended clients: • technical – for SUC, peer – reviewed journal publication; • LGU – info-graphics • c. farmers – cartoon/info graphics with social NPV	• This report is written in publishable form. In fact, each of the components of the report, in the Results and Discussion sections, can be separately submitted for journal publication. Maps and data were turned-over to partners – Bukidnon LGU (Agriculture, Planning and Development), Malaybalay City Agriculture Office, DA RFO-10 - in digital form. However, infographics and other KP were not done in this project. Data generated from this project are stored in computer and external drive.

1. Problems Encountered and Recommendations

1.1. Technical

Problems Encountered	Actions Taken/Recommendations
This project is dependent on CIAT for the standard protocols and procedures of specific methods for CRVA and CBA for cross-regional analysis.	CMU team participates in all the workshops/trainings and discussions on the standardization and refinements of the methodologies. There were several changes made on the model, calculation and map presentation to conform with the standard protocols. Concerns were immediately raised to CIAT for appropriate and correct actions.
Data generated, specially those used in the CRVA modelling and CBA tools, are dependent on the sources.	Data were validated on field and during the feedback and validation activities.
Since the project methodologies and standards are dependent on CIAT, the team has to wait for the schedules of trainings/workshops and discussions for standardization. This somehow had impact on the schedules.	Team constantly communicates to CIAT for clarification to ensure that the outputs conform with the standards. Team managed the activities and schedules to deliver outputs on time, as much as possible.

1.2. Administrative

Problems Encountered	Actions Taken/Recommendations
Delay in the delivery of requested supplies and equipment (laptop) due to bidding and procurement procedures	Constant follow-up with Administration. The Enumerator was requested to extend services for administrative work to enable timely release of supplies
The Financial Audited Report was only finished and delivered to the team on August 23, 2017 with unexpended balance, which could have been used within the duration of the project. The team was not able to meticulously monitor and keep track of the expenses since activities focused on the technical aspect of the project.	Team can request from DA-BAR to use the unexpended balance, with endorsement from the University President. The remaining amount could be used for general research equipment and production of IEC (e.g. printers; publication expenses, map atlas). The team should come up with the detailed expenses. Monitoring and tracking of expenses should have been closely done by the team and not solely rely on the reporting of Administration/Finance Office. An administrative staff should be able to focus on the financial transactions so it could have a more accurate financial recording.

2. Summary of the Project

    This project is just a component of the CIAT-led national AMIA2 project of the DA-SWCCO. As such, the protocols and procedures of the methodologies followed those set by CIAT for standardization and cross-regional analysis. Throughout the duration of the project, the team maintained close coordination and communication with CIAT to ensure that outputs generated follow the standards. These were done through a series of communication exchanges and active participation in the trainings/workshops.

    Administrative concerns are raised to DA-BAR who promptly attended and responded to the team's queries and clarifications. Thus, the team is extremely grateful to DA BAR technical staff, particularly to Mr. Danielle Sisican.

    Coordination and partnership with project partners were critical in the implementation and delivery of the outputs of this project. The team managed to regularly meet to level-off and discuss management concerns so these could be promptly responded. The main drawback of the implementation is the financial monitoring and reporting which resulted to an unexpended balance.

3. Audited Financial Report (BAR/QSF-B.01.05a)

    See attached copy

PDepartment of Agriculture
Bureau of Agricultural Research
RDMIC Bldg., Elliptical Rd. Cor. Visayas Ave., Diliman, Q.C. 1104
Phone Nos.: (632) 928-8624 & 928-8505 • Fax: (632) 927-5691
Email:bardegrants@bar.gov.ph• Website: http//www.bar.gov.ph

AUDITED FINANCIAL REPORT

From: August 2016-June 2017
(Period covered by the report)

Project Title: Region 10 Climate-Resilient Agri-fisheries (CRA) Assessment, Targeting & Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 2: Focus on Bukidnon Province
Proponent: Angela Grace Toledo Bruno
Lead Agency: Central Mindanao University
Address: Musuan, Bukidnon
Check No. / Amount / Date 101101-08-015-2016 / 499,996.50 / August 15, 2016 and 101101-12-010 / 499,996.50 /Jan. 20, 2017

Expense Code (Particulars)	Approved Budget (A)	Amount Released (B) Note: as per approved Re-alignment	Cumulative Expenditures (C)	Balance To Date (B-C)
Personnel Services (PS)	320,490	320,490	319,353.96	1,136.04
Maintenance and Other Operating Expenses (MOOE)	588,075	594,075	547,997.48 ~~548,957.48~~	46,077.52 ~~45,177.52~~
Equipment Outlay (EO)	46,000	40,000	39,500	500
Administrative Cost	45,428	45,428	22,644	22,784
TOTAL	**999,993**	**999,993**	929,495.44 ~~**930,455.44**~~	70,497.56 ~~**69,537.56**~~

PREPARED BY:	CERTIFIED CORRECT:	NOTED BY:	VERIFIED BY:
ANGELA GRACE TOLEDO-BRUNO	DYNNITH F. SUABERON	MARIA LUISA R. SOLIVEN	ROSALIE N. PELONIO
Project Leader/Director for Research	Chief Accountant	Agency Head	Auditor
8/25/2017	9-11-17	9/14/17	9/28/17
Date	Date	Date	Date