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REGIONAL CLIMATE-RESILIENT AGRI-FISHERIES (CRA) ASSESSMENT, TARGETING AND PRIORITIZATION FOR THE ADAPTATION AND MITIGATION INITIATIVES IN AGRICULTURE PHASE 2 (AMIA2) IN ISABELA OF CAGAYAN VALLEY REGION (REGION 02)

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EXECUTIVE SUMMARY

This research assessed and mapped the vulnerability of the agri-fisheries sector to climate change and climate-induced hazards in the Cagayan Valley Region (R02) focused in Isabela Province covering 34 municipalities and three cities. This is being carried-out in support to the launching of climate-resilient agri-fisheries (CRA) practices and technologies in local communities under the AMIA Phase 2 (AMIA2) program of the Philippines' Department of Agriculture (DA). Spearheaded by the DA-System Wide Climate Change Office (SWCCO), the Adaptation and Mitigation Initiatives in Agriculture (AMIA) is a flagship program of the Department of Agriculture (DA) that seeks to plan and implement strategies to support local communities in managing climate risks. In order to implement the program, the DA-Bureau of Agricultural Research (BAR) established a linkage with the International Center for Tropical Agriculture (CIAT) and DA RFO2 and the SUCs.

With the Isabela State University – Cabagan Campus (ISU-Cabagan Campus) as the implementing partner, carried-out the Climate Risk Vulnerability Assessment (CRVA) in the Province of Isabela through geo-spatial assessment or GIS-based modelling to assess vulnerability from climate change and variability and adaptive capacity of each municipality in the province.

In Isabela Province, the major agri-fisheries commodities that are focused of the analyses are rice, corn/maize, eggplant, squash, tilapia, and mango using modeling and statistical techniques that consider climate change and its impacts, climate variability, and social and economic variables, both at the level of local government units (LGUs) and households.

The CRVA in this research used modelling and statistical techniques that are appropriate considering climate models, crop distribution model, and econometric models, together with their uncertainties and limitations. The CRVA framework for the agriculture sector encompasses three major components: (1) Exposure – the nature and degree to which a system is exposed to significant climate variations (IPCC 2014); (2) Sensitivity – the increase or decrease of climatic suitability of selected crops to changes in temperature and precipitation, and (3) Adaptive Capacity – the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2014). The sensitivity analysis is based on the assumption of a high emission scenario by 2050 (RCP 8.5) whereas the adaptive capacity component is derived from the most up-to date available data mainly from 2015. Further, this research also identified a set of

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prioritized CRA practices to select for investment to scale up for decision support platform at the national level to plan using the CBA trade-offs and develop strategies to vulnerable areas in order to promote CRA communities. A series of workshops were conducted for data identification and processing, analysis and validation.

With 20 bioclimatic variables, the Maxent Model was used in assessing the climate and climate change suitability of crops considering the baseline conditions and Year 2050 future conditions. The most prominent hazards in Isabela Province – which was rated high by the Isabela Project Team – are typhoons, floods, and soil erosion. The adaptive capacity index for this vulnerability assessment considered different capitals, such as economic, natural, human, physical, and institutional capital. There are many indicators that could form a strong adaptive capacity index, but data availability was a driving factor in establishing the final index particularly for Isabela Province.

For the CBA, focus group discussions (FGD) and key informant interviews (KII) were conducted. Likewise, an interview schedule instrument was employed gathering primary data from the Municipalities of San Mateo, Cabagan, Sta. Maria, San Pablo, Delfin Albano, and Sto. Tomas. Some important data and other information on inputs and outputs were taken from the barangay profiles and other secondary information gathered during the series of workshops, FGD sessions, and fieldwork.

Based on the result of the model, the climate suitability areas for rice, maize (or corn), squash, eggplant, and tilapia production in the province is projected to expand with significant future gains (i. e.,Year 2050 projection) specifically for maize (or corn), rice, eggplant, squash, and tilapia in that order. This positive gains of climate suitability for these crops has corresponding consequences on the reduction of the Sierra Madre Natural Park and Protected Areas on the eastern side of Isabela Province. It is also interesting to note that the eastern part of the province up to the coastal areas found out to be having a low suitability to grow tilapia in the face of climatic change. These areas are adjacent or covered by the Sierra Madre Mountain Range and the coastal areas facing the Pacific Ocean.

On the other hand, mango production in the Isabela Province shows a declining trend in terms of climate suitability areas for the 2050 projection year. As affected by climate change, the result of this study showed that moderately high suitability of mango production is to be concentrated at the mid-western part of Isabela Province.

Typhoons, floods and erosion are the most prominent hazards in the Isabela Province. As a result, the overlay of these three major hazards (i.e., typhoon, flood and erosion) resulted to a

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high incidence of hazards in the province.

Six municipalities of the Isabela Province are classified as having very high adaptive capacity (i.e., Tumauini, Ilagan, Quirino, Gamu, Alicia, Angadanan) with about twelve (12) of them (i.e., Santa. Maria, San Pablo, Delfin Albano, Mallig, Divilacan, Luna, Cabatuan, San Mateo, Benito Soliven, Santiago City, San Guillermo, and Jones) having high adaptive capacity. The rest of the municipalities belong to moderate and low adaptive capacity index indicating that the access to quality basic services, private investments, productive employment opportunities, private linkages and other indicators of adaptive capacity in these LGUs of the province is not enough to overcome the negative impacts of climate change and hazards.

Also, the result of the assessment for adaptive capacity for each LGU in Isabela Province shows that the coastal Municipality of Dinapigue revealed its very low adaptive capacity index. During field validation, the team assessed that the ability of the community to cope with climate change and disaster impacts relies on the inadequate support facilities and services and capabilities of LGU Dinapigue. Accordingly, the main factor that constrains their capacity to adapt is the geographical location of the town indicating that supports and development opportunities to the populace of the municipality are quite weak and/or inadequate.

The results of the CRVA, on a province-wide area basis, indicated that 917,066 (86%) hectares of the province is vulnerable to climate change and variability. It only indicates that the capacity to adjust to climate change to the affected areas is very low. However, the remaining 149,390 (14%) hectares of the province showed low vulnerability but has higher adaptive capacity.

In general, it is observed that the LGUs' adaptive capacity has an inverse relationship with its vulnerability to climate change and variability and hazards. That is, an LGU with a low adaptive capacity is highly vulnerable to changes in climate (i.e., increasing temperature, rainfall and number of dry days) and hazards. For example, in the Province of Isabela, the Municipality of Divilacan has a low adaptive capacity and correspondingly is highly vulnerable to climate change and occurrences of hazards. On the other hand, Ilagan City is high in adaptive capacity but with low vulnerability. Therefore, enhancing the adaptive capacity of an LGU is necessary in order that such LGU will become climate-resilient.

Overall, the research on Climate Risk Vulnerability Assessment (CRVA) in the Province of Isabela through geo-spatial assessment or GIS-based modelling to assess vulnerability from climate change and variability taking into account sensitivity factors, exposure conditions and adaptive capacity of each municipality in the province showed that only one city (Ilagan City) and one municipality (San Mateo) have very low vulnerability index.

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Ilagan City is a first class city and fully realizes its potential as one of the investment hubs in the country and witnessed the extensive development. It is the largest LGU in Isabela Province with 91 barangays and also called as the "Corn Capital of the Philippines". The Municipality of San Mateo, on the other hand, is a second class municipality and popularly known as the "Mungo Capital of the Philippines" because of its extensive mungbean production employing the integration of mungbean as one crop in the crop rotation technique of the farmers production systems.

Thus, considering development opportunities such as agri-based industry, commercial establishments, tourism potential, cooperating private organizations and socio-economic base income that ensures well-being in an equitable and sustainable manner, these two LGUs would definitely entails a secured community due to its ability to overcome the effects of climate change and hazards. Furthermore, four municipalities (i.e., San Mariano, Cauayan City, Santiago City, and San Agustin) have moderate vulnerability index. The more interesting concern is the very high vulnerability to climate change and hazards of the remaining 31 municipalities. It implies that these municipalities do not have the appropriate adaptation measures and so they are vulnerable to natural hazards brought about by climate change and variability.

For the CBA conducted for the purpose of prioritizing CRA practices in order to have a basis for the selection of projects or investments to scale up by DA-RF02 in AMIA2+ structure, the results showed that the CRA practices in the study sites yielded wide ranges of the values of the profitability indicators such as NPV and IRR. One of the CRA practices is the Climate Resilient Varieties (CRV) which undertakes the planting of short-maturing rice varieties (NSIC Rc 216 or NSIC Rc 222) while the Adaptive Crop Diversification/Rotation (ACDR) is the planting of rice-rice-mungbean. Basically, the Integrated Farming System (IFS) refers to agricultural systems that integrate livestock and crop production. Based on the CBA, the CRV practice has an IRR only of about 40 percent while the ACDR has about 50 percent and IFS has about 118 percent IRR. Except for IFS, the values of the IRR almost doubled when the externality factor of 50 percent increases in soil fertility due to the CRA practice. Accordingly, it is also important to look at the other financial values, such as initial investment and annual costs and yearly income, as well as the socio-cultural and policy support aspects of the CRA practices in order to build up knowledge and find clear explanations why farmers adapt these CRA practice,. Many researchers also observed the significant contribution of the above factors to households' decision-making related to their livelihood and existence. As indicated above these decisions emerged as adaptive strategies due to climate change and natural hazards.

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The CRAs are adapted as a way of spreading risks due to climate change thereby affecting production quantity and quality, price fluctuations and ultimately farmers' net income. A drought or too much rainfall immediately after planting or during flowering stage of plants causes crop yield to decline. Likewise, prices of agricultural products during harvesting time ultimately decrease agricultural income even with good harvest. In a rural setting, some period of the year, especially between harvest time and summer season, household members usually experience idleness. Thus, the other components of an integrated farming particularly growing vegetables and other cash crops can be done during the idle period thereby allowing farmers to generate relatively good income for the family.

Correspondingly, the DA – RFU Region 02, as the main user of the CRVA output, have already selected vulnerable sites (municipalities) where CRA actions will be implemented, particularly in the Municipality of Benito Soliven and the City of Ilagan. The Municipality of Benito Soliven is highly vulnerable to climate change and natural hazards although it has high adaptive capacity. The City of Ilagan, on the other hand, it has very low vulnerability to climate change and natural hazards although exposed to climate change and natural hazards. This low vulnerability condition of the city may be due to the very high adaptive capacity of the city government that indicates their capability to overcome the negative effects of climate change and variability.

Lastly, it is important to note that the results are based on modeling results (and realistic assumptions for CBA) which have intrinsic uncertainties and limitations. As such, any agricultural development initiatives using the output of this study in the Province of Isabela should be made in consideration with specific conditions of local communities. However, with all these limitations, the results of this research are in broad agreement with existing literatures on climate change impacts as well as realities in terms of vulnerability.

Furthermore, the CRVA output can be used to inform and guide decision makers from government agencies, extension staff, and private sectors on geographic areas that are in most need of interventions, and what package of interventions are needed for each geographical area. It also provides options and other opportunities for cross-sector collaboration between different government agencies, non-government organizations, and private sectors.

It is highly recommended to expand the assessment to a landscape scale vulnerability assessment on a municipality level. It is also suggested that there should be continuous checking and scrutiny of the accuracy of data and other information at the local level to ensure correctness to the future scenarios (as in the case of climate suitability models) as well the economic sustainability.

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While the climate crop suitability scenarios generated in this research are important component of CRVA, they are also indispensable in conceptualizing and developing research interventions in terms of improving agricultural practices and crop management to adapt climate change and variability and natural hazards.

It is expected that the result of the CRVA in the Province of Isabela is now being used to apply for bigger funding from international donors to help Philippines adapt to climate change and variability and natural hazards. It is also now used by the Department of Agriculture for planning and prioritizing project interventions in the Philippines.

BASIC INFORMATION

1. Title of the Project: **Regional Climate-Resilient Agri-Fisheries (CRA) Assessment, Targeting and Prioritization for the Adaptation and Mitigation Initiatives In Agriculture (AMIA2+) Phase 2 in Isabela of Cagayan Valley Region (Region 02)**

2. Proponent (s):

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3. Implementing Agency:

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3.2 Collaborating Agency (s):

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3.2.2 International Center for Tropical Agriculture (CIAT)
3.2.3 Local Government Units (LGUs) of Isabela
3.2.4 Department of Agriculture-Cagayan Valley Research Center (DA-CVRC), San Felipe, Ilagan, Isabela

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4. Project Site(s)
   4.1 Province (s):
   - 4.1.1 Region I – Ilocos
   - **4.1.2 Region II – Cagayan Valley**
   - 4.1.3 Region III – Central Luzon
   - 4.1.4 Region IVA – Southern Luzon
   - 4.1.5 Region V – Bicol
   - 4.1.6 Region VI – Western Visayas
   - 4.1.7 Region X – Northern Mindanao
   - 4.1.8 Region XI – Southern Mindanao
   - 4.1.9 Region XII – North Cotabato
   - 4.1.10 Region XVIII – Negros Island

5. Project Duration:
   5.1 Starting date of Implementation: June 2016
   5.2 Approved Duration: 13 months (1 June 2016 to 30 July 2017)

6. Project Location: Isabela Province, Cagayan Valley, Region 02

7. Total Budget Requirement:

7.1. Approved Budget:	Php1,000,000.39
7.2 Total expenses used:	Php.1,000,000.39
7.3 Remaining/Actual Budget:	Php.0.00

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This research project efficiently attained its goal and objectives because of the sustained cooperation of key informants, FGD and validation participants, survey informants, other LGU officials and bonafide residents in the Province of Isabela. To everyone, the Project Team Members extend their wholehearted thankfulness and appreciation.

Above all, to the Almighty God, the Creator of heaven and earth, for all the blessings He bestowed upon the Project Team, for the sustained strength, provision of every need and protection during field works as well as the spiritual and intellectual inspiration to persevere under various strenuous circumstances.

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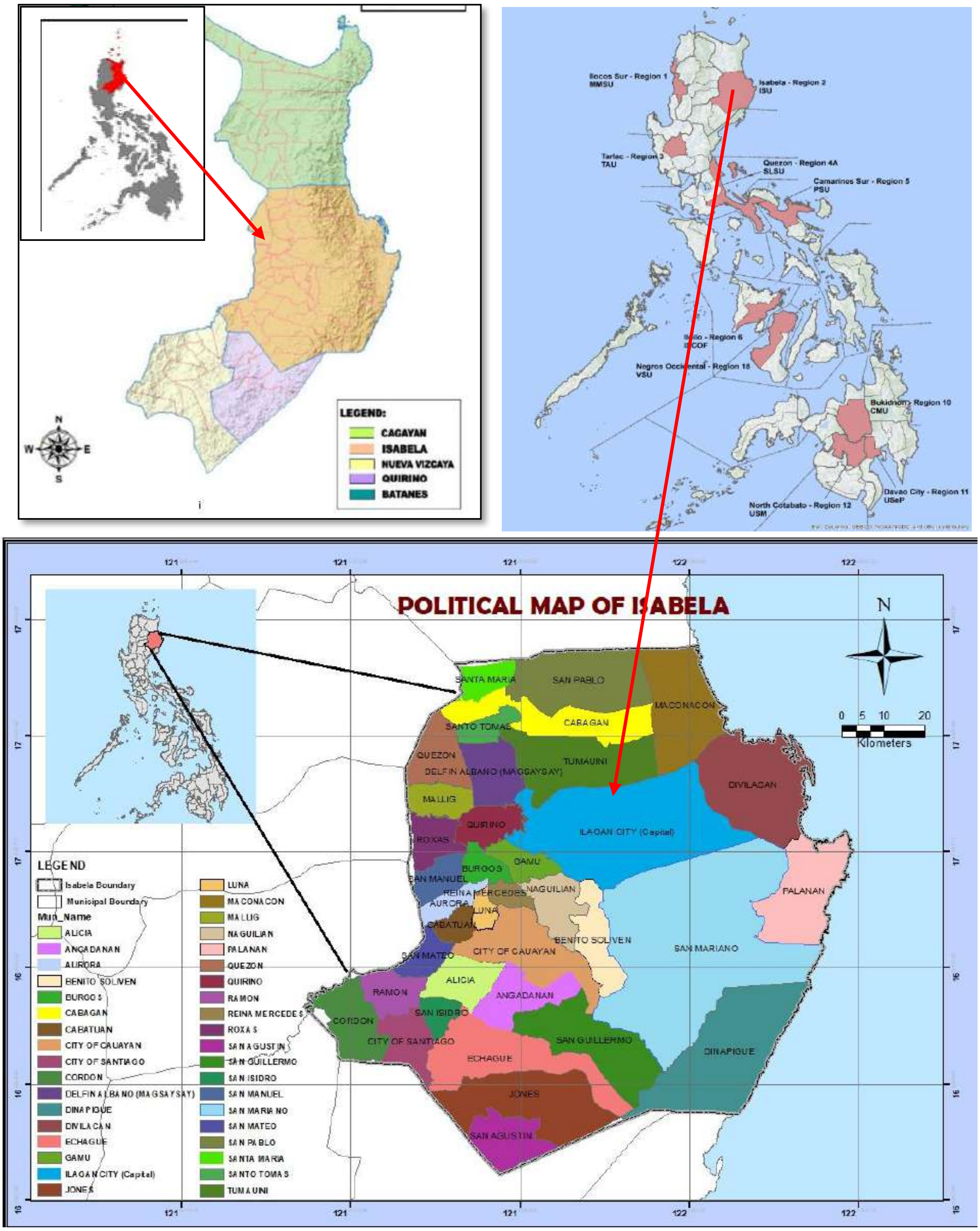
ADMINISTRATIVE MAP OF THE PROVINCE OF ISABELA, REGION 02



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LIST OF ABBREVIATIONS

AC	Adaptive Capacity
ACDR	Adaptive Crop Diversification/Rotation
AMIA	Adaptation and Mitigation Initiatives in Agriculture
ATI-RTC	Agricultural Training Institute – Regional Training Center
BAS-BAPS	Bureau of Agricultural Statistics – Barangay Profiling System
CBA	Cost and Benefit Analysis
CC	Climate Change
CCVPED	Center for Cagayan Valley Programme on Environment and Development
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
CLUP	Comprehensive Land Use Plan
CRA	Climate Resilient Agri–Fisheries
CRV	Climate Resilient Varieties
CRVA	Climate Risk Vulnerability Assessment
CSI	Climate Suitability Index
DA-BAR	Department of Agriculture – Bureau of Agricultural Research
DA-CVRC	Department of Agriculture – Cagayan Valley Research Center
DA-RFO	Department of Agriculture – Regional Field Office
DA-SWCCO	Department of Agriculture – System-Wide Climate Change Office
DENR-EMB	Department of Environment and Natural Resources – Environmental Management Bureau
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GCMs	Global Climate Models
GIS	Geographic Information System
IFS	Integrated Farming System
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
IRRI	International Rice Research Institute

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LFP	Livelihoods and Forestry Programme
LGU	Local Government Units
M & E	Monitoring and Evaluation
MAO	Municipal Agriculture Office
MGB	Mines and Geosciences Bureau
MOOE	Maintenance and Other Operating Expenses
NCCA	National Consumer Credit Protection Act
NEDA	National Economic and Development Authority
NGO	Non-Government Organization
NPV	Net Present Value
OCD	Office of Civil Defense
PAR	Philippine Area of Responsibility
PCAARRD	Philippine Council for Agriculture and Aquatic Resources Research and Development
PSA	Philippine Statistics Authority
ISU	Isabela State University
RCP	Representative Concentration Pathways
RTWG	Regional Technical Working Group
SFR	Small Farm Reservoir
SI	Sensitivity Index
SIRR	Social Internal Rate of Return
SNPV	Social Net Present Value
SUC	State Universities and Colleges
VA-TURF	Vulnerability Assessment of Coastal Fisheries Ecosystems to Climate Change – Tool for Understanding Resilience of Fisheries

1. RATIONALE

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 SCCO), AMIA Phase 1 in 2015 – 2016 implemented activities to strengthen DA's capacity to mainstream climate change adaptation and mitigation strategies in its core functions of Research and Development, Extension, and Regulation. It is also designing complementary activities for building appropriate climate responsive DA support services.

With AMIA Phase 2 (AMIA2) in 2016-17, the next big challenge is making climate-resilient agri-fisheries (CRA) an operational strategy through field-level action that directly involves and impacts on the livelihoods of farming communities. 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. The program is launching an integrated and multi-stakeholder effort to operationalize CRA at the community level in ten (10) target regions.

The AMIA2 program framework consists of nine key clusters of inter-related activities, whose cumulative and combined results are envisioned to help AMIA achieve its goal for 2016 and beyond. For each cluster, a set of projects and activities would be designed towards operationalizing the AMIA framework as follows:

Cluster 1: Enabling environment;
Cluster 2: Vulnerability assessment and risk targeting;
Cluster 3: Developing knowledge pool of CRA options;
Cluster 4: CRA community participatory action research initial phase;
Cluster 5: Enhancing services and institutions;
Cluster 6: Integrating CRA in food systems and value chains;
Cluster 7: Implementing CRA on scale; and
Cluster 8: Knowledge Management for results

The AMIA2 framework provides overall guidance in the planning and design of research and development interventions in 10 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 XII – North Cotabato
10. Region XVIII – Negros Island

Successful implementation of AMIA2 at the regional level requires the strong collaboration and support of key research and development institutions within the region. This proposed 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).

2. OBJECTIVES

The overall objective of this project is to assess, target and prioritize climate-resilient agri-fisheries (CRA) research and development in Region 02 in support of AMIA2.

Specifically, the project aims to:

1. Strengthen capacities for CRA methodologies such as: climate-risk vulnerability assessment (CRVA), CRA decision-support platform, and monitoring and evaluation (M&E) baseline study, of key research and development organizations in the region;
2. Assess climate risks in the region's agri-fisheries sector through geospatial and climate modeling tools;
3. Determine local stakeholders' perceptions, knowledge and strategies for adapting to climate risks; and
4. Document and analyze local CRA practices to support AMIA2 knowledge-sharing and investment planning.
5. Establish AMIA baseline for outcome monitoring and evaluation (M&E) of CRA communities and livelihoods.

3. REVIEW OF LITERATURE

Climate Risks in Agri-Fisheries Sector of Region II

The Cagayan Valley Region is the largest political administrative region located within the Cagayan River Basin, the largest catchment area in the Philippines covering about 27,300 square kilometers. The river basin covers 127 municipalities within Region II (Nueva Vizcaya, Quirino, Isabela, and Cagayan), CAR (Ifugao, Kalinga, Apayao, and Mountain Provinces), and Region IV (mountainous portion of Aurora). With agriculture as the primary economic sector in the Cagayan Valley Region, the impacts of climate change are extremely affecting the majority of the population that depends much of their livelihoods in various agri-aqua production activities. Accordingly, the Office of Civil Defense (OCD) in Cagayan Valley Region (Region 2), reported that the total damages due to floods alone from 2004 to 2006 reached about PhP 4.57 billion. From this amount, approximately 90 percent is accounted for damages to agriculture. The reported values on damages however, accounted only damages to properties and production losses but do not include opportunity losses in production and business activities during flooding. Other climate change events other than flooding as indicated above may have overwhelming socio-economic impacts.

Cagayan Valley has a high rainfall amount (2000-3000 mm per year) and also experiencing rapid rate of deforestation. Typhoon usually bring heavy rainfall causing frequent floods that cause economic problems and damage in the flood plain areas adjacent to the river system (Oosterberg, 1997). Aside from earthquakes, flood cause the most disaster in the Philippines accounting for about 30 percent of all disasters. They affect large number of people because floods usually happen in the floodplains which have distinct damages in terms of magnitude and quality. In comparison, earthquake has more random sequence of occurrences (Bankoff, 2002) than floods.

Rivers usually provide food and drink for business and means of transportations. It enhances productivity of arable land through irrigation. If water flows are harness, it also provides power while an aesthetic environment is realized if its natural conditions are sustained. However, people lived near rivers are also being subjected to floods (Bruijnzeel, 2004).

The effects of floods have been rising in the last decade due to human-induced activities that make communities more vulnerable such as, deforestation, overgrazing, and urbanization. According to Oosterberg (1997), flooding is largely affected by deforestation. In the Cagayan Valley, flooding is mostly induced by storm flows which increased by about 25% with a complete removal of forest vegetation. In terms of sedimentation rate, the magnitude of effect is almost three times higher after forest denudation (Oosterberg, 1997).

Socio-economic Effects of Flooding and Other Natural Hazards

Floods and landslides are often the side effect of tropical cyclones causing much damages and death. Annually, there are about twenty (20) typhoons that passed through the Philippine Area of Responsibility (PAR) (although not all reach on land) and with varying frequencies per year from about 4 to 19 events annually (Mula, 1999). The trends show an increasing impact on the people which can not only linked to demographic trend but the growing concentration of people in marginal urban and degraded rural environment which make them, all the more, vulnerable to natural hazards.

In the study of socio-economic effects of typhoons, Huigen and Jens (2006) concluded that the farm households in the Municipality of San Mariano, Isabela had suffered severe financial damages due to crops loss, livestock loss, and damage of their houses.

Palmiano-Reganit (2005) emphasized in her study about the coping strategy in relation to flood in Naga City, that economic and social coping mechanisms were the most viable strategies in the community. Saving money and storage construction are the mitigating measures included in economic coping mechanism. She stated that social coping mechanism like staying at the house of neighbors or borrowing food and money from relatives were the examples of response and recovery measures that households more focused on. At the different stages of flooding, one of her findings (Palmiano-Reganit, 2005) was that income influenced coping mechanism. Households with less income were more vulnerable than that of households with higher income where they had more access to assistance.

Relevant Case Studies on Coping Strategies

Based on the vulnerability mapping and geo-spatial study in the Cagayan River Basin, Floresca (2011) found out that the highest concentration of high vulnerability are along the Cagayan River and its major tributaries and at the eastern part of Cagayan Valley. This is attributed to the typhoon tracks, steep slopes, presence of protected areas and non-coverage of infrastructure (electricity, irrigation, telecoms). In terms of spatial distributions of vulnerability by province, Isabela has the highest land area with high vulnerability. He concluded that LGUs vary in their adaptation approaches ranging from policy formulation, funding and institution development, manpower development, and project development. The local populace observed climate variability and extremes specifically drought, typhoons and heavy and continuous rains usually causing floods in low-lying areas as well as affecting agricultural areas. Furthermore, different farms vary in the degree of impacts on climate variability and extremes. For example, drought and typhoons highly affected rainfed corn while typhoons and floods highly affected irrigated rice. Typhoons highly affected banana. Cold weather conditions affected tobacco. LGUs were willing to address concerns of vulnerable flood-prone communities through viable project proposals indicated in their formulated climate change adaptation plans with technical assistance from universities.

Decision-making plays an important role in coping strategies which is influenced by the knowledge that a particular risk has earlier occurred and has given the people some experiences (Blaikie *et al.*, 1994). Unprecedented and unknown situation caused much uncertainty because the events cannot show familiar patterns in coping with the disastrous events. People's ideas about how and why hazards occur ultimately govern their actions and behavior and have impacts on their coping mechanisms.

In the Philippines, cultural concepts towards natural hazards can be driven by the belief in the power of God's wrath and religious mysticism. In her study of households in the Cagayan Province, Van der Zanden (2008) observed that the closely related cultural concepts of "being part of the group" (*pakikipagkapwa*), "sanction against breaking ranks with the group" (*pakikisama*), and "toiling on another's behalf and assuming another's burden" *(bayanihan)* are important elements in Filipino's coping strategies. These practices show the influence of shared community values which are important coping practices in cultures with continuing environmental uncertainty.

In coping with natural disaster, Mula (1999) observed that most of the household membership was rather weak and became very loose in a situation of crisis like the Mt. Pinatubo volcanic eruption. The process of coping with the damaged livelihood resources was still a matter of household concern.

In the study of Van der Zanden (2008) on flooding in the Province of Cagayan, most households used important strategies which include translocation, cleaning, supplementing, borrowing and precautionary savings as a risk reduction. These short-term strategies were dominant before, during and after the flood. She also stressed that despite of these traditional and short-term coping strategies, there was a vulnerable relationship between flood and farming because most inhabitants in the floodplains of Cagayan are related to agricultural production and the flood damaged the crops.

Dolcemascolo (2004) likewise concluded that there is a difference between prevention and mitigation in terms of coping strategies. Prevention is based on the avoidance of the adverse impact of hazards and related environmental, technological and biological disasters. Mitigation includes structural and non-structural measures, undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

Factors in coping mechanisms are influenced by the resources and assets available and the magnitude of the flooding. Blaike (1994) observed that households with greater income have often a more diversified livelihood and more financial assets and therefore, recover faster after a disaster.

In Bangladesh, Rasid and Bimal (1987) found out that the inhabitants of the floodplains of Bangladesh have developed a series of indigenous or traditional adjustments to flood over a period of many generations. Cropping patterns have been adjusted to the annual flood and to spread the risk, specific intercropping is used. Silt transported by the floods has a positive influence on the crop fertility and this makes floods as an asset in normal years. However, abnormal floods are considered a hazard because of the damage on crops and properties.
According to the IPCC 2001 report, weather and climate play essential roles on life on earth. Weather and climate play a significant role on human being’s daily routine particularly on health, food production, and water supply, to name a few, to develop their general well-being. The demand for food is said to be endless. The major source of our food is supplied by the agricultural industry. This sector primarily depends on weather and climate.

Climate change will have a domino effect on agricultural and production operations. Climate Change would have a definite impact on crop yields, whether locally, regionally, nationally, and even globally. The additional heat stresses, shifting monsoons, drier soils, and water shortages, to name a few, arising from higher temperatures due to climate change could severely affect farmers including fisher folks. When coupled with pests including weeds and insects, and diseases, this will lead to reduced agricultural productivity and scarcity of water. Consequently, it leads to a reduced food supply. The economic environment will be affected such as lower food supply and thus higher food prices, therefore, poses threats to food security. Thus, steps to avoid damage and likewise, steps in avoiding unwanted or ineffective mitigation measures which may worsen the situation, should be given focus (Fiselier, 1990; Rosenberg *et al.*,1989*;* DENR-EMB, 2010; and http://www.icimod.org). Climate change can radically alter rainfall patterns and therefore require the mitigation of people and shifts in agricultural practices (GKCCBT, 2005).

In the Municipality of Cabagan, Isabela, it was perceived by corn farmers that climate change effects include damage to crops, decrease in crop production, decrease in sales, and doubling of work, of which they were strongly affected. Other effects were increase in expenses to agricultural inputs, and water and food shortage. However, to lessen the degree of impacts; adaptation practices of corn farmers include replanting of the damaged crops, application of pesticides, diversification of crops, application to loaning agency/ies, application of technology like tractors, threshers, water pumps, sprayers and center cars, etc. other adaptation practices were hiring of labor, transfer of things into higher elevation, change planting season and use organic fertilizer and/or compost (Peñaflor, 2014 and Bernardo, 2010).

In other areas of the Province of Isabela, Manguilin (2009) observed that the adaptive strategies of most of the households in the flooded barangays is translocation of their belongings in the rooftops while others secure their livestock or animals, undertook savings, and some borrowed money. Few of the households evacuate to other areas. After the flood event, belongings that were stored in a safe place were placed back. Moreover, cleaning of the house and surroundings, replanting of crops destroyed and borrowing of money from relatives and neighborhood were the other adaptive activities done by the respondents of the study. Based on the correlation analysis of her study (Manguilin, 2009), damage cost is positively correlated with income of the households, corn output, price of corn and loan money. However, there is a negative correlation of damage cost with new activities performed by the households after the flood. Area flooded is positively correlated with area planted, corn output, price of corn and amount of fertilizer. A negative correlation is also observed between current loan and income.

Research and development initiatives for climate-resilient agri-fisheries (CRA) in Region 02

The Cagayan Valley Region (Region 02), in general, is subjected to a wide range of climatic and hazard variability, from typhoons to monsoon rains, to earthquakes and droughts, which perennially bring destruction to agricultural crops, human lives and properties, including social and material resources.

In the Province of Cagayan where majority of its towns are located in a low-lying areas along the banks of major river systems and coastal regions that regularly face the risk of flooding and other calamities. The towns of Enrile and Amulung are on the deltas of the Cagayan River (the biggest and the longest river in the country) while the towns of Pamplona, Ballesteros, Sta.Teresita and Aparri are along the coastal areas. The river systems and coastlines meandering through these towns are the major source of livelihoods for them but also a major source of risks.

Climate change is a global problem and its potential impacts are becoming more severe and the planet itself is becoming more vulnerable as well (DENR-EMB, 2010). In this connection, international conventions discussed environmental issues to have an agreement among governments to accept certain environmental obligations (Blanco, 2004).

In the Philippines, Republic Act 7160, otherwise known as the Local Government Code of 1991, is a national law which grants autonomy to Local Government Units (LGUs) to effectively distribute its powers, functions, responsibilities, and resources to the different LGUs. LCCAD (2012) farther added that RA 7160 indicates plans or programs for development through aggressive and pro-active adaptation and resiliency towards climate change and disasters. In fact, DENR-EMB (2010) stressed that the government must work hand in hand with the different sectors of the society such as Non-government Organizations (NGOs), the academe, private sectors, and others to develop necessary adaptation and formulate policies to cope up with the impacts vis-a-vis climate change. These sectors should be taken into account for the decision-making process. According to Nordhaus (1998), to address complex problem like climate change, policy analysis is essential.

Policies should be on the front line to address complex issues like climate change. The Climate Change Act of 2009 mandates the LGUs on the formulation, planning, and implementation of the Climate Change Action Plans in their respective jurisdiction. And adaptation is one of their regular functions (DENR-EMB, 2010).

4. METHODOLOGY

The project contributed specific outputs as targeted to the national-level research projects as support to the overall AMIA2 program framework. It has five key components:

1. Capacity strengthening for CRA research & development
2. Geospatial assessment of climate risks
3. Stakeholders’ participation in climate adaptation planning
4. Documenting and analyzing CRA practices

As shown in Figure 1, these project components are designed to be directly aligned with the research agenda of three AMIA2 projects: (1) climate-risk vulnerability assessment (CRVA), (2) decision-support platform for CRA, and (3) institutional and policy innovations.

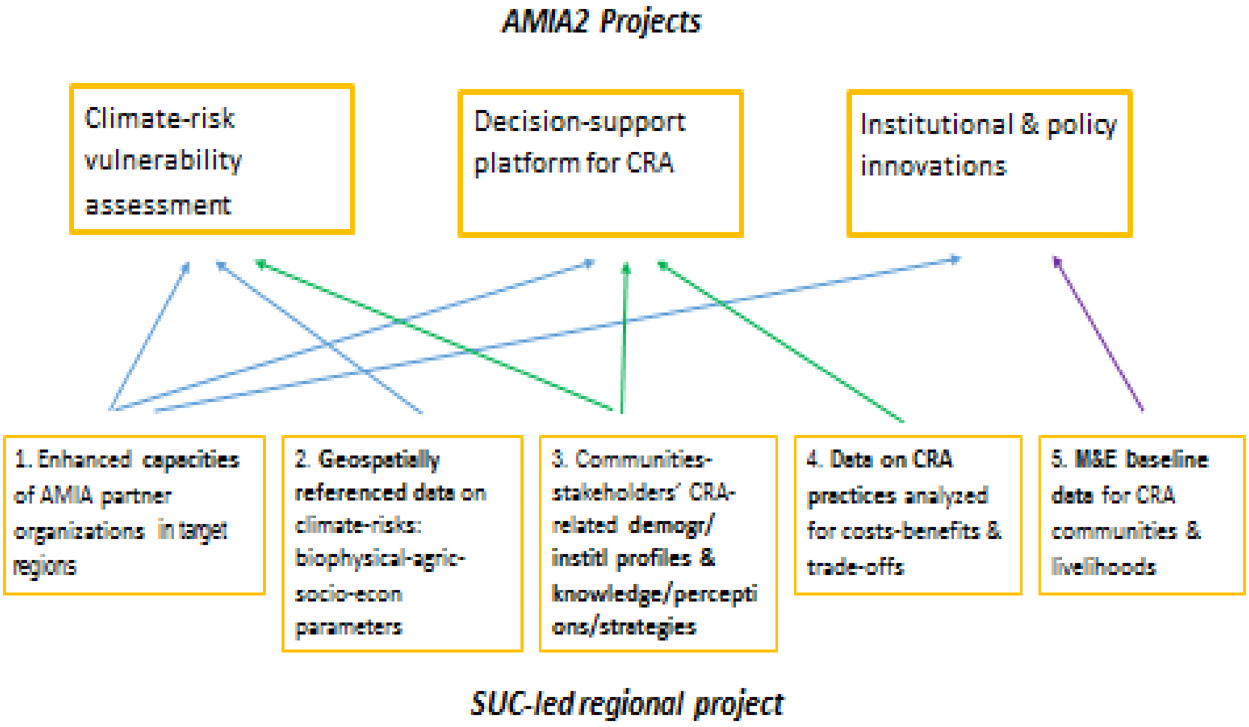

Figure 1. Linking SUC-led Regional Project with AMIA2 Project Portfolio

Component 1 - Capacity strengthening for CRA research & development

The regional project team participated in a series of trainings, workshops and learning events organized by AMIA2 projects. It focused on the two (2) key methodologies: 1) CRVA, 2) CRA prioritization

The project provided training support to key research and development stakeholders in the region through a well-organized intra-regional trainings that covered key learning contents from the national-level trainings.

Component 2 - Geospatial assessment of climate risks

The regional project team collected and organized geo-referenced data on vulnerability to climate risks of the region's agri-fisheries sector. These datasets, from both primary and secondary sources, were based on the methodological guidelines provided by the AMIA2 CRVA project covering climate-risk exposure, sensitivity and adaptive capacity.

Data gathering: The regional team identified five major crops that represented sensitivity to climate risks. Using Global Positioning System (GPS) survey, significant data points were collected with the assistance of the Local Government Units (LGUs) in the province. Moreover, the Adaptive Capacity data were gathered both primary and secondary sources provided by the Municipal Agriculture Offices (MAOs) of each LGU.

Preliminary analysis: GIS and climate modelling tools were undertaken at the regional level. The project team participated in a national-team level joint analysis of cross-regional data.

Component 3 - Stakeholders' participation in climate adaptation planning

The regional project team organized a series of stakeholders' meetings and Focus Group Discussions (FGD) to collect supplementary data and validate preliminary results of CRVA, and commencing with CRA prioritization and planning.

These activities were guided by process facilitation and data collection tools developed by the AMIA2 projects on CRVA and CRA decision-support platform.

Component 4 - Documenting &analyzing CRA practices

The regional project team conducted a semi-structured survey with local stakeholders to identify and document CRA practices, as well as collect existing CRA-relevant statistical and other secondary data.

These data were systematically analyzed, using cost-benefit and trade-off analyses tools (online tool) as input to AMIA2 CRA prioritization and investment planning. These likewise contributed to developing knowledge products, such as searchable online portal, under the AMIA2 project on CRVA decision-support platform. A national working team, consisting of representatives from regional teams, had undertaken these joint tasks.

5. RESULTS AND DISCUSSIONS PER OBJECTIVE

An Overview of Isabela Province

Isabela is the second largest province among the 80 provinces in the Philippines. It is the largest province on Luzon Island having a total land area of 10,655 square kilometers comprising more than three percent of the Philippine territory and almost 40 percent of the Cagayan Valley Region (Figure 2). It has three cities and 34 municipalities with a total of 1,055 barangays and a total land area of 1,066,456 hectares. As of 2010, the total population of the province is 1,489,654 individuals with Average Annual Population Growth Rate of 1.62.

A first class province, Isabela generates an annual total revenue of PhP 1,777,780,001.82**.** Its strategic location is between the Cagayan Economic Zone and the National Capital Center of the country, the Metro Manila. It has productive forest land and watershed areas traversing the Sierra Madre Mountain Range.

Isabela is called as the hybrid corn and rice champion of the Philippines. It is home of the Magat High Dam, a major source of power and water supply of the Northern Luzon. Also, it is the place where the biggest corn processing facility (known as Mindanao Grains) in Southeast Asia is located.

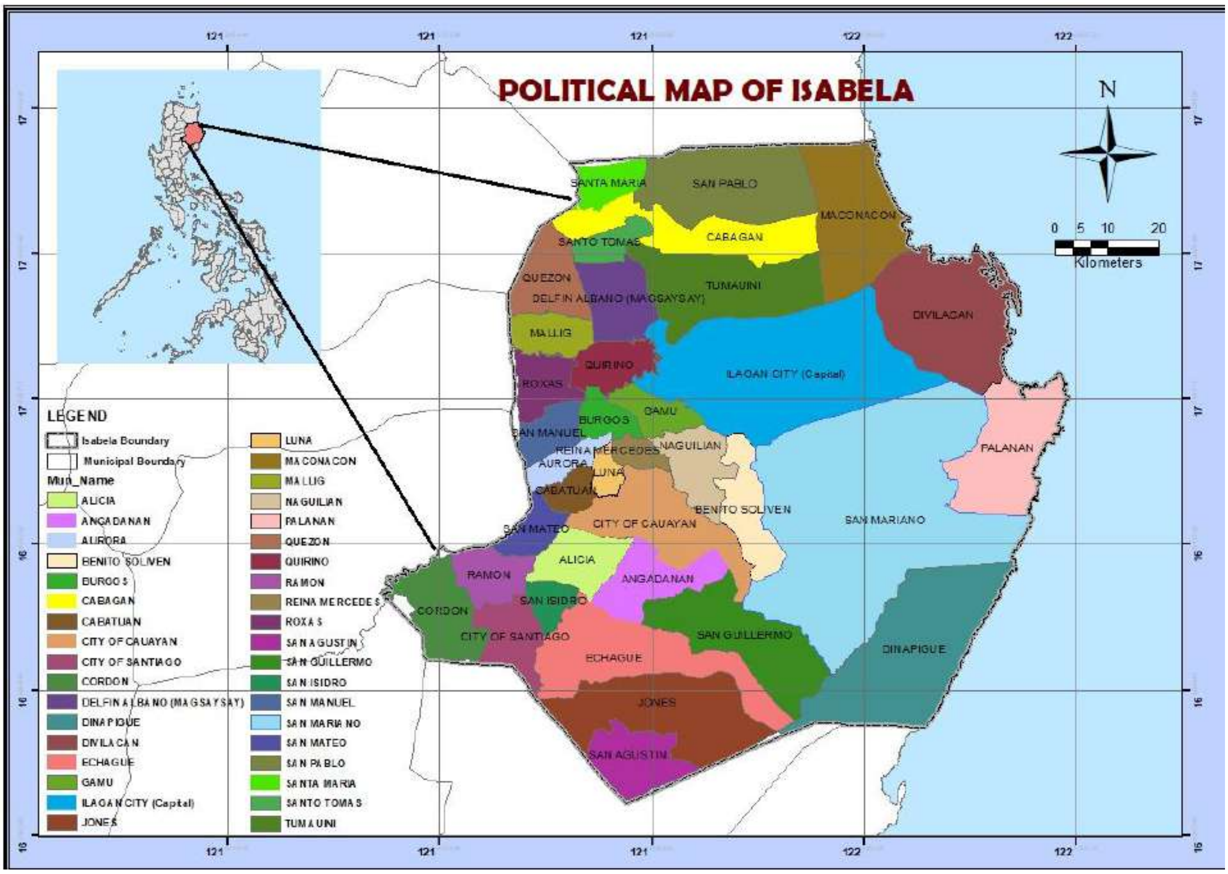

Figure 2. The Political Administration of Isabela Province

The province is a surplus producer of the Filipino's staple crop (i.e., rice), and popularly known also as the Regional Trade and Industrial Center of Northeastern Luzon. With agriculture as the biggest industry in the province, the country's top corn producer – Isabela Province – has an area planted to corn of 235,998 ha and high rice-growing province nationwide with 339,605 ha. However, due to the poor infrastructural development and its geographical location, Northern Isabela is particularly more vulnerable to climate change. From year 2003-2011, nine super typhoon hit the whole Province of Isabela that causes the loss of billions of pesos due to damages to properties and infrastructures with the highest rate of damage in the agricultural industry and human lives. Just last year, Super Typhoon Lawin (Haima) hit Northern Philippines and the Province of Isabelawas heavily impacted by its havoc with 2.5 billion recorded cost of damage in the agriculture sector.

In terms of physiography, Isabela Province is divided into three distinct areas: Western, Eastern, and Coastal Isabela. All three areas are interlinked by the majestic Sierra Madre Mountains, the longest mountain range in the Philippines from which encompassing one of the largest remaining rainforests in the world known as the Northern Sierra Madre Natural Park (NSMNP). This park is a government reservation covering 3,590 square kilometers of terrestrial and marine ecosystems that are rich in genetic species and biodiversity. The park is also considered among the global top ten biodiversity hotspots.

Western Isabela has a flat and rolling terrain subdivided by several tributaries into smaller valleys and plains. It is a fertile valley between the foothills of the Central Cordillera mountain range to the west and the Sierra Madre to the east. Criss-crossing the Western Isabela area is the Cagayan River, the Philippines' longest river.

Vast portions of Eastern Isabela are considered unexplored territory, characterized by thick forestlands and rugged terrain because it is adjacent to the Sierra Madre Mountain Range. These largely unexplored hinterlands may be abounded with a variety of still unnamed flora and fauna with majority of the country's endemic species represented in the protected areas.

Coastal Isabela has 113-kilometer shoreline on the eastern part of Isabela and facing the world's biggest ocean, the Pacific Ocean. It is separated from the rest of the province by the mountain peaks of the Sierra Madre Mountain Ranges. Likewise, the bay area is dotted with small islands and white sand beaches which are also abundant in untapped fisheries and other aquatic resources.

5.1 Component 1 - Capacity strengthening for CRA research & development

Objective 1 – Strengthen capacities for CRA methodologies such as: climate-risk vulnerability assessment (CRVA), CRA decision-support platform, and monitoring and evaluation (M&E) baseline study, of key research and development organizations in the region

A series of trainings and workshops were conducted for learning events as it is indicated in the project objective and overall timeline activities. As shown in Table 1, the training-workshops were focused on planning, capacity building for the project team members in CRVA methodologies, knowledge/methodology and output sharing and validation, and focus group discussion (FGD) on the economic analysis of climate-resilient agri-fisheries (CRA) practices and technologies.

5.2 Component 2 - Geospatial assessment of climate risks

Objective 2 – Assess climate risks in the region's agri-fisheries sector through geospatial and climate modelling tools

To assess climate risks in the region's agri-fisheries sector through geospatial and climate modelling tools, the AMIA2-CIAT Project Team organized and facilitated various workshops, seminars and trainings capacitating the Region 02 Project Team in conducting

CRVA. This is based on the methodological framework formulated by AMIA-CIAT team as shown in Figure 3.

Table 1. Lists of trainings and seminars conducted within the project timeline

EVENT	PURPOSE	VENUE	DATE	REMARKS/ PERSON (S) INVOLVED
1. Planning Workshop on AMIA2-CIAT Projects	Introduction and discussion of the over-all design, target outputs and work plan of the AMIA2-CIAT projects.	UP Los Baños Laguna City	May 19-20, 2016	UPLB-FI DA-RFO's STRIARC AMIA-CIAT Team ISU team Other SUCs team
2. Training and Workshop on Climate Risk Vulnerability Assessment	Capacitating the regional team in conducting CRVA base on the methodology formulated by AMIA-CIAT team	Torre Venezia Suite, Quezon City	June 6-8, 2016	DA-BAR Representatives DA-RFO's CIAT Team ISU Team Other SUCs team
3. Training and Workshop on Cost-Benefit Analysis (CBA) for Climate Resilient Agriculture (CRA) Practices	Strengthening the capacities of regional teams in conducting CBA using the recommended methodological guidelines/tool Discussion and sanctions of the tasks of regional team in Decision- Support platform for CRA Updating of progress report and general planning for CRVA and Decision-support platform for CRA	Torre Venezia Suite, Quezon City	August 4-6, 2016	DA-BAR Representatives DA-RFO's CIAT Team ISU Team Other SUCs team
4. Participatory Training Workshop on CRVA for AMIA2project	Orientation planning for the Municipal Agriculture Office in the province of Isabelaconcerning the AMIA Program	CCVPED, ISU, Cabagan, Isabela	September 08, 2016	ISU Team, CIAT-ASIA, AMIA RFO2, Municipal Agriculturist (s) in Isabela Province
5. Workshop on CRVA	Give an update on the status of data collection for crop occurrences and adaptive capacity	SEARCA, UP Los Baños	January 10-12, 2017	CIAT-ASIA Representatives SUC's

		Run Maxent model to generate crop suitability each provinces Assess and revisit weighting for exposure II - climate related environmental hazards		
6. AMIA-CIAT Project: Results Sharing and Validation Workshop on CRVA & CRA Decision Support	Sharing and validation of results of AMIA 2 (Phase 1) Identifying further variables and improvements of the upcoming CRVA AMIA 2++ (Phase 2) Discussion of a resulting evidence-based strategic plan for climate-resilient agri-fisheries communities CRVA Stakeholder Validation Workshop	Cebu City	February 6-7,2017	Team AMIA 1 BSWM CIAT-AMIA Team DA-RFO's SUC's ISU-AMIA Team
7. AMIA-CIAT Project: Workshop on Finalizing Results on CRA Prioritization, CRVA, and extended CBA	Update on the status of CBA activities and present pre-final results Re-visit of the CBA methodology and explore additional assessment of social and environmental dimensions Preparation for investment briefs	Quezon City	March 1-3, 2017	CIAT-ASIA Team SUC's ISU-AMIA Team
8. Workshop for CRA practices processing	Planning and strategy for data collection process	CCVPED, Cabagan, Isabela	March 21-22, 2017	ISU team
9. Focus Group Discussion of Farmers	Identification of practices and validation of data	CCVPED, Cabagan, Isabela	March 23, 2017	ISU- Team, LGU's and local farmers
10. Output Sharing and Validation of Result of AMAI2 project of ISU-CIAT	Presentation and validation of results on CRVA and CBA in Isabela province	DA-CVRC, San Felipe, Ilagan	April 11, 2017	DA RFO 2 DA-CVRC Manager ISU-Team
11. Output Sharing and Validation of	Presentation and validation of results on	DA-CVRC, San Felipe,	May 17, 2017	LGUs in Isabela ISU-team

Result of AMAI2 project of ISU-CIAT	CRVA and CBA in Isabela province	Ilagan		DA-CVRC Manager
12. Methodology, Output Sharing and Validation of result of AMAI2 project of ISU-CIAT	Sharing of methodology and output developed by CIAT	CCVPED, Cabagan-Campus, Isabela	May 24-26, 2017	ISUC Researchers ISU team
13. Appreciation Course on the use of Climate Resilient/ Vulnerability Assessment for Climate Resilient Agriculture Livelihood Project (CRLP)	Sharing-in valuable technical expertise on CRVA in the province of Isabela	ATI-RTC, CabaganCenter,Isabela	June 27, 2017	ATI-RTC 02 employees, Isabela LGUs, Local farmers, ISU-Team
14. Completion review and Standardization workshop	Finalization and standardization of terminal report	May 31-June 2, 2017	Partido State University (PSu), Goa, Camarines Sur	CIAT SUC's
15. Monitoring and Evaluation workshop	Formulation of Monitoring and Evaluation of AMIA Phase 2+	April 21-23, 2017	Sequoia Hotel, Quezon City	DA RFOs SUCs CIAT

The Climate-risks Vulnerability Assessment (CRVA) framework has three components:

(1) Sensitivity – indicates the changes in climatic suitability measured through external inputs, changes in temperature and precipitation that result in climatic suitability to grow crops from present to future conditions.

(2) Exposure – denotes the nature and degree to which a system is exposed to significant climate variations. It is a combination of natural hazards data sets to which extent a different municipalities are under pressure from climate and hydro-meteorological risks. Most of the datasets refer to historical databases from AMIA1 result. Three out of eight hazard datasets were selected based on the selection process of the project team.

(3) Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. In this study, Adaptive Capacity was classified into five capitals, namely: the economic, natural, social, physical and institutional. The resulting vulnerability assessment will serve as a based spatial targeting agricultural extension and financial investment in areas most at risk or

tailored to a specific hazard, crop or lack of adaptive capacity.

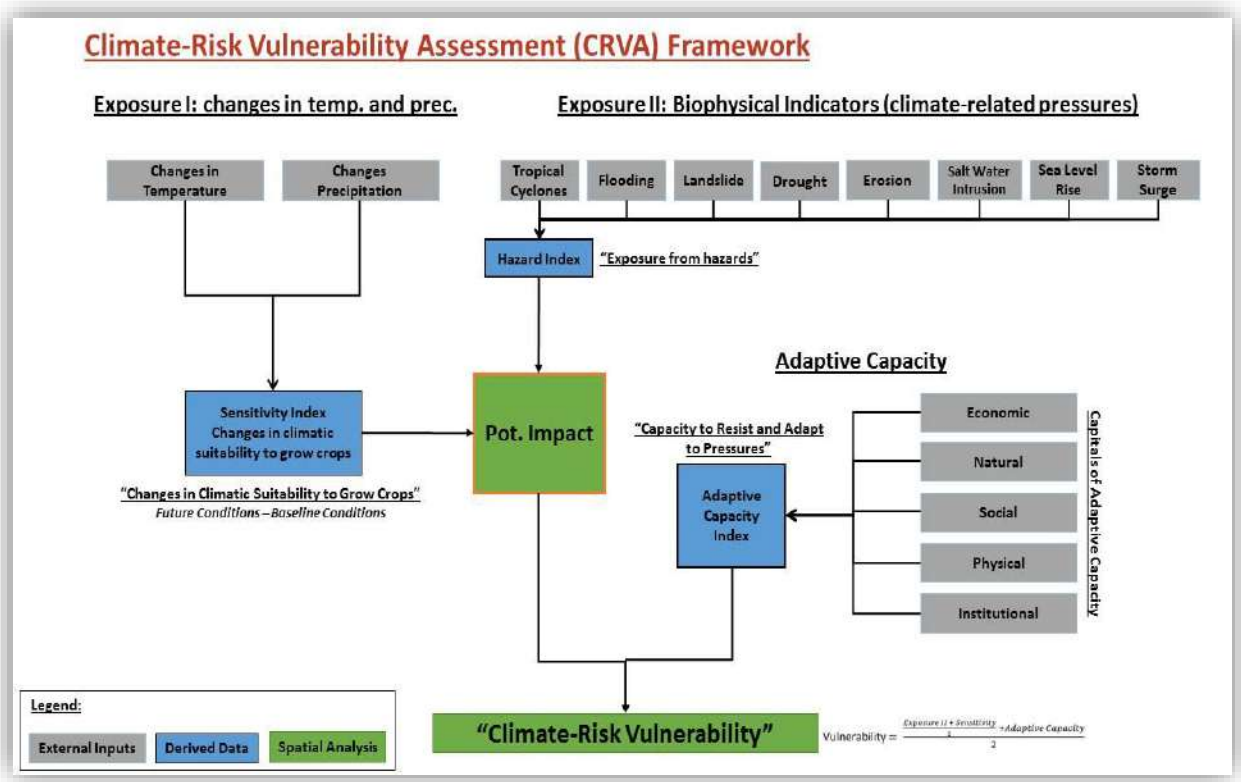

Figure 3. The CRVA Framework of the ISU/CIAT/DABAR Research Project

$(Haz, Sens, AC) = \sum 1\ 2\ (((wh) + (\ )) + 1 - (wa))\ nn{=}i$ Eq. 1

Where: Haz = hazard index, Sens = sensitivity index (i = crop), and AC = adaptive capacity index.
Wh = weight given for hazard, Ws = weight given for sensitivity, and Wa = weight given for adaptive capacity.

Sensitivity Analysis for Climate Change

Sensitivity Analysis is one of the components on CRVA framework as shown in Figures 3 and 4. In this analysis, Representative Concentration Pathways (RCPs) 8.5 was used as an assumption to a high scenario by year 2050 with 33 GCMs ensemble into one to provide input on climate models because it is the most recent and policy relevant and projection based on IPCC AR5. This can be done through statistically downscaling into 1km resolution to predict scenarios with 20 bioclimatic variables (as shown in Table 2) using the Maximum Entropy (Maxent) model. The output was used to determine the impact of climate change to crop suitability Year Present, Year 2030 and Year 2050 Condition to six priority commodities in the Province of Isabela namely; rice, corn, squash, eggplant, mango and tilapia. For this research, Year Present Condition and Year 2050 were exclusively shown and discussed.

Baseline Condition: A set of selected 20 bioclimatic variables was chosen to assess climate suitability of crops. For baseline conditions, the Wordclim dataset (available at Worldclim.org) (Hijman, 2012) was used. Bio 20 (Number of consecutive dry days), processed by the International Center for Tropical Agriculture (CIAT), was added to the Worldclim dataset and it is found to be one of the major driving factors of crop distribution of certain crops. The described bioclimatic factors are relevant to understand species responses to climate change (O'Donnell, M and D. Ignizio, 2012).

Future Conditions: Global circulation models (GCMs) are presently an important tool to represent future climate condition. The GCMs were spatially downscaled by CIAT using spatial statistical downscaling techniques (CIAT, 2017) to produce the 1 kilometer resolution bioclimatic variables. The description of the methodology is available at https://ccafs.cgiar.org/spatial-downscaling-methods.

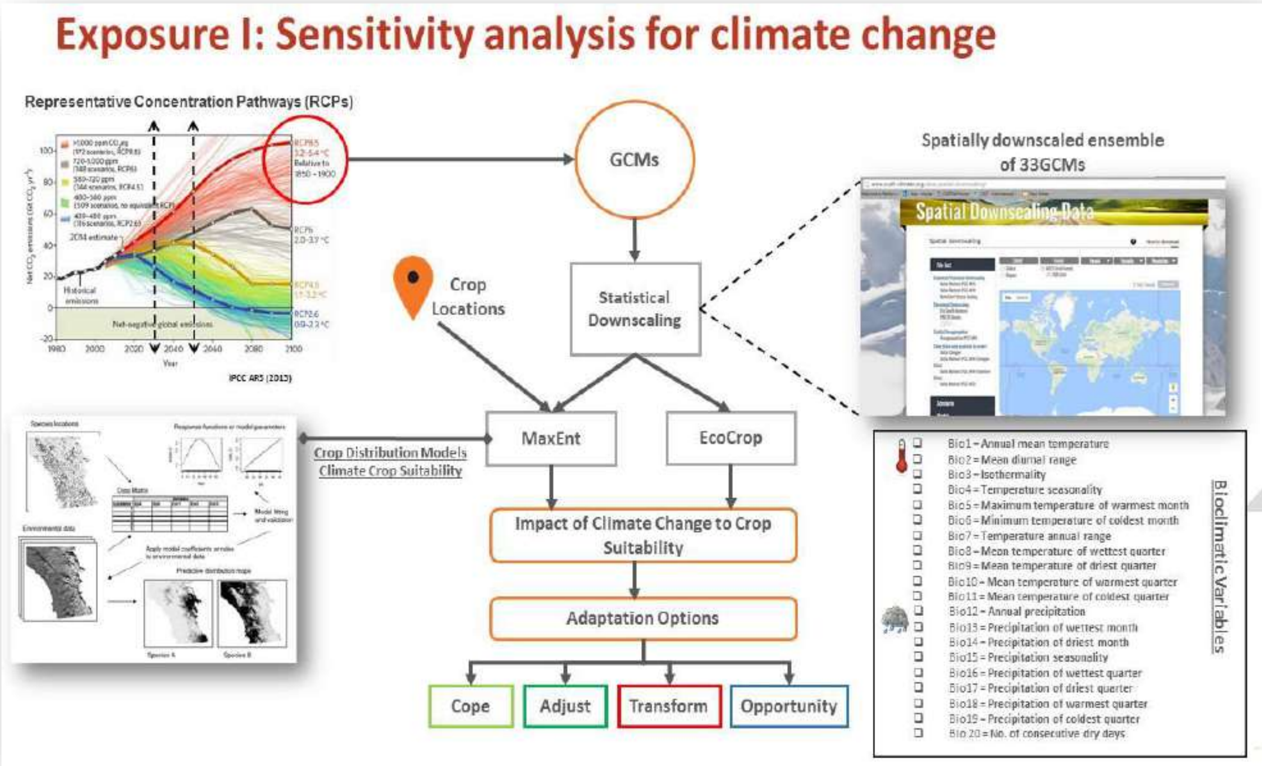

Figure 4. Sensitivity Analysis for Climate Change

Table 2. Bioclimatic variables in crop distribution modeling

PARAMETERS	DESCRIPTION (O'DONNELL, M AND IGNIZIO, D., 2012)
A. TEMPERATURE-RELATED PARAMETERS	
Bio_1 - Annual mean temperature	Annual mean temperature derived from the average monthly temperature.
Bio_2 - Mean diurnal range	The mean of the monthly temperature ranges (monthly maximum minus monthly minimum).
Bio_3 - Isothermally	Oscillation in day-to-night temperatures.
Bio_4 - Temperature seasonality.	The amount of temperature variation over a given year based on standard deviation of monthly temperature averages.
Bio_5 - Maximum temperature of warmest month	The maximum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal).
Bio_6 - Minimum temperature of coldest month	The minimum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal).
Bio_7 - Temperature annual range	A measure of temperature variation over a given period.
Bio_8 - Mean temperature of wettest quarter	This quarterly index approximates mean temperatures that prevail during the wettest season.
Bio_9 - Mean temperature of driest quarter	This quarterly index approximates mean temperatures that prevail during the driest quarter.
Bio_10 - Mean temperature of warmest quarter	This quarterly index approximates mean temperatures that prevail during the warmest quarter.
Bio_11 - Mean temperature of coldest quarter	This quarterly index approximates mean temperatures that prevail during the coldest quarter.
B. PRECIPITATION-RELATED PARAMETERS	
Bio_12 - Annual precipitation	This is the sum of all total monthly precipitation values.
Bio_7 - Temperature annual range	A measure of temperature variation over a given period.
Bio_8 - Mean temperature of wettest quarter	This quarterly index approximates mean temperatures that prevail during the wettest season.
Bio_13 - Precipitation of wettest month	This index identifies the total precipitation that prevails during the wettest month.
Bio_14 - Precipitation of driest month	This index identifies the total precipitation that prevails during the driest month.
Bio_15 - Precipitation seasonality	This is a measure of the variation in monthly precipitation totals over the course of the year. This index is the ratio of the standard deviation of the monthly total precipitation to the mean monthly total precipitation and is expressed as percentage.
Bio_16 - Precipitation of wettest quarter	This quarterly index approximates total precipitation that prevails during the wettest quarter.
Bio_17 - Precipitation of driest quarter	This quarterly index approximates total precipitation that prevails during the driest quarter.
Bio_18 - Precipitation of warmest quarter	This quarterly index approximates total precipitation that prevails during the warmest quarter.
Bio_19 - Precipitation of coldest quarter	This quarterly index approximates total precipitation that prevails during the coldest quarter.
Bio_20 - Number of consecutive dry days	Consistent number considered as dry days.

Spatial downscaling is necessary to create high resolution climate surfaces from coarse resolution output of GCMs. The GCMs used in this study are already based on Coupled

Model Intercomparison Project "CMIP5" Global Circulation Models (GCMs) and already corresponding to the Representative Concentration Pathways (RCPs) with four time periods (year 2030, 2050, 2070, and 2080) based from IPCC Assessment Report 5(IPCC, 2015). So far, RCPs are the most recent and policy relevant scenarios. To analyze climate change crop suitability, an ensemble of the 33 GCMs was used based on the Representative Concentration Pathway (RCP) scenario 8.5 from IPCC Assessment Report 5 and a time period of Year 2050. Scenario 8.5 was used because of the observed trends in greenhouse gas emissions.

Maxent Model Implementation

Maxent (Maximum Entrophy) Model is a distribution model of species or crop commonly used to estimate most suitable areas for a species or crop based on probability in geographic areas where the distribution of crops is scarce (Burgman, 2002). Climate and climate change suitability of crops was assessed using a two-step process:

First, the model was run and assessed for baseline conditions. The CIAT collaborative agency employed two ways to assess the performance of the model: (1) value of the "Area under curve" or AUC if greater than 85 percent, and (2) visual inspection where a crop is reported to be present. For instance, for cacao and coffee, it should not expect a higher prediction in the island (Luzon), because the majority of those crops are present in Visayas and Mindanao study sites. Then, this should be expected a higher suitability in Mindanao.

Second, if those criteria for step 1 were satisfied, then it must be run for future conditions. Before it runs each instance of Maxent, it filtered geographic records of presence data. Points are removed if these are within a specified distance from each other using a script available in GitHub (https://github.com/lpalao/point_distance_filter/blob/master/point_distance_filter.py) to reduce point spatial autocorrelation due to high point density which can affect model performance (model overfit).

Crop Selection and Crop Presence Data Collection

A series of workshops was conducted in identifying the crops analyzed for climate suitability. In collaboration with the DA-Regional Field Office, the list of crops for sensitivity analysis is ascertained and shown in Table 3. The main criteria for selecting the crops were based on two factors:

(1) crops are important for food security, and

(2) crops are important sources of cash.

The crops were classified into grains (rice and maize), vegetables (mango, squash, and eggplant), and aquaculture (tilapia). Point data for crop occurrences were collected with the assistance of the local government units in the province. Some of the points collected for rice are from IRRI (2013) and the other points of the crops were collected through a rapid collection on-field. A total of 689 points were used to model crop distribution across six crops.

An index was developed from – 1.0 to 1.0 for Sensitivity Analysis which was subsequently used for CRVA in this research. An index range from 0.25 to 1.0 indicates a loss in suitability, while – 0.25 to – 1.0 indicates a gain in suitability.

Table 3. List of crops identified for sensitivity analysis

CROPS	NUMBER OF POINTS
Rice	92
Maize	157
Eggplant	138
Squash	120
Tilapia	96
Mango	86

The differences (expressed as percentage) in future and baseline suitability determines the climate change crop suitability, and reflects the degree of crop sensitivity to changing environmental conditions. Higher change in a negative direction reflects higher impact of climate change. Table 4 shows the sensitivity indexes based on percent change in crop suitability from baseline to future conditions.

Table 4. Sensitivity index based on percent change in crop suitability from baseline to future conditions.

PERCENT CHANGE IN SUITABILITY (%)		INDEX	DESCRIPTION
Range	**Description**		
<=-50	(Very High loss)	1.0	Loss
>-50 & <= -25	(High Loss)	0.5	
> -25 & <=-5	(Moderate)	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	

Climate Suitability Index

Rice and Corn Climate Suitability

Popularly known as *palay* (or *pagay* in Ilokano), rice is the main staple food of the Filipinos. It is usually grown in a submerged and ponded condition (for lowland rice) but other farmers, especially the *kaingineros*, are planting rice in newly cleared slash-and-burn lands (for upland rice). Climate is the limiting factor affecting crop production. Water availability depends on rainfall needed to provide the average water requirement of rice per cropping season of 1,200 mm or about 10-13 mm per day. Because of erratic rainfall patterns, finding an ample amount of supply of water for irrigation purposes is an important requisite for rice production (Romero, 2006). Ambient temperature should be above 18 degrees centigrade during the panicle initiation or flowering stage of rice to attain sufficient production. Generally, rice growing season for the first cropping is from May to September while the second cropping starts November and ends up to February.

As shown in Figure 5, rice (*Oriza sativa*) in present condition is high to moderately suitable in the flat and low-elevation areas of the province. Some of the areas in the province belong to moderate to low suitability indicating that planting rice in these areas can only generate moderate to low yield. Thus, it implies that planting rice in these areas must be done with technological supports such as irrigation services to avoid crop damages due to climate change.

But in year 2050, the areas with high suitability to plant rice expanded with moderate to high suitability along the river systems. On the eastern side of Isabela Province (i.e., the coastal Municipalities of Maconacon, Divilacan, Palanan, and Dinapigue overlooking the Pacific Ocean) rice plant has moderate climatic suitability. As shown in the climatic suitability map, the areas with low suitability are only in the Sierra Madre Mountain Ranges on the eastern part of the province. This indicates that the elevation and forestland uses of the area provide the strong factors in determining the climatic suitability conditions of the corresponding areas.

Figure 5 also shows that, at current condition, corn or maize (*Zea maize*) has moderate to high climatic suitability in areas along the flood plains of Isabela Province. However, the corn areas with high climatic suitability expanded by the Year 2050. A high climatic suitability to plant corn is also projected to increase along the coastal areas of Isabela overlooking the Pacific Ocean on the eastern side. As observed also in rice production areas, the Sierra Madre Mountain Ranges of the province has the area with low climatic suitability of growing corn or maize. However, the corn production areas enlarge more into the Sierra Madre Mountain Ranges than the rice production areas as shown in Figure 5.

Squash and Eggplant Climatic Suitability

The vegetables that are considered in this research are squash (*Cucurbita maxima*) and eggplant (*Solanum melongena*). In agri-economic industry, squash has been a customary element as a high value crop to market-based industries and consumers. In Figure 6, this crop has currently moderately high suitability in some areas of the province particularly on the flat lands. There were only few areas that are suitable from planting (high to moderate) which indicates that the potential production of this vegetable crop cannot be attained without appropriate technology interventions.

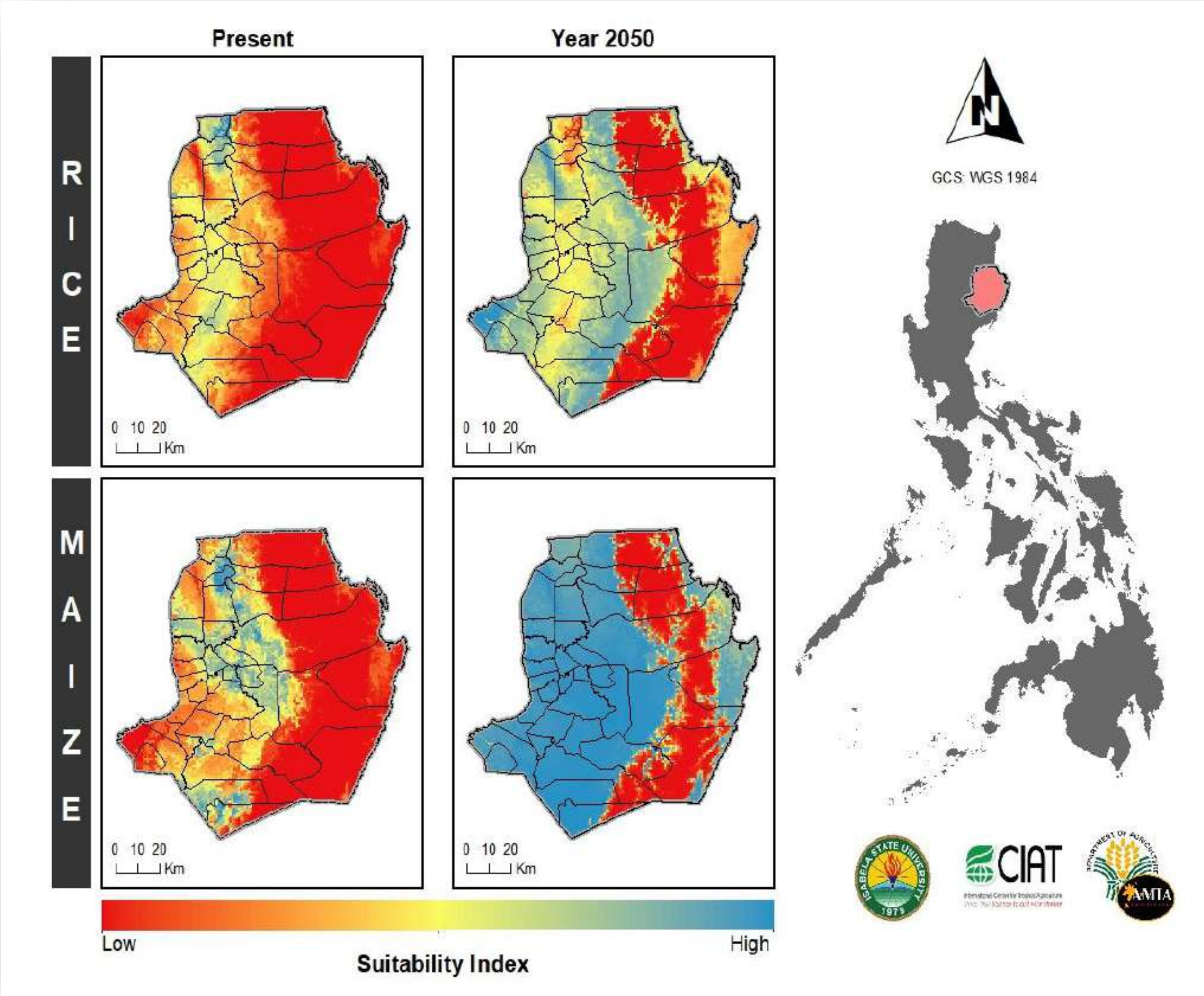

Figure 5. Climatic Suitability for Rice and Maize (Corn)

For Year 2050, the areas with high climatic suitability of squash in the province increases with about a little more than 30 percent of the total area of Isabela Province. The remaining areas (i.e., the high elevation and forestland and coastal areas) has low climatic suitability for squash production systems. At the eastern part and coastal areas, this situation may be due to more likely to be vulnerable to climate change and variability.

Eggplant (*Solanum melongena)*, on the other hand, is known as a climate resistant vegetable crop. This crop can survive in any climatic events like so much rain, flood, high temperature, and typhoon. As shown in Figure 6, eggplants are currently suitable in almost similar growing areas as in squash. In Year 2050, however, the areas having high climatic suitability due to climate change expanded particularly on the valley area (western part) of the province. If compared with squash, eggplant production in the province is projected to have higher areas of climatic suitability (with about 50% of the total provincial area) than squash production.

Climatic Suitability for Mango (Fruit Trees) and Tilapia (Aquaculture)

Among the tropical fruit trees, Philippine mangoes are among the most favored varieties of fruits in the world for their sweet taste and aroma. Mango production has been emerging into a fast growing agri-based industry in the country. In the last five years, latest export average earning is totalling an average of $61 million from over a million metric tons annual production.

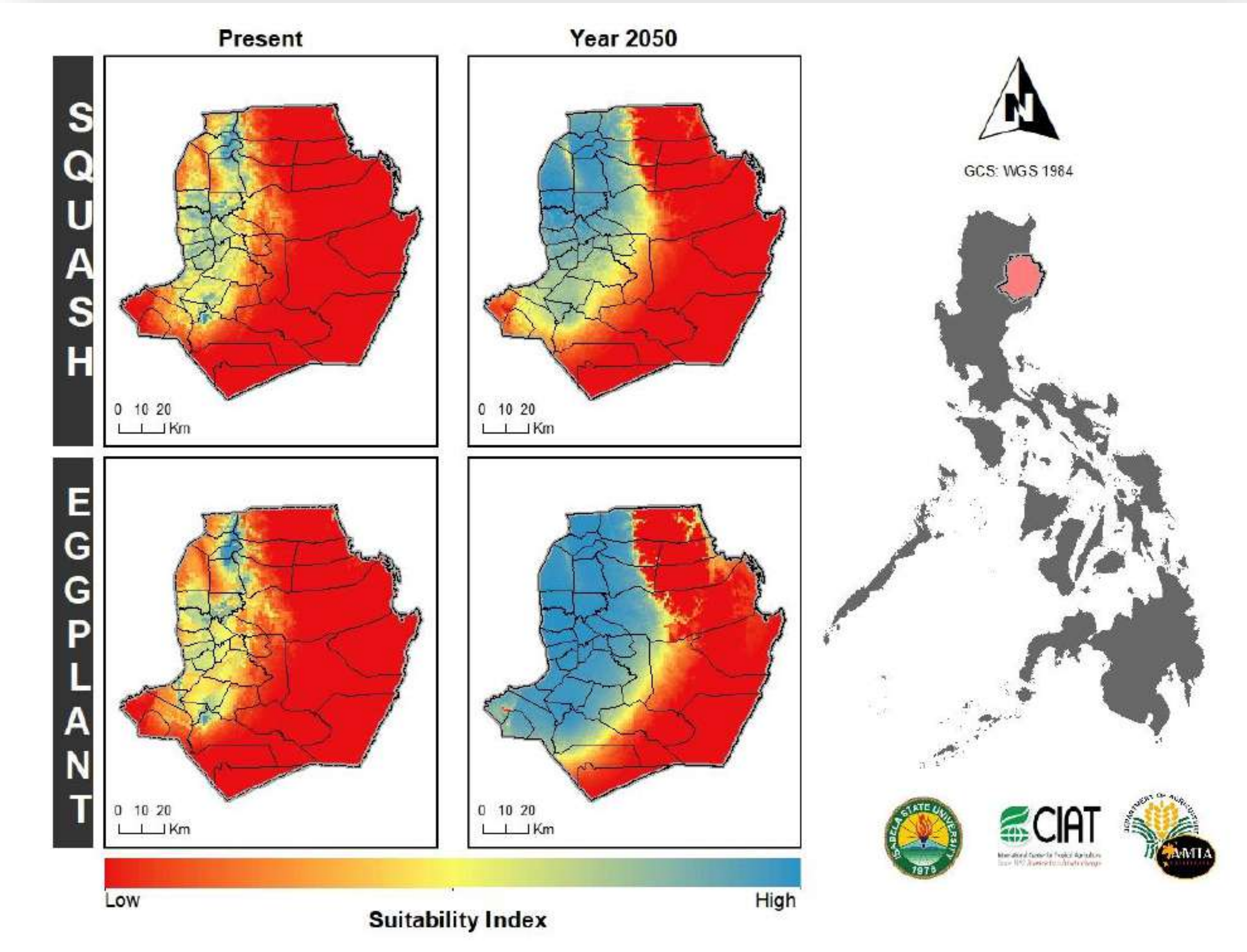

Figure 6. Crops Suitability Index for Squash and Eggplant

In Figure 7, it shows that a small area of mangoes have high to moderately suitable for mango production at present condition. This can be found at the mid-southern portion of Isabela

Province with some at the mid-eastern and north-western (sporadic) parts. The mango production areas that are highly climatically suitable will be decreasing by Year 2050 although moderately suitable areas for mangoes are expanding due to climate change.

For the aquaculture industry, the Mozambique tilapia (*Oreochromis mossambicus*) is the first tilapia introduced to the Philippines which was imported from Thailand in 1950. Later, in 1972, the Nile tilapia (*Oreochromis niloticus*) was first introduced to the Philippines and rapidly gained popularity with farmers and consumers. Presently known as the "aquatic chicken", it is now the main species of tilapia farmed in the Philippines and throughout tropical Asia and the Pacific because of its suitability for farming in diverse systems, from backyard ponds to large commercial ponds and cages.

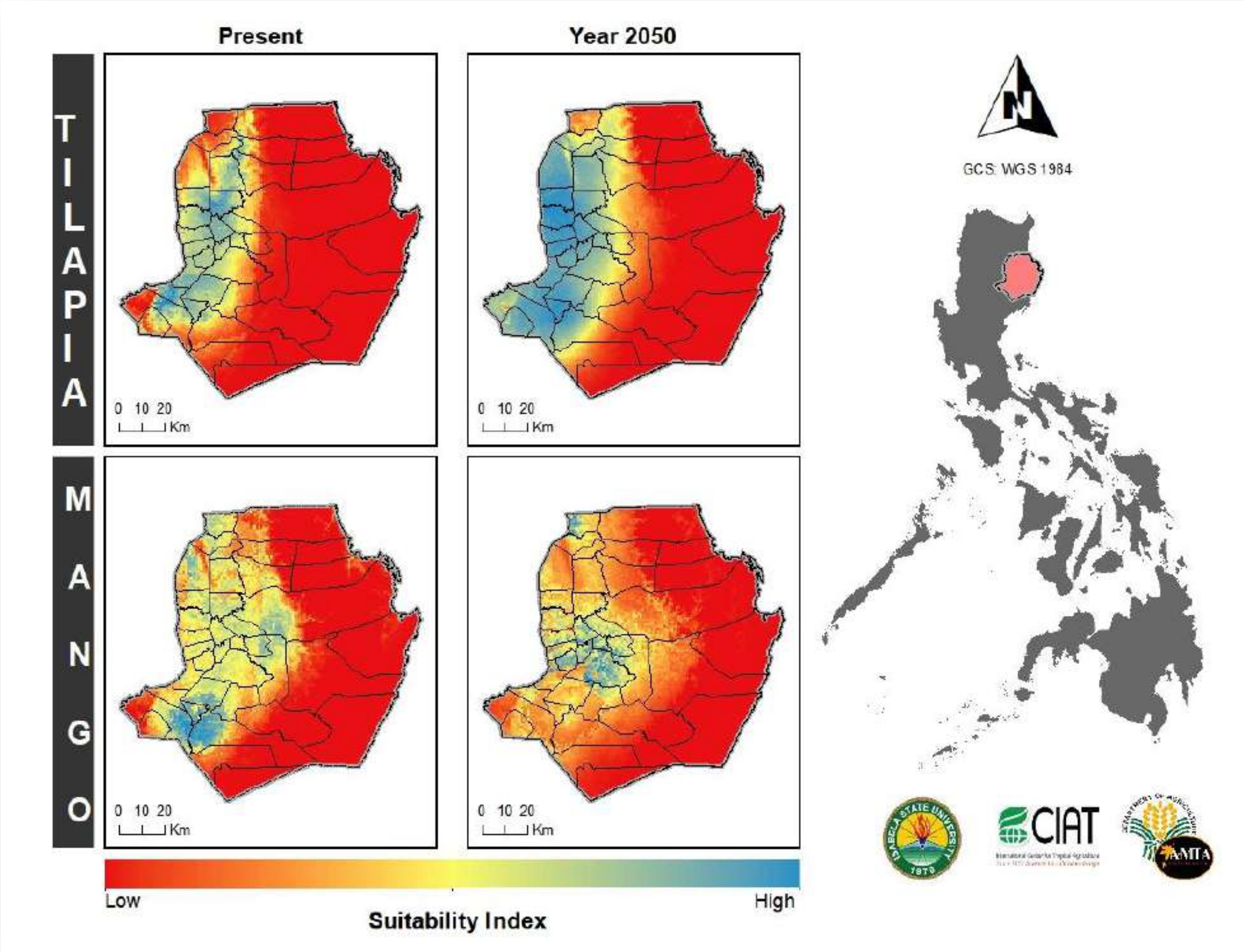

Figure 7. Climatic Suitability Index for Mango and Tilapia

On January 11, 2008, the Bureau of Fisheries and Aquatic Resources (BFAR) Region 02 reported that tilapia production grew and Cagayan Valley and is now the tilapia capital of the Philippines. Since 2003, tilapia production grew by 37.25 percent increasing to 14,000 tons (MT) in 2007. The recent aquaculture congress found the growth of tilapia production was due to government interventions: that is, provision of fast-growing species, accreditation of private hatcheries to ensure supply of quality fingerlings, establishment of demonstration farms, providing free fingerlings to newly constructed fishponds, and the dissemination also of tilapia to Diadi, Nueva Vizcaya.

Based on the result of the model, tilapia production, at present condition, is highly suitable to almost one-fifth of Isabela Province at the Western Isabela areas with about one-eight of the province is moderately suitable. The main part of the province (i.e., western and coastal areas) has low suitability at present condition. However, the Year 2050 projection showed an expansion of the high suitability areas for tilapia culture of about one-third of the province concentrated at the Western Isabela with about one-sixth of the province with moderately suitable for establishing tilapia production.

The eastern part of the province up to the coastal areas found out to be having a low suitability tilapia to grow tilapia in the face of climatic change. These areas are adjacent or covered by the Sierra Madre Mountain Range and the coastal areas facing the Pacific Ocean.

In summary, the climate suitability areas for rice, maize (or corn), squash, eggplant, and tilapia production in the province is projected to expand with significant future gains (i. e.,Year 2050 projection) specifically for maize (or corn), rice, eggplant, squash, and tilapia in that order. This positive gains of climate suitability for these crops has corresponding consequences on the reduction of the Sierra Madre Natural Park and Protected Areas on the eastern side of Isabela Province.

On the other hand, mango production in the Isabela Province shows a declining trend in terms of climate suitability areas for the 2050 projection year. As indicated above, moderately high suitability of mango production as affected by climate change is to be concentrated at the mid-western part of Isabela Province.

Exposure to Natural and Climate-related Hazards *(This part is taken from: Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces by CIAT, 2017)*

A combination of natural hazard datasets has been used to estimate to which extent a different regions in the Philippines are under pressure from climate and hydro-meteorological risks. Most of these datasets refer to historical databases to evaluate the current potential risk because many climate hazards can be large scale singular events and projections of climate hazards to the year 2050 would add further layers of uncertainty. However, while it is not possible to attribute singular extreme events to progressing climate change, it is agreed that the likelihood of most extreme events is increasing under progressing climate change (IPCC 2012). The succeeding section below discusses the procedure to develop the hazard index, and a brief description of each hazard that was considered in the study.

Hazard Dataset

The development of a hazard index relies on spatial analysis of the weighted combination of different historical climate-related natural hazards in the Philippines using data that are open-sourced or developed by partner institutions, such as the Department of Agriculture (DA). Eight (8) hazards were identified for the Philippines, and these are typhoon, storm surge, flood, drought, erosion, landslide, saltwater intrusion and sea level rise. The selection of hazards was based on consultation with project partners, such as state universities and colleges (SUCs) and the System-Wide Climate Change Office in the Philippines' (Department of Agriculture). The hazard maps represent the current risk and exposure of crops, people and institutions, while some are likely scenarios such as sea level rise. Since each hazard has different degree, intensity and frequency, the potential damage also varies, especially across the three main islands of the Philippines, i.e., Luzon, Visayas, and Mindanao (herein referred as "island groups"), hence each of the hazards were weighed in each of the island groups. These island groups are unique in terms of exposure to hazards, rainfall pattern, landform, and crop distribution. For instance, the Luzon Island will have more areas planted with rice because of large basins and the abundance of flat terrains and also records the highest number of typhoons in the Philippines. Seven out of eight hazard dataset used in this study was from the output of the Adaptation and Mitigation Initiative in Agriculture (AMIA) Phase 1 project of the Department of Agriculture and are described [in Table 5] below.

Developing Hazard Weights

A workshop has been conducted to identify appropriate weights per hazard for each island group. The SUC experts/focal persons were invited and were asked to score (1 is low and 5 is high probability/impact) hazard risk based from qualitative assessment using the following criteria: (1) probability of occurrence, (2) impact of local household income, (3) impact to key natural resources to sustain productivity (refers to how key resources such as water quality and quantity, soil fertility, and biodiversity are affected), (4) impact to food security of the country, and (5) impact to national economy.

Table 6 summarizes the different weights for each island group in the Philippines. The criteria used also reflect the impact of hazards at different scales from local, landscape, and national level. A weighted sum was used to develop with the overall aggregated weight for hazards. For each municipality, the mean value of aggregate weight was computed. A subset of each province was created and values were normalized (0 to 1) per municipality. 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).

Table 5. Source and description of each dataset.

PARAMETER	SOURCE	UNIT OF MEASUREMENT, SPATIAL AND TEMPORAL RESOLUTION
Typhoon	UNEP / UNISDR, 2013. (http://preview.grid.unep.ch/index.php?preview=data&events=cyclones&evcat=2&lang=eng)	1 kilometre pixel resolution. Estimate of tropical cyclone frequency based on Saffir-Simposon category 5 (> 252 km/h) from year 1970 to 2009.
Flooding	AMIA multi-hazard map / baseline data from Mines and Geosciences Bureau, Department of Environment and Natural Resources (MGB, DENR)	1:10,000 scale. Susceptibility of flood risk for Philippines from the past 10 years
Drought	AMIA multi-hazard map / baseline data from National Water Resources Board	Groundwater potential for the Philippines
Erosion	AMIA multi-hazard map / baseline data from Bureau of Soils and Water Management	1:10,000 scale. Soil erosion classified from low to high susceptibility
Landslide	AMIA multi-hazard maps / baseline data from MGB, DENR	1:10,000 scale. Landslide classified from low to high susceptibility
Storm Surge	AMIA multi-hazard maps / baseline data from Disaster Risk and Exposure Assessment for Mitigation, Department of Science and Technology (DREAM, DOST)	
Sea level rise	AMIA multi-hazard map	Assumption based on 5m sea level Rise
Saltwater intrusion	AMIA multi-hazard map / baseline data from the NWRB	Groundwater potential for the Philippines
Typhoon	UNEP / UNISDR, 2013. (http://preview.grid.unep.ch/index.php?preview=data&events=cyclones&evcat=2&lang=eng)	1 kilometre pixel resolution. Estimate of tropical cyclone frequency based on Saffir-Simposon category 5 (> 252 km/h) from year 1970 to 2009.
Flooding	AMIA multi-hazard map / baseline data from Mines and Geosciences Bureau, Department of Environment and Natural Resources (MGB, DENR)	1:10,000 scale. Susceptibility of flood risk for Philippines from the past 10 years
Drought	AMIA multi-hazard map / baseline data from National Water Resources Board	Groundwater potential for the Philippines

Table 6. Hazard scores per island group based from consultation with SUCs.

HAZARDS	ISLAND GROUP		
	Luzon (%)	**Visayas** (%)	**Mindanao** (%)
Typhoon	20.00	18.21	16.95
Flood	19.05	16.40	15.25
Drought	14.25	16.17	16.95
Erosion	11.43	12.57	12.71
Landslide	8.57	10.72	14.41
Storm Surge	9.52	10.39	8.47
Sea Level Rise	5.71	8.33	5.08
Saltwater Intrusion	11.43	7.21	10.17

Climate-related Exposure across the 10 Provinces

Heat map (Figure 8) shows the degree of hazard incidence by province and indicates the province-specific climate risk that threatens the resilience of agri-fisheries communities. The analysis is based on the number of pixel counts by which indicates spatial coverage of each hazard for each province, except for typhoon which is based on mean frequency of typhoon events. This is to compare the degree of exposure across provinces.

Higher incidences of hazards are observed in Luzon (Ilocos Sur, **Isabela**, Tarlac, Quezon, and Camarines Sur) and Visayas (Iloilo and Negros Occidental) island groups. **Isabela** and Camarines Sur are at high risk of typhoon events (historical data), since these provinces are located in areas considered as typhoon belt. Occurrence of flood is high in Tarlac, **Isabela**, and Negros Occidental because these provinces have large river basins and wide flood plains. On the other hand, Camarines Sur and Quezon are at high risk of sea level rise. In terms of potential drought, the map from AMIA1 indicates that higher spatial coverage area in the provinces of **Isabela** and Quezon. North Cotabato which experienced two consecutive drought in 2015 and 2016 is ranked 5th among the 10 provinces in terms of drought risk.

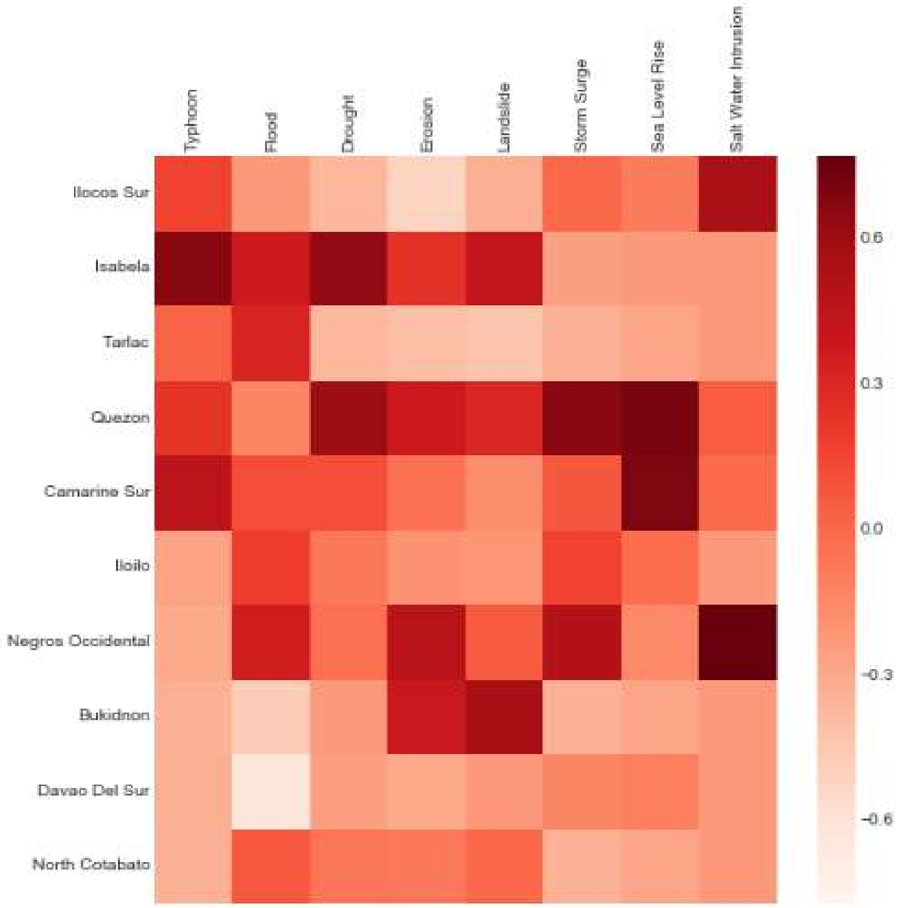

Figure 8. Degree of Incidence of Hazards per Province

Exposure to Climate-related Hazards for Isabela Province

Figure 9 shows the hazards' exposure condition in Isabela Province. As rated high by the Isabela Project Team, typhoon, flood and erosion are the most prominent hazards in the province. Hazard datasets that has been used was accumulated based on historical databases of AMIA1 (See Tables 5 & 6). Each hazard has a normalized value of zero to one. The CIAT partners provided standard equal breaks classification as follows:

0.00-0.20 (Very Low),
0.20-0.40 (Low),
0.40-0.60 (Moderate),
0.60-0.80 (High),
0.80-1.00 (Very High).

As a result, the overlay of these three major hazards (i.e., typhoon, flood and erosion) resulted to a high incidence of hazards in Isabela Province.

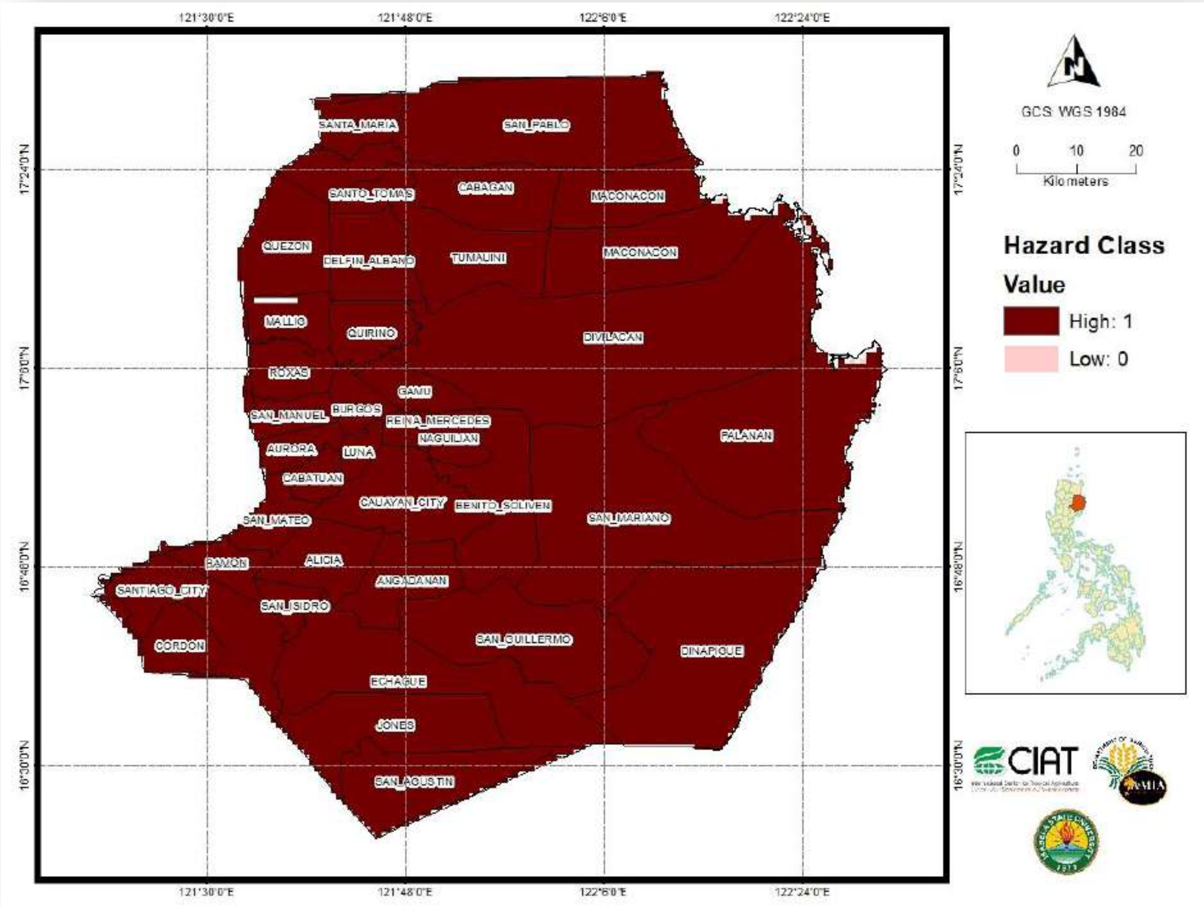

Figure 9 – Exposure to Hazards of Isabela Province

Adaptive Capacity of Isabela Province

Adaptive capacity forms one of the three pillars of the vulnerability assessment in addition to exposure and sensitivity to climate change (Figure 3). In this research, "*Adaptive capacity* is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC, 2014). Due to the country-wide scale, this vulnerability assessment thus takes a broader approach to adaptive capacity than more in-depth resilience assessments.

The adaptive capacity index for this vulnerability assessment is compiled by a set of proxies: none of them alone can give a reliable statement of the current level of adaptive capacity alone. But as a group, considering different capitals they become a more powerful tool to understand how well and with which tangible and intangible assets a population can cope with climate change and variability. This methodology aims to compile information on a set of different capitals, such as economic, natural, human, physical, and institutional capital. There are many indicators that could form a strong adaptive capacity index, but data availability was a driving factor in establishing the final index for the Philippines and for Isabela Province, in particular.

This vulnerability assessment is aiming to provide a high resolution analysis on municipality level as this is where most socio-economic data can be derived. However, often key indicators are only available on national or province level. Hence, the list of indicators in Table 7 presents the list of Adaptive Capacity attributes or capitals indicators and sub-indicators gathered. It shows that the list is not restrictive but further socio-economic data can be added to have a better understanding to what extent is the population able to cope with climate change and related risks.

Economic Capital

Economic Capital indicates the productivity of development opportunities. In this study, economic capital was measured based on agricultural engagement and production, access in the aspects of institutions like banks, potable water, electricity, and source of income and other sub-indicators of economic activities in certain area.

From Figure 10, it can be seen that only two municipalities (i. e., Tumauini and Alicia) and one city (i.e., Ilagan City – the capital city) showing very high economic activities. This is particularly true since city and high classes' municipalities tend to have high and sustainable economic performances.

Human Capital

Human Capital is a fundamental indicator of adaptive capacity. In Figure 10, it also shows that the three cities in Isabela (Ilagan, Cauayan, and Santiago) and one municipality (Tumauini) shows high literacy rates as cities and high classes' municipality is more likely educated and or well-informed, and with high presence rate of health workers and facilities. However, majority of the municipalities in the province belong to a very low human capital.

Institutional Capital

Institutional Capital in this study was measured through the number of well-informed constituency of farmers visited/consulted by the agricultural extension officers, farmers trainings attended, the presence of functional DRRMC offices and facilities, and early warning systems of the LGUs. As shown in Figure 10, five municipalities (i.e., Cabagan, San Manuel, Ramon, Echague, and San Agustin) and Cauayan City can be seen having very high institutional capital indicating that these LGUs received an adequate technical and social supports and assistances. The three Municipalities of Divilacan, Benito Soliven, and Angadanan have the lowest values of their institutional capital.

Table 7. List of Adaptive capacity indicators for CRVA in Isabela Province

ATTRIBUTE CAPITAL	INDICATORS	SUB-INDICATORS	SOURCE
Economic	Yield of target commodities	Kg/Ha of crop commodities present in the area	Municipal Agriculture Office, 2016Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)
	Agricultural Insurance	% of farmers cover	Philippine Crop Insurance Corporation (PCIC) 2016
	Agriculture engagement	% of population employment	Municipal Agriculture office , Philippine Statistics Authority (PSA) Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) 2007, 2016, 2017
	Income level	Municipality Class	
	Assets	Ownership in percent of population	
	Water Services	% of household with access to water services	Municipal Agriculture office
	Electricity	% households having electricity	Municipal Agriculture office
	Other source of income	% of farmers with other source of income	Municipal Agriculture Office, 2016 Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)
Natural Capital	Groundwater accessibility	% of farmers	Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)
	Surface irrigation accessibility	% of farmers	Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)
	Soil organic matter	% of soil organic matter	Municipal Agriculture Office (2016)
	% of supporting ecosystems (Agriculture, Forest Fisheries)		Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)
Human Capital	Education	% Literacy rate, # of farmers with indigenous knowledge, Number of	Municipal Agriculture Office, 2016 Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)

		private and public doctors, number of health workers, number of public and private health	
	Health	Ratio to population: Public health services, Private doctors, Private health services, Health services manpower, Public doctors, Local citizens with Philhealth	Municipal Agriculture Office, 2016 Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)
Physical Capital	Farm ownership	% of farmers owning their farm	Municipal Agriculture Office, 2016
	Farmers Registered groups or unions	Number of farmers	Municipal Agriculture Office, 2016
	Farm size		Municipal Agriculture Office, 2016, Philippine Statistics Authority (PSA)
	Irrigated areas	ha per municipality	Municipal Agriculture Office, 2016, Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)
	Trading Center	Number of trading Center	Municipal Agriculture Office, 2016, Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007)
	Access to fertilizer and pesticides	% of farmers	Municipal Agriculture Office, 2016,
	Financial Institutions and Cooperative	# of micro-finance and Cooperatives	Municipal Agriculture Office, 2016, Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007),
	Road Density	Road density in %	NCCP (2015)
	Machinery and equipment	Number of Machinery and equipment	Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007),
	Livestock	Number of livestock	Barangay profiling system (BAPS) of Bureau of Agricultural Statistics (BAS) (2007),

Institutional Capital	Registered trainings held	Number of trainings	Municipal Agriculture Office, 2016,
	Agricultural extension officer consultancy	% of famers visited	Municipal Agriculture Office, 2016,
	Capacity to anticipate shocks and could develop responding strategies	% of traditional farmers shifting to CRA technologies	Municipal Agriculture Office, 2016,
	Functional MDRRMC		Municipal Agriculture Office, 2016,
	Early warning system and communication technology accessibility		Municipal Agriculture Office, 2016,
	Effective government and/or CSO programs for climate change		Municipal Agriculture Office, 2016,
	Government response to previous shocks		Municipal Agriculture Office, 2016,

Natural Capital

Natural capital is being measured through the presence of forest cover, water resources access of farmers, ecosystems support systems such as forests, mangroves, and other ecosystems. (See Figure 10).

This result showed a perspective scenario of natural resources manifestation in a particular area. The more the resources are available, the more it supports the quality of life and the result shows a very significant natural resource outlook of the present condition of Tumauini, Gamu, and Alicia with also corresponding high natural capital of the municipalities of Ilagan City, Quirino, and Angadanan. The Municipality of Dinapigue has the lowest natural capital while the Municipalities of Palanan, San Mariano, Cauayan City, Roxas, and Quezon are correspondingly characterize with low natural capital as described above.

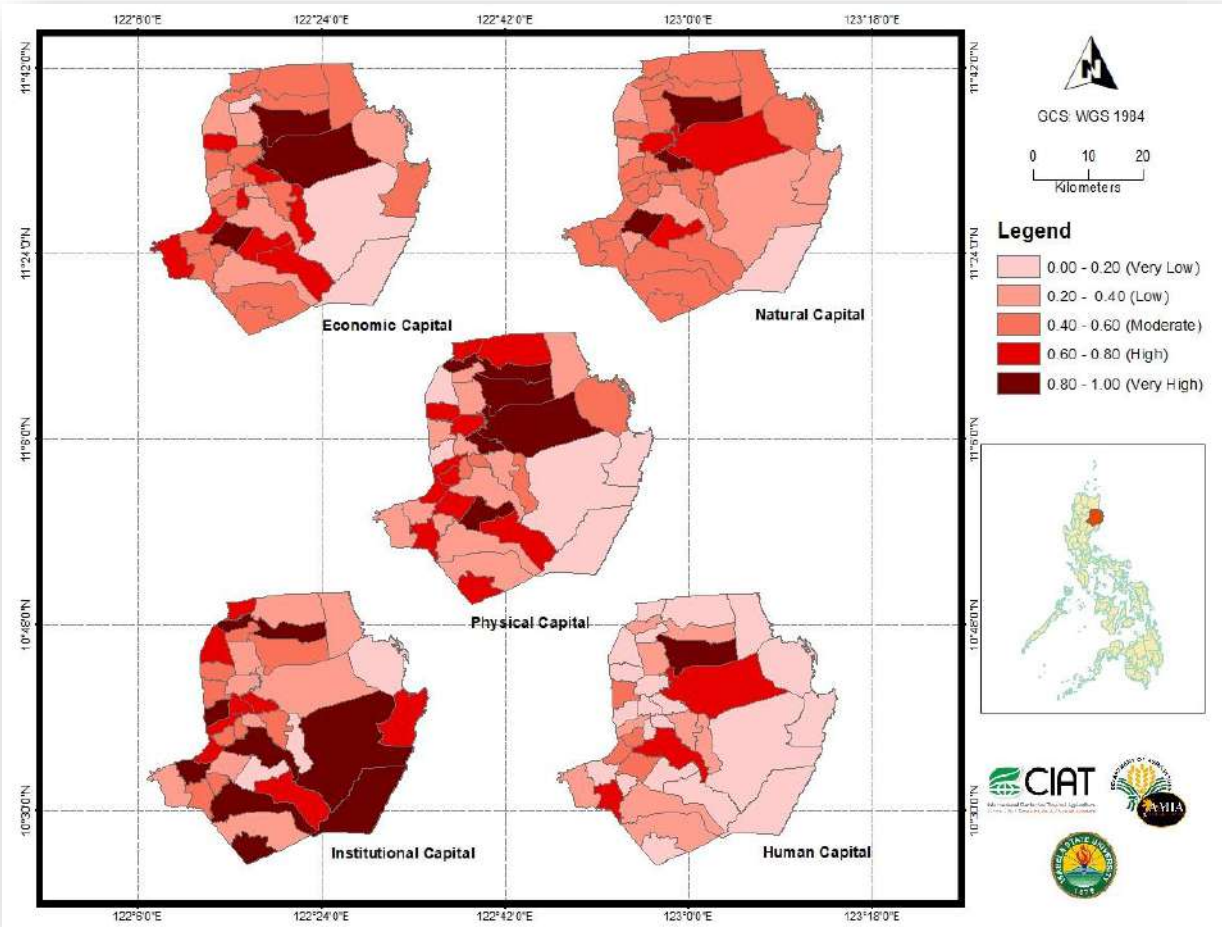

Figure 10. LGUs Adaptive Capacity in Isabela Province

Physical Capital

As shown in Table 7, the indicators of *Physical Capital* are in terms of the farmers' characteristics in the municipalities, accessibility in terms of road density, as well as the farmers' access to financial institutions, training centers, and markets of production inputs such as fertilizers and insecticides.

Figure 10 also shows that Cabagan, Tumauini, Ilagan City, Gamu, and Angadanan have very high physical capital while the municipalities with high physical capital are San Pablo, Sta. Maria, Quirino, Mallig, Aurora, Cabatuan, San Mateo, Alicia, San Guillermo, and Santiago City. The municipalities with very low physical capital are Quezon, San Manuel, San Mariano, Palanan, and Dinapigue.

Overall Adaptive Capacity Index of LGUs in Isabela Province

Inadequate climate change adaptation measures intensify the spectacle scenario of vulnerability to climate change. As a result, without proper adaptation measures, it would bring distressful conditions over each municipality or any other locations. In this research, the adaptive capacity index indicates the ability or capacity of the Local Government Units (LGUs) to cope and adapt to climate risks as shown by the five major attribute capitals and its indicators. Adaptive capacity embodies a sustainable economic growth and provides equalization of access and development opportunities and effective social nets.

As shown in Table 8 and Figure 11, about six municipalities of the Isabela Province have very high adaptive capacity (i.e., Tumauini, Ilagan, Quirino, Gamu, Alicia, Angadanan) with about twelve (12) of them (i.e., Santa. Maria, San Pablo, Delfin Albano, Mallig, Divilacan, Luna, Cabatuan, San Mateo, Benito Soliven, Santiago City, San Guillermo, and Jones) are classified as having high adaptive capacity. The rest of the municipalities belong to moderate and low adaptive capacity index. It only signifies that the access to quality basic services, private investments, productive employment opportunities, private linkages and other indicators of adaptive capacity in these LGUs of the province is not enough to overcome the negative impacts of climate change and hazards.

Also, the result of the assessment for adaptive capacity for each LGU in Isabela Province shows that the coastal Municipality of Dinapigue revealed its very low adaptive capacity index. During field validation, the team assessed that the ability of the community to cope with climate change and disaster impacts relies on the inadequate support facilities and services and capabilities of the LGU. According to them, the main factor that constrains their capacity to adapt is the geographical location of the town indicating that supports and development opportunities to the populace of the municipality are quite weak and/or inadequate.

Table 8. Adaptive Capacity Classification of the LGUs in Isabela Province

CLASSES	MUNICIPALITY
Very High Adaptive Capacity	Ilagan City, Tumauini, Quirino, Gamu, Alicia, Angadanan
High Adaptive Capacity	Santa. Maria, San Pablo, Delfin Albano, Mallig, Divilacan, Luna, Cabatuan, San Mateo, Benito Soliven, Santiago City, San Guillermo, and Jones
Moderate Adaptive Capacity	Cabagan, Maconacon, Aurora, Naguilian, Reyna Mercedes, Cordon, San Agustin
Low Adaptive Capacity	Sto. Tomas, Quezon, Roxas, San Manuel, Burgos, Cauayan City, San Mariano, Palanan, Ramon, San Isidro, and Echague
Very Low Adaptive Capacity	Dinapigue

Vulnerability Index of LGUs in Isabela Province

Vulnerability is antonymic to adaptive capacity; that is, the higher the adaptive capacity to adapt and cope from hazards and climate risks, the lower the vulnerability from the effects of these risks. Logistically, if the LGU is incapacitated, the more the community is vulnerable.

Developing Vulnerability Indeces

Analysis of weights for each component of vulnerability assessment is highly subjective. In order to explore the impact of varying proportions of weights to the overall vulnerability classes, a workshop has been conducted to appropriate weights of the overall assessment of vulnerability components. This is in participation of different SUCs focal persons and experts from DA (from different agencies), NEDA, FAO, and NGOs. The team have carefully come up to these resulting weights. Adaptive capacity scored the highest weight since it was pondered as the powerful tool to deal with climate change and variability with a weight of 70 percent, followed by the Sensitivity of 15 percent and Exposure (Hazard) of 15 percent as shown in Box1.

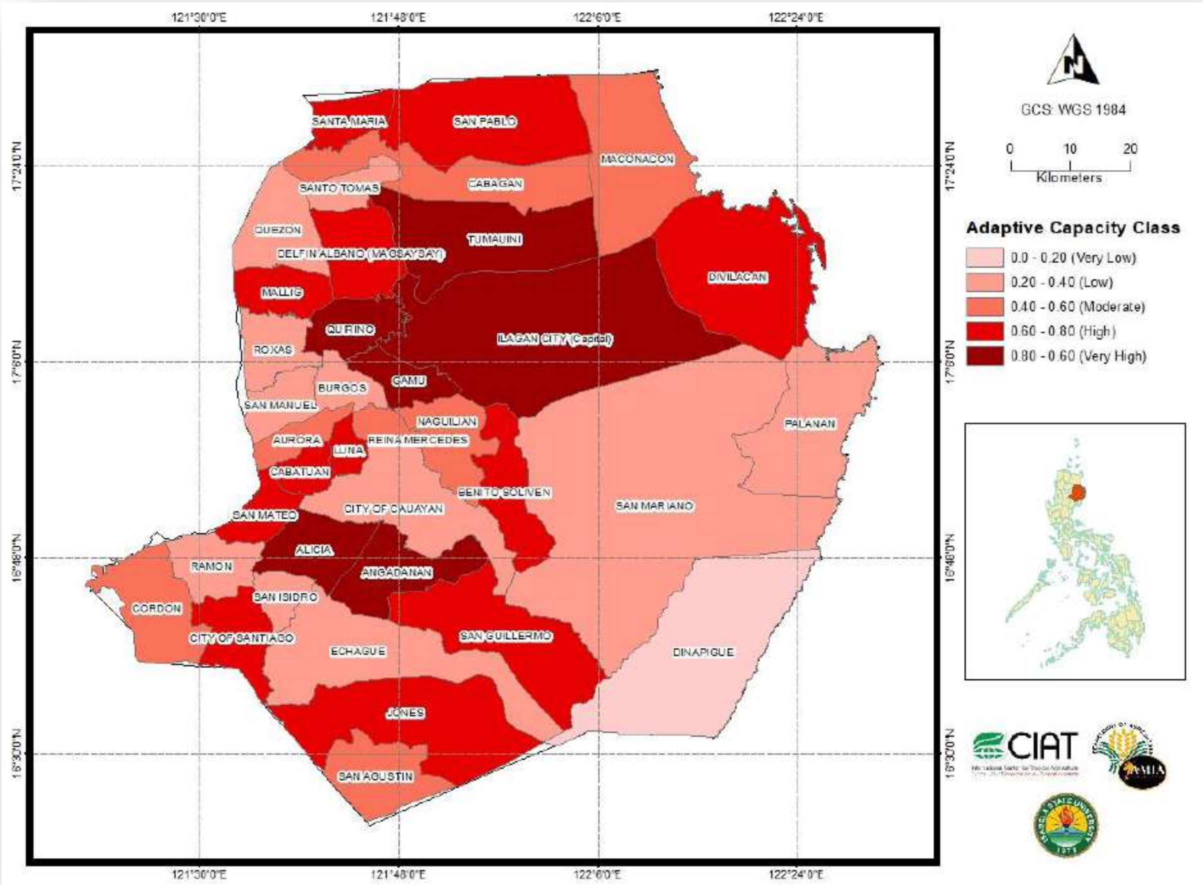

Figure 11. Adaptive Capacity Index of the LGUs in Isabela Province

Box 1. Indicator Selection Process of the Components for Vulnerability Assessment

Step 1: The dataset that were used to come up with the adaptive capacity index came from: National Competitive Council of the Philippines (NCCP), Philippine Statistics Authority (PSA), International Water Management Institute (IWMI), and National Mapping and Resource Information Authority (NAMRIA)

Step 2: Relevant variables were pre-selected from the database of NCCP, 2015

Step 3: Principal Component Analysis (PCA) and Random Forest was used to explore the geographic variances, correlation, and feature importance of data across provinces and indicators. The shortlisted indicators were cross checked and some more variables were included to complete the representation of the other AC capitals.

Steps 4 and 5: Experts from DA (from different agencies), NEDA, FAO, NGOs, and Academe were joined to the workshop. They were grouped into 2 clusters and ask to rank each of the indicators according to importance. Each group should discuss and decide for a common value/rate for each indicator. They were provided with 1-5 score/rates, where 5 is the highest/most important. Only those indicators that got rate/score of 4 and 5 were considered. Some of the variables were lumped into a single variable and was given a high score as suggested by experts. Overall weights for "Sensitivity (15%)", "Hazards (15%)", and "Adaptive Capacity (70%)" were also identified by the experts during the workshop.

Step 6: The values of the 16 indicators were integrated in the shapefile municipal boundaries. Each of the indicators was normalized and was treated with equal weights. The sum of the 16 indicators provided the adaptive capacity index.

Step 7: Five equal breaks were arbitrarily used with 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).

recommended that careful evaluation should be undertaken when comparing weights since other literatures will have different spatial scale, time resolution, and type of vulnerability being assessed.

As shown in Table 9 and Figure 12, only one municipality (San Mateo) and one city (Ilagan City) have very low vulnerability index. Ilagan City is a first class city and fully realize its potential as one of the investment hubs in the country and witnessed the extensive development. It is the largest LGU in Isabela Province with 91 barangays and also called as the "Corn Capital of the Philippines". The Municipality of San Mateo, on the other hand, is a second class municipality and popularly known as the "Mungo Capital of the Philippines" because of its extensive mungbean production employing the integration of mungbean as one crop in the crop rotation technique of the farmers production systems.

Table 9. Vulnerability Classification of LGUs in Isabela Province

CLASSES	MUNICIPALITY
Very Low Vulnerability	Ilagan City, San Mateo
Moderate Vulnerability	San Mariano, Cauayan City, Santiago City, San Agustin
Very High Vulnerability	Alicia, Angadanan, Aurora, Benito Soliven, Burgos, Cabagan, Cabatuan, Cordon, Delfin Albano, Divilacan, Echague, Dinapigue, Gamu, Jones, Luna, Maconacon, Mallig, Naguilian, Palanan, Quezon, Quirino, Ramon, Reina Mercedes, Roxas, San Guillermo, San Isidro, San Manuel, Santa Maria, Santo Tomas, Tumauini

In general, it is observed that the LGUs' adaptive capacity has an inverse relationship with its vulnerability to climate change and variability and hazards. That is, an LGU with a low adaptive capacity is highly vulnerable to changes in climate (i.e., increasing temperature, rainfall and number of dry days) and hazards. For example, in the province of Isabela, the Municipality of Divilacan has a low adaptive capacity and correspondingly is highly vulnerable to climate change and occurrences of hazards. On the other hand, Ilagan City is high in adaptive capacity but with low vulnerability. Therefore, enhancing the adaptive capacity of an LGU is necessary in order that such LGU will become climate-resilient.

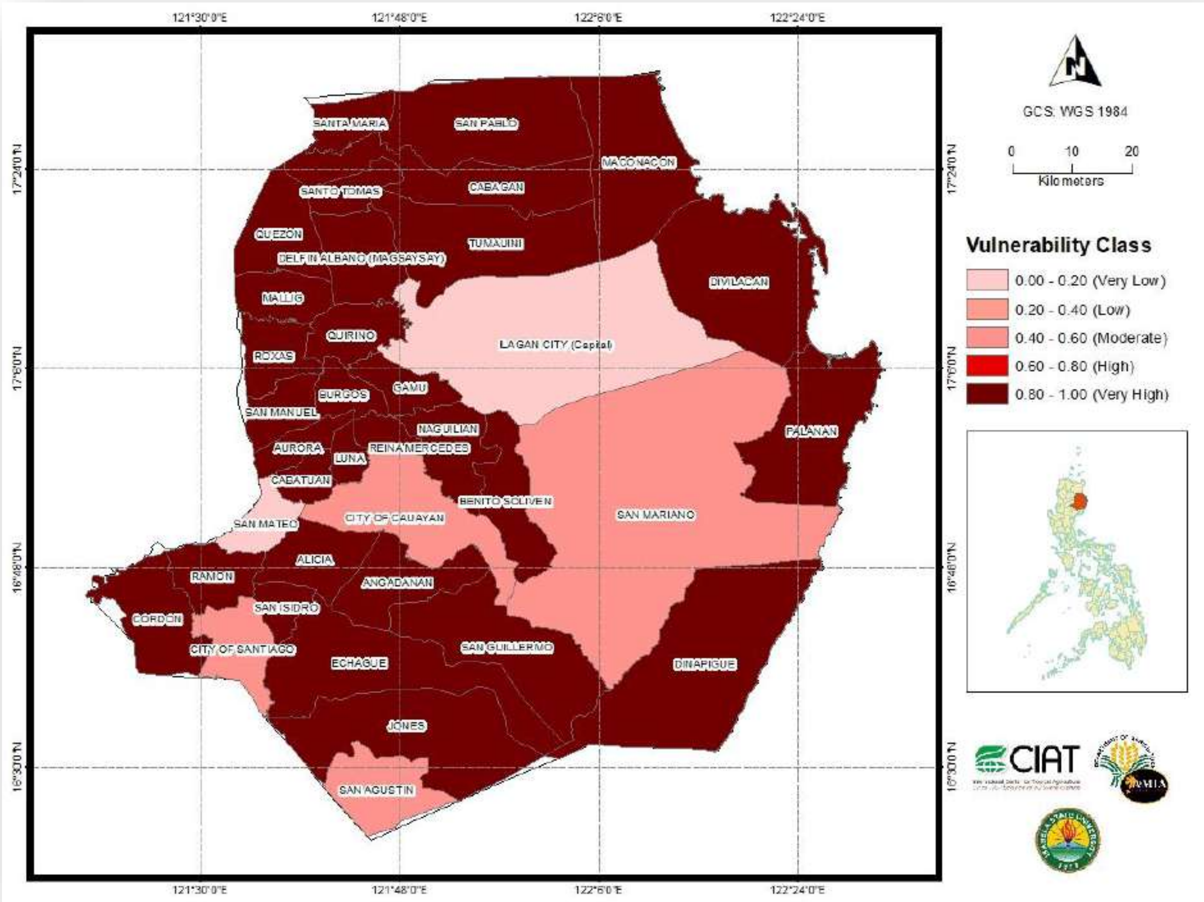

Figure 12. Vulnerability Index of the LGUs in Isabela Province

In terms of priority investment areas or development opportunities like agri-based industry, commercial establishments, tourism potential, cooperating private organizations and socio-economic base income that ensures well-being in an equitable and sustainable manner, these two areas would definitely entails a secured community as a productive manpower overcoming the effects of climate change and hazards.

Furthermore, four municipalities (i.e., San Mariano, Cauayan City, Santiago City, and San Agustin) have moderate vulnerability index. The more interesting concern is the very high vulnerability to climate change and hazards of the remaining 31 municipalities. It implies that these municipalities do not have the proper adaptation measures and so vulnerable to abrupt hazards brought about by the climate change and variability.

5.3 Component 3 - Stakeholders' participation in climate adaptation planning

Objective 2 – Determine local stakeholders' perceptions, knowledge and strategies for adapting to climate risks

In order to determine the local stakeholders' perceptions, knowledge and strategies in adapting climate risks, the Isabela State University (ISU)-Cabagan Campus made the necessary coordination with LGUs in the Province of Isabela requesting them to provide the data needed for CRVA as well as the lists of current CRA practices for Cost Benefit Trade-offs. Initially, the CRVA data was collected through distribution of questionnaires to the different Isabela LGUs from which the respondents identified their resilient agricultural practices. The agri-fisheries data and other information were systematically analysed by the team.

Similarly, the ISU-Cabagan team also organized technical workshops consisted of municipal agriculturist, technicians, DA-RFO2 AMIA resource persons and other representatives to gather supplementary data for CRVA and prioritized CRA practices and technologies. Through these workshops, knowledge-sharing and perceptions of the participants in regards to their agri-fisheries practices and technologies were generated proceeding towards the assertion of the farmers' production systems as CRA practices. Furthermore, some of the generated data were preliminary analyzed using the introduced models (Maxent) as discussed above and cross-regional/national data analysis workshop with an open source using GIS for a standard processing. Focus Group Discussions (FGD) of farmer leaders, LGUs and DA RFO2 was also conducted to validate the data and result.

These activities were guided by process facilitation and data collection tools developed by the AMIA2 projects on CRVA and CRA decision-support platform.

Planting of climate-resilient rice varieties (CRV) is another climate resilient production system practiced by farmers from the Municipalities of Cabagan, Sta. Maria, San Pablo, Delfin Albano, and Sto. Tomas. This practice can be described as the planting of NSIC 222 – a short maturing variety – in the first cropping and PSB Rc 18 – a long maturing variety – during the second cropping season. According to the farmers, aside from the high acceptability and pest and diseases resistant of PSB RC 18, it can also tolerate drought which is usually experienced during the second cropping season (November/December – February/March). Also, this variety (PSB Rc 18) while it is preferably chosen by farmers because of its high yielding characteristics and good eating quality, it is a long maturing variety when planted during the first cropping season (May/June – August/September). Thus, the farmers preferred to plant this rice variety during the second cropping period because of the reasons stated above.

Based on the above activities, it was described that planting of mungbean after the harvesting of rice at the end of the month of March (second cropping) which is the onset of the dry season month was practiced. This agricultural practice, described in this research as Adaptive Crop Diversification/Rotation (ACDR) originated from and is widely adapted by the farmers in the Municipality of San Mateo, Isabela, so that the municipality was declared "Mungo Capital of the Philippines". Through this production system (crop diversification/rotation with mungbean), "green manure technique" enhances the fertility of the soil as well as providing additional income for the farmers. This practice is already adopted by other municipalities such as, San Manuel, Roxas, Cabatuan, and Mallig.

Integrated Farming System (IFS) was also identified as one of the climate resilient practices practiced by farmers in Isabela Province, particularly in the Municipalities of Delfin Albano and Cabagan. Integrated farming is a whole management system which aims to deliver more sustainable agricultural output that includes crop, livestock, fish, tree crops, plantation crops and vegetables. Basically, it refers to agricultural systems that integrate livestock and crop production. One of the important components of this type of farming system is the establishment of a water supply system such as deep well pumps (utilizing underground water) or Small Farm Reservoirs (SFR). Inland fishery technique is also being integrated as one of the components usually practicing tilapia production system as part of the establishment of the SFR.

Accordingly, these three CRA practices and technologies were selected and prioritized as adaptive strategies due to indicators that majority of the municipalities of Isabela Province is highly vulnerable to climatic changes.

5.4 Component 4 – Documenting & Analysing CRA practices

Objective 4 – Document and analyze local CRA practices to support AMIA2 knowledge-sharing and investment planning

Climate Resilient Agri-fisheries (CRA) practices aims to support efforts from the local to global levels for sustainably using agricultural systems to achieve food and nutrition security for all people at all times, integrating necessary adaptation, and capturing potential mitigation" where possible and appropriate (Lipper *et al.,* 2014). In the study of Chemuliti (2017), they found out that Kenyan farmers had reasonable perceptions of climate change and climate variability and had taken steps to adjust their farming activities which are in accordance with their observed changes in rainfall pattern and intensity over the last couple of decades. Diversification of farm enterprises, changing of crop varieties, reducing flock sizes and changing of livestock breeds were the most common adaptation strategies. Lack of financial resources, insufficient labor and limited access to information were the major constraints that impeded adaptation. The results of their study suggest that the farmers are able to discern and to some extent disaggregate the climate stimuli from other stressors. However, the adaptation strategies were closely intertwined with other stressors that go beyond the climate dimension.

Systematically, cost and benefit analysis (CBA) helps to prioritize investments in a world with scarce resources, evaluate impacts of project interventions or investments, identify key variable that are likely to determine with the project's success, indicate actors who gain or lose the most from project establishment, and assess the long-term impacts or sustainability of the project implementation. In this study, CBA was conducted with a substantial purpose of prioritizing CRA practices in order to have a basis for the selection of projects or investments to scale up by DA-RF02 in AMIA2+ structure establishing accelerated CRA communities. To achieve this, the four steps conducted were:

(1) Conduct of farmer-leaders and agri-fisheries experts' workshop;
(2) Conduct of household survey of key-informants/farmer-leaders;
(3) CBA analysis through the CBA*tool* software program; and
(4) Identification of CRA adoption opportunities.

The production of result relies on the CBA online tool which was developed by CIAT. This online tool also aims to produce a user-friendly cost and benefit analysis tool.

Prioritization Criteria

The Project Team identified CRA practices and developed the criteria for the selection process in the province and correspondingly presented this list of CRA practices to group of experts as well as to farmer-leaders. Finally, the CRA practices selected to be subjected for CBA are: (1) adaptation of climate resilient varieties (CRV), (2) crop diversification/rotation practices, and (3) integrated farming system. These CRA practices are being described in the previous section (Objective 3).

The CRA practices for CBA analysis were evaluated on the following criteria:

A. Project Team initial evaluation criteria to be labelled as CRA for the CBA Analysis

1. Climate resilient varieties (resistant to growing conditions such as submergence, drought resistant/tolerant, and early maturing);
2. Adaptive crop calendar; and
3. Crop diversification

After the initial identification of CRA practices, the list were further evaluated considering the following technologies and practices:

1. Organic Agriculture

2. Permaculture
3. Good Agricultural Practices (GAP)
4. Climate Smart Varieties (described in terms of submergence, salinity, drought and heat-resistant/tolerant, early maturing)
5. Soil Conservation Technology (minimum tillage, contour cropping)
6. Weather-index based insurance
7. Water Conservation Technology (Small Water Impounding Project (SWIP)/Small Farm Reservoir (SFR), Alternate Wetting and Drying, Drip Irrigation)
8. Community-Based Management (forest, coastal, farm tourism)
9. Adaptive crop calendar/Crop switching/Diversification
10. Others practices (plastic mulch, rain shelter, hydroponics)

After undergoing the prioritization process as described above, the three CRA practices; that is, adaptation of climate resilient varieties (CRV), crop diversification/rotation practices, and integrated farming system were prioritized. It is interesting to note that these practices are the most common agricultural practices adopted by farmers in the six Municipalities of San Mateo, Cabagan, Sta. Maria, San Pablo, Delfin Albano, and Sto. Tomas.

Data Gathering and Methodology

In order to generate the necessary data and other information for the CBA, focus group discussions (FGD) and key informant interviews (KII) are being conducted. An interview schedule instrument was employed gathering primary data from the Municipalities of San Mateo, Cabagan, Sta. Maria, San Pablo, Delfin Albano, and Sto. Tomas. With the assistance and recommendations of the Local Government Units (LGUs) visited, the team have identified 17 farmers (with average age of 53) practicing the use of Climate Resilient Varieties (CRV) of rice namely; NSIC RC 216/222 (early maturing) during the first cropping (May/June-August/September) and PSB RC 18, during the second cropping season (November/ December-February/March) while four farmers (with average age of 50) practicing rice-rice mungbean crop pattern, called Adaptive Crop Diversification/Rotation (ACDR) in the Municipality of San Mateo. Five conventional farming practitioners in Climate Resilient Varieties (CRV) and (4) old conventional from the same group of respondents were interviewed in order to compare the current CRA and the old (conventional) farming practice. Five KII were also conducted for the integrated farming systems (IFS). The data gathered, analyzed and inputted into the Cost-Benefit Analysis (CBA) online tool developed by the International Center for Tropical Agriculture (CIAT).

Results of the Cost and Benefit Analysis (CBA)

To be meaningful, this study compared the values of NPV and IRR for the various CRV practices. As presented in Table 10, the period of analysis is 10 years using a discount rate of 12 percent. The decision to use a 10-year period of analysis is based on the observation that the IRR values become stable even before the ten-year period. Likewise, longer than 10 years would inefficiently capture realistic data especially in agricultural production such as vegetable cultivation and other agricultural production systems because entries for costs and benefits will be repetitious. The interest rate of 12 percent has been determined as the average of the prevailing interest rate of borrowing by the households from informal credit markets which ranges from 10 to 14 percent. The externality factor of 50 percent increase in soil fertility is considered in the estimation of the social NPV and social IRR.

Due to possible changes in the values of the households' resources, specifically land quality (i.e., decrease in soil fertility), sensitivity analysis is conducted for each of the CRA practices to determine the possible effects on the economic criteria.

Table 10. Parameters for the Cost and Benefit Analysis (CBA) of CRA practices

DATA SETS	CRA PRACTICES			SOURCE/BASIS
	CRV	**Rice-Rice-Mungbean Diversification/ Rotation**	**Integrated Farming System**	
1. Sample size, N	22	9	10	MAO
2. Discount Rate, %	12	12	12	Based on the average prevailing periods of credits of farmers
3. Adoption rate, %	30	30	30	ISU Project Team Assumption
5. Exchange rate, PhP	50	50	50	Present exchange rate of dollar to peso (2016)
6. Change rate of yield	-0.3	-0.3	-0.3	Philippine Statistics Authority (PSA)
7. Financial period of analysis, years	10	10	10	ISU Project Team assumption
8. Externalities	50% increase in soil fertility	50% increase in soil fertility	50% increase in soil fertility	MAO & Farmers experiences in the field

For purposes of this research, the CBA techniques use the survey data on agricultural practices for the various CRA practices described above. Likewise, some important data and other information on inputs and outputs are taken from the barangay profiles and secondary information gathered during the workshops, FGD sessions, and fieldwork. This is to ensure that the production budgets considered in the analysis accurately reflect the activities practiced by the households and prices of inputs and outputs in the production sites.

1. *CRA 1: Climate Resilient Varieties (CRV) – Planting of Short-maturing Rice Varieties (NSIC Rc 216 or NSIC Rc 222)*

NSIC Rc 216 or NSIC Rc 222 are short maturing varieties planted during the cropping period May/June-August/September (i.e., first cropping) while PSB RC I8 is being grown from November/December-February-March (second cropping). A longer maturing variety, PSB RC 18 is a lowland rice variety which is drought and heat tolerant and resistant to major diseases, insects, pests, and having high rice recovery and good grain quality. Its maturity is 123 days after seeding with a height of 102 cm, long grain size, and 65.34 percent milling recovery. It reaches a maximum yield of 8.1 tons/ha with an average yield of 5.1 tons/ha. The variety can recover from or withstand submergence during floods or too much rain.

PSB Rc 18 was identified by the Office of the Municipal Agriculture in San Mateo, Isabela as an effective climate resilient agricultural practice. During the field visits, the local farmers recognized this rice variety as having good growth performance in the last 10 years. According to the farmers, the use of Climate Resilient Varieties (CRV) of rice indicated above with the cropping calendar practice was prioritized and adapted as it can avoid or minimize the unpredictable risks to their crops due to the changing climate conditions.

Using the software *CBA tool* developed by CIAT, the results of the analysis indicate that the Net present Value (NPV) of the CRV practice is about US$ 10,483.00 and its Internal Rate of Return (IRR) is about 40.00 percent. The Social Net Present Value (SNPV) is US$ 28,850.00 while the Social Internal Rate of Return (SIRR) is about 93.00 percent. The Initial Investment Cost is about US$ 7,500 with a payback period of three years.

In the aggregate analysis, Table 11 shows that the Net Present Values (NPV) of the practice is about US$ 6,077,934.00, while the aggregate Social Net Present Value (SNPV) is about US$ 12,662,311.00. The Scenario of analysis indicates that the current price of PhP16/kg of rice will decrease by 20 percent after 10 years of adoption of the CRA practice.

2. *CRA 2: Adaptive Crop Diversification/Rotation (ACDR): Planting of Rice-Rice-Mungbean Crops*

Adaptive Crop Diversification/Rotation (ACDR) or planting of rice-rice-mungbean is a major CRA practice in the Municipality of San Mateo, Isabela. This cropping pattern has been institutionalized as a primary farming system because of its benefits in terms of income generation and climate change adaptation strategy since mungbean is a drought-tolerant crop. Mungbean is dubbed as “black gold” by the farmers of San Mateo, Isabela, and subsequently the municipality became known as the “mungo capital” of the Philippines. For this CRA practice, planting of mungbean (known also as mungo) is done immediately after the harvesting of rice at the end of the month of March which is the onset of the dry season month.

Table 11. Results of Cost and Benefit Analysis (CBA) of CRA 1: Planting of NSIC Rc 216 or 222/152 (1st cropping) and PSB Rc 18 (2nd cropping)

CBA TOOL SUMMARY RESULTS (For 1.0 ha)	NET PRESENT VALUE (NPV)	INTERNAL RATE OF RETURN (IRR)	PAYBACK PERIOD	INITIAL INVESTMENT	SOCIAL NPV	SOCIAL IRR	SCENARIO IN THE ANALYSIS (10 YEARS)	
Unit	**US$**	**%**	**Year/s**	**US$**	**US$**	**%**	**Before**	**After**
1. Value	10,483.42	40.05	3	7500	28,850.37	93.40	Current price of PhP16.00 /kg of rice	20% decrease in price
2. Aggregate analysis/ CBA tool summary	Total harvested area, ha 523,031	Current adoption rate, % 1	Adoption rate, % 30	Aggregated private NPV 6,077,933.9	Aggregated Social NPV 12,662.311.08			

Aside from the additional income from mungbean production, mungbean is also beneficial to farmers because of its ability to enhance soil fertility. It improves the quality of soil thereby reducing the use of farm inputs like synthetic or commercial fertilizers for the next planting season of rice. With this, some municipalities in Isabela are now imitating this practice because it is evidently a good intervention to increase family income in the face of the negative effects of climate change.

In Table 12, it shows that the Net present Value (NPV) of the practice is about US$ 16,231.00 and its Internal Rate of Return (IRR) is about 50 percent. The Social Net Present Value (SNPV) is about US$ 29,598.00 while the Social Internal Rate of Return (SIRR) is about 104 percent. The Initial Investment Cost is US$ 7500 with a payback period of three years.

In the aggregate analysis, Table 12 shows that the Net Present Value (NPV) is about US$ 5,396.811.00, while the Aggregate Social Net Present Value (SNPV) is about US$ 9,173,017.00. The Scenario analysis also indicates that the current price of PhP 16/kg of rice and PhP 60/kg of mungbean will decrease by 20 percent within the 10-year period of adoption of the CRA practice.

Table 12. Results of Cost and Benefit Analysis (CBA) of CRA 2: Adaptive Crop Diversification/Rotation (ACDR) –Planting of Rice-Rice-Mungbean Crops

CBA TOOL SUMMARY FARM (1 ha)	NET PRESENT VALUE (NPV)	INTERNAL RATE OF RETURN (IRR)	PAYBACK PERIOD	INITIAL INVEST-MENT	SOCIAL NPV	SOCIAL IRR	SCENARIO IN THE ANALYSIS IN 10 YEARS	
Unit	**US$**	**%**	**Year/s**	**US$**	**US$**	**%**	**Before**	**After**
1. Value	16,230.92	50.14	3	7500	29,597.87	103.73	PhP 16/kg, price of rice	20% decrease in price
							PhP60/kg, price of mungbean	20% decrease in price
2. Aggregate analysis CBA tool summary	**Total harvested area, ha**	**Current adoption rate, %**	**Adoption rate, %**	**Aggregated Private NPV**	**Aggregated Social NPV**			
	523,031	1	30	5,396.810.52	9,173,017.12			

3. CRA 3: Integrated Farming System (IFS)

Integrated farming is a whole management system which aims to deliver more sustainable agriculture that includes crop, livestock, fish, vegetables, tree crops, and plantation crops. Basically, it refers to agricultural systems that integrate livestock and crop production. Integrated farming system has been prioritized due to its numerous benefits and advantages in terms of productivity per unit area, profitability, sustainability, balance of food, income throughout the year, adoption of new technology, and increasing input efficiency.

Integrated farming system practice was identified as a CRA practice with the assistance of the Office of the Municipal Agriculture Office (MAO) of the two Municipalities of Delfin Albano and Cabagan, Province of Isabela. During the field visits and FGD, the LGU

Officials and farmer-leaders recognized this practice as a resilient practice due to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.

Integrated farming strategies are preferred by households because of risks and uncertainty due to bad weather, such as drought and the occurrence of typhoons and price fluctuations. Maintaining a rice paddy provides stable food supply. Through the vegetable farms and tilapia grown in small farm reservoir (SFR), cash can be generated in a short time which the household needs throughout the year. Trees are maintained at a very low cost while ensuring a future income and a source of timber for house construction.

Table 13 shows the results of the economic analysis of IFS applying the Excel software technique. The output of the program however, is in Philippine Peso (PhP) value. Also, through the software program, the conventional agri-fisheries technique is employed as an agri-fisheries practice for comparison with IFS. The conventional practice is being described as a production system with SFR as a component but rice crops alone are only cultivated throughout the year in an agricultural land. In Table 13, it shows that the Net present Value (NPV) of the IFS CRA practice is about PhP 110, 829.00 and its Internal Rate of Return (IRR) is about 118 percent with an initial investment cost of about PhP 607,791.00. The Social Net Present Value (SNPV) is about PhP 124,129.00 while the Social Internal Rate of Return (SIRR) is about 132 percent with the payback period of one year. Compared with the conventional practice, its NPV is about PhP 8,300.00 while its IRR is about 110 percent with the initial investment cost of about PhP 81,244.00. For this practice (conventional), the Social Net Present Value (SNPV) is about PhP 9,296.00 while the Social Internal Rate of Return (SIRR) is about 123 percent which is lower than the IFS.

Table 13. Results of Cost and Benefit Analysis (CBA) of CRA 3: Integrated Farming Systems (IFS)

CBA TOOL SUMMARY FARM	NET PRESENT VALUE (NPV)	INTERNAL RATE OF RETURN (IRR)	PAYBACK PERIOD	INITIAL INVESTMENT	SOCIAL NPV	SOCIAL IRR
1. Unit	**PhP**	**%**	**Year/s**	**PhP**	**PhP**	**%**
2. Value	110,829.00	118	1	607,790.78	124,128.73	132
3. Conventional Practice	8,300.00	110	1	81,244.00	9,296.00	123

In summary, the cost benefit analysis (CBA) carried out for the different CRA practices of households in the study sites yielded wide ranges of the values of the profitability indicators such as NPV and IRR. That is, the CRV practice has an IRR only of about 40 percent while the IFS has about 118 percent IRR. Except for IFS, the values of the IRR almost doubled when the externality factor of 50 percent increases in soil fertility due to the CRA practice.

In order to build up knowledge and find clear explanations why farmers adapt these CRA practice, it is also important to look at the other financial values, such as initial investment and annual costs and yearly income, as well as the socio-cultural and policy support aspects of the CRA practices. Many researchers also observed the significant contribution of the above factors to households' decision-making related to their livelihood and existence. As indicated above these decisions emerged as adaptive strategies due to climate change and natural hazards.

The CRAs are adapted as a way of spreading risks due to climate change thereby affecting production quantity and quality, price fluctuations and ultimately farmers' net income. A drought or too much rainfall immediately after planting or during flowering stage of plants causes crop yield to decline. Likewise, prices of agricultural products during harvesting time ultimately decrease agricultural income even with good harvest. In a rural setting, some period of the year, especially between harvest time and summer season, household members usually experience idleness. Thus, the other components of an integrated farming particularly growing vegetables and other cash crops can be done during the idle period thereby allowing farmers to generate relatively good income for the family.

Government and non-government agencies encourage this farming practice mostly making it an integral component of any government programs.

5.5 Component 5 – Establish AMIA baseline for outcome monitoring and evaluation (M&E) of CRA communities and livelihoods.

Objective 5 – To establish AMIA baseline for outcome monitoring and evaluation (M&E) of CRA communities and livelihoods

For this component of the research, the regional project team conducted the collection of baseline data and other secondary information on the target CRA communities identified by the DA-RFO2 and the corresponding farmers' livelihoods. This was undertaken following the development of outcome-oriented M&E guidelines for CRA, under the AMIA2 project on institutional and policy innovations.

AMIA Phase 2+ Village: Climate Resilient Communities (CRC) and Livelihoods

CRC 1 – Profile of Municipality of Benito Soliven, Isabela

From the CRVA results presented above, it was found out that the Municipality of Benito Soliven is highly vulnerable to climate change and natural hazards although it has high adaptive capacity.

Benito Soliven is a fourth class municipality and situated nearly at the center of the province of Isabela. It has a total land area of 16,680 hectares and subdivided into 29 barangays. As of year 2016, the total population is 29,593 people with about 23 percent of the population are employed in agricultural production. Seventy percent (70%) of the farmers are owners of their land they cultivated. The common agri-fisheries crops grown by farmers in the area are corn, rice and tilapia. Based on the record of Municipal Agriculture Office (MAO), corn reaches the average annual yield of up to 4,750 kilogram per hectare while rice is 4,500 kilogram per hectare and tilapia with an average of 2,629 kilogram per hectare. The current agricultural practices adopted by the farmers in the municipality are: the use of Genetically

Modified Organism (GMO), biological pest and diseases, hybridization (use of hybrid varieties), inbred varieties, adoption of crop rotation or diversification, organic farming, and cropping calendar activities.

Table 14 presents the programs, projects, and activities undertaken in the municipality by concerned agencies. Most of these are in support to agricultural production and infrastructural development.

Table 14. Programs/Projects/Activities (PPA) in the Municipality of Benito Soliven, Isabela

PROGRAMS/PROJECTS/ACTIVITIES	SOURCE
Adaptation Mitigation and Initiatives in Agriculture (AMIA) Village	DA
Provision of post-harvest facilities	DA
Agricultural Machineries	DA
Farm to market road	DA
Farmer led extension	DA
Seed and livestock dispersal	DA
Vaccination	DA and LGU

CRC 2 – Profile of City of Ilagan, Isabela

The results of the CRVA presented above showed that Ilagan City, although exposed to climate change and natural hazards, it has very low vulnerability to climate change and natural hazards. This low vulnerability condition of the city may be due to the very high adaptive capacity of the city government.

City of Ilagan is a first class city and known as the province’s capital city and fully realizing its potential as one of the investment hubs in the country and witnessed the extensive development. This city has total land area of 139,370 hectares with 91 barangays and 153,504 number of population and 12 percent of these are engaged in agriculture. Major crops present of the said municipality are the following rice, corn and tilapia. Corn production reaches an average yield of 5,000 kilogram per hectare. Likewise, rice yield reaches 5,000 kilogram, and 3,800 of tilapia per hectare, respectively. Common agricultural practices of the city are described below.

1. Rice production system

Planting Details

a. Planting Dates: *Dry Season – November – December (Irrigated) – January (Rainfed)*
Wet Season – May-June (Irrigated)/July (Rainfed)

b. Distribution Population: *25 hills/m^{2}so for 1 ha.= 250,000 hills*
Recommended Seeding Rate: *=20-40kg/ha (Registered/Certified Seeds)*
=15-20kg/ha (Hybrid Varieties)

c. Row Spacing: *Dry Season- 15cm x 20cm; Wet Season – 20cm X 20cm*

d. Row Direction: *Usually farmers follow the east to west orientation*

e. Depth: *5cm depth*

f. Soil Type: *Clay Loam Soil*

g. Rooting Depth: *15cm-20cm Depth*

h. Cultivar, Variety Used: *Hybrid and Inbred*

2. Corn production system

Planting Details

a. Planting Dates: ***Dry Season**: October – Rolling areas and other broad plains areas*
November – Broadplains and upper vega of flooded plains
December – Floodplains
***Wet Season**: April – Rolling areas and other broad plains areas*
May – Broadplains and upper vega of flood plains
June – Flood plains

b. Population at seedlings depends on row and plant spacing:
b.1. = 70 x 20 cm – 75,000 plants (approximately)
b.2. = 65 x 20 cm – 76,000 plants (approximately)
b.3. = Double row – 80 x 30 x 30 cm - 90,000 plants (approximately)

c. Row Direction: *East to West Orientation*

d. Planting Method: -*Manual*
-Manual with the use of farmalite or jabber planter
-Mechanical – with the use of Mini Corn Planter

e. Cultivar/Variety Used:
Hybrid Varieties: *1. DK 6919* *7. NK 6502*
2. DK 6818 *8. NK 6414*

3. PIONEER 4097	*9. EVOGENE*
4. PIONEER 3774	*10. HEALER*
5. NK 8840	*11. CW HR 8 PLUS*
6. NK 8850	

f. Fertilizer Application: -*Two times (2X) application of fertilizer*
-Basal- during planting
-Pitik – 15 DAP
-Side dressing- 30-35 DAP

Table 15 shows the various PPA of Ilagan City indicating the major components, such as crops development, livestock development, fishery development, and capability building in support for agri-fisheries development. It is interesting to note that the PPA focused on the support for the utilization of hybrid varieties for rice, corn and high-value crops, acquisition of farm machineries as well as the conduct of capability building in the agri-fisheries production systems.

Table 15. Programs/Projects/Activities (PPA) in the City of Ilagan, Isabela

PROGRAMS/PROJECTS/ACTIVITIES	SOURCE OF FUND
I. Agricultural Extension Development	
A. Crops Development	
1. Corn Program	
1.1. Purchase of 24,000 bags of hybrid corn seeds	City Government of Ilagan
1.2. Purchase of small scale corn planter	City Government of Ilagan
1.3. Establishment of 4 sites for SCoPSA	City Government of Ilagan-DA
1.4. Purchase of assorted fruit trees for SCoPSA and to rolling corn areas	City Government of Ilagan
*1.5. Purchase of Calcium Sulfate (Gypsum)	City Government of Ilagan
1.6. 10 Units PISOS	DA and LGU
*1.7.Contruction of 20 units MPDP with shed	DA and LGU
2. Rice Program	
2.1. Organic Fertilizer Program	BSWM-LGU
2.2. Rice Transplanter Walk behind (5 units)	DA and LGU
2.3. Purchase of 3 Units Combine Harvester	City Government of Ilagan
2.4. Shallow Tube Well	DA and LGU
2.5. Purchase of 3 units 36-40 HP Tractor	DA and LGU
3. High Value Commercial Crop Program	
3.1. Distribution of Seedlings (291 barangays)	City Government of Ilagan
3.2. Establishment of organic farm at LGU-Breeding Station	DA and LGU
3.3. Establishment of Organic Demo Farm	DA and LGU
3.4. Cassava Granulator	DA and LGU
B. Livestock Program	
1. Vaccination of large animals (hemosept)	LGU
2. Vaccination of small ruminants	LGU
3. Castration	LGU
4. Rabies vaccination	OPA and LGU
5. Treatments	LGU
6. Establishment of Multiplier Farm	DA and LGU
7. Swine Production	DA and LGU
8. Native Chicken Production	DA and LGU
C. Fishery Development Program	
1. Establishment of City Fishery Hatchery	DA and LGU
2. Fisherfolk and Boat R Registration	DA and LGU
II. Capability Building	

1. Fish-Registration	DA and LGU
2. Farmers(GAP Training)	DA and LGU
3. AEW's (Season - Long Training)	DA and LGU
4. Fishery (Training on aquaculture)	DA and LGU
5. HVCC (Training on High Value Commercial Crops)	DA and LGU

6. SUMMARY AND CONCLUSIONS

This research assessed and mapped the vulnerability of the agri-fisheries sector to climate change and climate-induced hazards in the Cagayan Valley Region (R02) focused in Isabela Province covering 34 municipalities and three cities. This is being carried-out in support to the launching of climate-resilient agri-fisheries (CRA) practices and technologies in local communities under the AMIA Phase 2 (AMIA2) program of the Philippines' Department of Agriculture (DA). In Isabela Province, the major agri-fisheries commodities that are focused of the analyses are rice, corn/maize, eggplant, squash, tilapia, and mango using modeling and statistical techniques that consider climate change and its impacts, climate variability, and social and economic variables, both at the level of local government units (LGUs) and households.

The CRVA in this research used modelling and statistical techniques that are appropriate considering climate models, crop distribution model, and econometric models, together with their uncertainties and limitations.

With 20 bioclimatic variables, the Maxent Model was used in assessing the climate and climate change suitability of crops considering the baseline conditions and Year 2050 future conditions. The most prominent hazards in Isabela Province – which was rated high by the Isabela Project Team – are typhoons, floods, and soil erosion. The adaptive capacity index for this vulnerability assessment considered different capitals, such as economic, natural, human, physical, and institutional capital. There are many indicators that could form a strong adaptive capacity index, but data availability was a driving factor in establishing the final index particularly for Isabela Province.

For the CBA, focus group discussions (FGD) and key informant interviews (KII) were conducted. Likewise, an interview schedule instrument was employed gathering primary data from the Municipalities of San Mateo, Cabagan, Sta. Maria, San Pablo, Delfin Albano, and Sto. Tomas. Some important data and other information on inputs and outputs were taken from the barangay profiles and secondary information gathered during the series of workshops, FGD sessions, and fieldwork.

Based on the result of the model, the climate suitability areas for rice, maize (or corn), squash, eggplant, and tilapia production in the province is projected to expand with significant future gains (i. e.,Year 2050 projection) specifically for maize (or corn), rice, eggplant, squash, and tilapia in that order. This positive gains of climate suitability for these crops has corresponding consequences on the reduction of the Sierra Madre Natural Park and Protected Areas on the eastern side of Isabela Province. It is also interesting to note that the eastern part of the province up to the coastal areas found out to be having a low suitability to grow tilapia in the face of climatic change. These areas are adjacent or covered by the Sierra Madre Mountain Range and the coastal areas facing the Pacific Ocean.

On the other hand, mango production in the Isabela Province shows a declining trend in terms of climate suitability areas for the 2050 projection year. As affected by climate change, the result of this study showed that moderately high suitability of mango production is to be concentrated at the mid-western part of Isabela Province.

Typhoons, floods and erosion are the most prominent hazards in the Isabela Province. As a result, the overlay of these three major hazards (i.e., typhoon, flood and erosion) resulted to a high incidence of hazards in the province.

Six municipalities of the Isabela Province are classified as having very high adaptive capacity (i.e., Tumauini, Ilagan, Quirino, Gamu, Alicia, Angadanan) with about twelve (12) of them (i.e., Santa. Maria, San Pablo, Delfin Albano, Mallig, Divilacan, Luna, Cabatuan, San Mateo, Benito Soliven, Santiago City, San Guillermo, and Jones) having high adaptive capacity. The rest of the municipalities belong to moderate and low adaptive capacity index indicating that the access to quality basic services, private investments, productive employment opportunities, private linkages and other indicators of adaptive capacity in these LGUs of the province is not enough to overcome the negative impacts of climate change and hazards.

The result of the assessment for adaptive capacity for each LGU in Isabela Province shows that the coastal Municipality of Dinapigue revealed its very low adaptive capacity index. During field validation, the team assessed that the ability of the community to cope with climate change and disaster impacts relies on the inadequate support facilities and services and capabilities of LGU Dinapigue. Accordingly, the main factor that constrains their capacity to adapt is the geographical location of the town indicating that supports and development opportunities to the populace of the municipality are quite weak and/or inadequate.

In general, it is observed that the LGUs' adaptive capacity has an inverse relationship with its vulnerability to climate change and variability and hazards. That is, an LGU with a low adaptive capacity is highly vulnerable to changes in climate (i.e., increasing temperature, rainfall and number of dry days) and hazards. For example, in the Province of Isabela, the Municipality of Divilacan has a low adaptive capacity and correspondingly is highly vulnerable to climate change and occurrences of hazards. On the other hand, Ilagan City is high in adaptive capacity but with low vulnerability. Therefore, enhancing the adaptive capacity of an LGU is necessary in order that such LGU will become climate-resilient.

Overall, the research on Climate Risk Vulnerability Assessment (CRVA) in the Province of Isabela through geo-spatial assessment or GIS-based modelling to assess vulnerability from climate change and variability embodying sensitivity factors, exposure conditions and adaptive capacity of each municipality in the province showed that only one city (Ilagan City) and one municipality (San Mateo) have very low vulnerability index. Ilagan City is a first class city and fully realizes its potential as one of the investment hubs in the country and witnessed the extensive development. It is the largest LGU in Isabela Province with 91 barangays and also called as the “Corn Capital of the Philippines”. The Municipality of San Mateo, on the other hand, is a second class municipality and popularly known as the “Mungo Capital of the Philippines” because of its extensive mungbean production employing the integration of mungbean as one crop in the crop rotation technique of the farmers production systems.

Thus, considering development opportunities such as agri-based industry, commercial establishments, tourism potential, cooperating private organizations and socio-economic base income that ensures well-being in an equitable and sustainable manner, these two LGUs would definitely entails a secured community due to its ability to overcome the effects of climate change and hazards. Furthermore, four municipalities (i.e., San Mariano, Cauayan City, Santiago City, and San Agustin) have moderate vulnerability index. The more interesting concern is the very high vulnerability to climate change and hazards of the remaining 31 municipalities. It implies that these municipalities do not have the appropriate adaptation measures and so they are vulnerable to natural hazards brought about by climate change and variability.

For the CBA conducted for the purpose of prioritizing CRA practices in order to have a basis for the selection of projects or investments to scale up by DA-RF02 in AMIA2+ structure, the results showed that the CRA practices in the study sites yielded wide ranges of the values of the profitability indicators such as NPV and IRR. That is, the CRV practice has an IRR only of about 40 percent while the ACDR has about 50 percent and IFS has about 118 percent IRR. Except for IFS, the values of the IRR almost doubled when the externality factor of 50 percent increases in soil fertility due to the CRA practice. Accordingly, it is also important to look at the other financial values, such as initial investment and annual costs and yearly income, as well as the socio-cultural and policy support aspects of the CRA practices in order to build up knowledge and find clear explanations why farmers adapt these CRA practice,. Many researchers also observed the significant contribution of the above factors to households’ decision-making related to their livelihood and existence. As indicated above these decisions emerged as adaptive strategies due to climate change and natural hazards.

The CRAs are adapted as a way of spreading risks due to climate change thereby affecting the production quantity and quality, price fluctuations and ultimately farmers’ net income.

A drought or too much rainfall immediately after planting or during flowering stage of plants causes crop yield to decline. Likewise, prices of agricultural products during harvesting time ultimately decrease agricultural income even with good harvest. In a rural setting, some period of the year, especially between harvest time and summer season, household members usually experience idleness. Thus, the other components of an integrated farming particularly growing vegetables and other cash crops can be done during the idle period thereby allowing farmers to generate relatively good income for the family.

Correspondingly, the DA – RFU Region 02, as the main user of the CRVA output, have already selected vulnerable sites (municipalities) where CRA actions will be implemented, particularly in the Municipality of Benito Soliven and the City of Ilagan. The Municipality of Benito Soliven is highly vulnerable to climate change and natural hazards although it has high adaptive capacity. The City of Ilagan, on the other hand, it has very low vulnerability to climate change and natural hazards although exposed to climate change and natural hazards. This low vulnerability condition of the city may be due to the very high adaptive capacity of the city government that indicates their capability to overcome the negative effects of climate change and variability.

Lastly, it is important to note that the results are based on modeling results (and realistic assumptions for CBA) which have intrinsic uncertainties and limitations. As such, any agricultural development initiatives using the output of this study in the Province of Isabela should be made in consideration with specific and changing conditions of local communities. However, with all these limitations, the results of this research are in broad agreement with existing literatures on climate change impacts as well as realities in terms of vulnerability. Furthermore, the CRVA output can be used to inform and guide decision makers from government agencies, extension staff, and private sectors on geographic areas that are in most need of interventions, and what package of interventions are needed for each geographical area. It also provides options and other opportunities for cross-sector collaboration between different government agencies, non-government organizations, and private sectors.

It is highly recommended to expand the assessment to a landscape scale vulnerability assessment on a municipality level. It is also suggested that there should be continuous checking and scrutiny of the accuracy of data and other information at the local level to ensure correctness to the future scenarios (as in the case of climate suitability models) as well the economic sustainability. While the climate crop suitability scenarios generated in this research are important component of CRVA, they are also indispensable in conceptualizing and developing research interventions in terms of improving agricultural practices and crop management to adapt climate change and variability and natural hazards. It is expected that the result of the CRVA in the Province of Isabela is now being used to apply for bigger funding from international donors to help Philippines adapt to climate change and variability and natural hazards. It is also now used by the Department of Agriculture for planning and prioritizing project interventions in the Philippines.

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Annex 1

CRVA Methodological Guidelines and Result for 10 Provinces, Philippines

DEPARTMENT OF AGRICULTURE
ADAPTATION AND MITIGATION INITIATIVE IN AGRICULTURE
INTERNATIONAL CENTER FOR TROPICAL AGRICULTURE

A Climate Risk Vulnerability Assessment for the Adaptation and Mitigation Initiative in Agriculture program in the Philippines

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Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces

Introduction and Framework

Climate change and variability continue to exert increasing pressure upon the agricultural sector of the Philippines. The three sectors that record the highest economic damage resulting from geophysical hazards in the Asia Pacific region are transport, housing and agriculture, whereas the agricultural sector is recognized as the most vulnerable of all sectors (UNESCAP 2015). A better understanding of major agricultural vulnerabilities to climate risks, thus fundamental to achieving more resilient farming systems, especially among poor rural households. Therefore, it is necessary to identify and prioritise at a high resolution scale the municipalities and relevant crops that are most vulnerable to climate risks. In this context, building resilience is not perceived as the ultimate goal, but rather as the intermediate main outcome contributing to the long-term goal of improved communities' coping capacities to a high degree of climate risks (Béné et al. 2015).

Under the umbrella of the Department of Agriculture project “Adaptation and Mitigation Initiative in Agriculture” (AMIA), a climate risk vulnerability assessment for 10 selected provinces (figure 1) has being conducted to guide AMIA targeting and planning for building climate-resilient agri-fisheries communities. In 2017, AMIA aims to launched integrated field-level action for establishing climate-resilient agri-fisheries (CRA) communities. It also seeks to introduce complementary activities for building appropriate climate responsive financial and other key support services. A key step in the targeting and planning for CRA communities is to assess climate-risk vulnerability in the proposed AMIA sites. This ensures that AMIA investments are cost-effectively channeled to support its overall goals and outcomes. Furthermore, it addresses the inherent spatial and temporal variabilities within and across sites.

Region	Province	Partner SUC
Ilocos Region (Reg. 1)	Ilocos Sur	Mariano Marcos State University
Cagayan Valley (Reg. 2)	Isabela	Isabela State University
Central Luzon (Reg. 3)	Tarlac	Tarlac Agricultural University
CALABARZON (Reg. 4A)	Quezon	Southern Luzon State University
Bicol (Reg. 5)	Camarines Sur	Partido State University
Western Visayas (Reg. 6)	Iloilo	Iloilo State College of Fisheries
Northern Mindanao (Reg. 10)	Bukidnon	Central Mindanao University
Davao (Reg. 11)	Davao City	University of Southeastern Philippines
Soccsksargen (Reg. 12)	North Cotabato	University of Southern Mindanao
Negros Island (Reg. 18)	Negros Occidental	Visayas State University

Figure 1. Target provinces in the Philippines and SUC partners for CRVA analysis.

Therefore, the following presents an assessment of the three key dimensions of vulnerability for the agricultural sector:

1. Exposure: The nature and degree to which a system is exposed to significant climate variations (IPCC 2014).
2. Sensitivity: The increase or decrease of climatic suitability of selected crops to changes in temperature and precipitation.
3. Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. (IPCC 2014).

The sensitivity analysis is based on the assumption of a high emission scenario by 2050 (RCP 8.5) whereas the adaptive capacity component is derived from the most up-to date available data mainly from 2015. The detailed composition of each component is visualized in Figure 2. The resulting vulnerability assessment enables evidence-based spatial targeting of agricultural extension and financial investment in areas most at risk or tailored to a specific hazard, crop or lack of adaptive capacity.

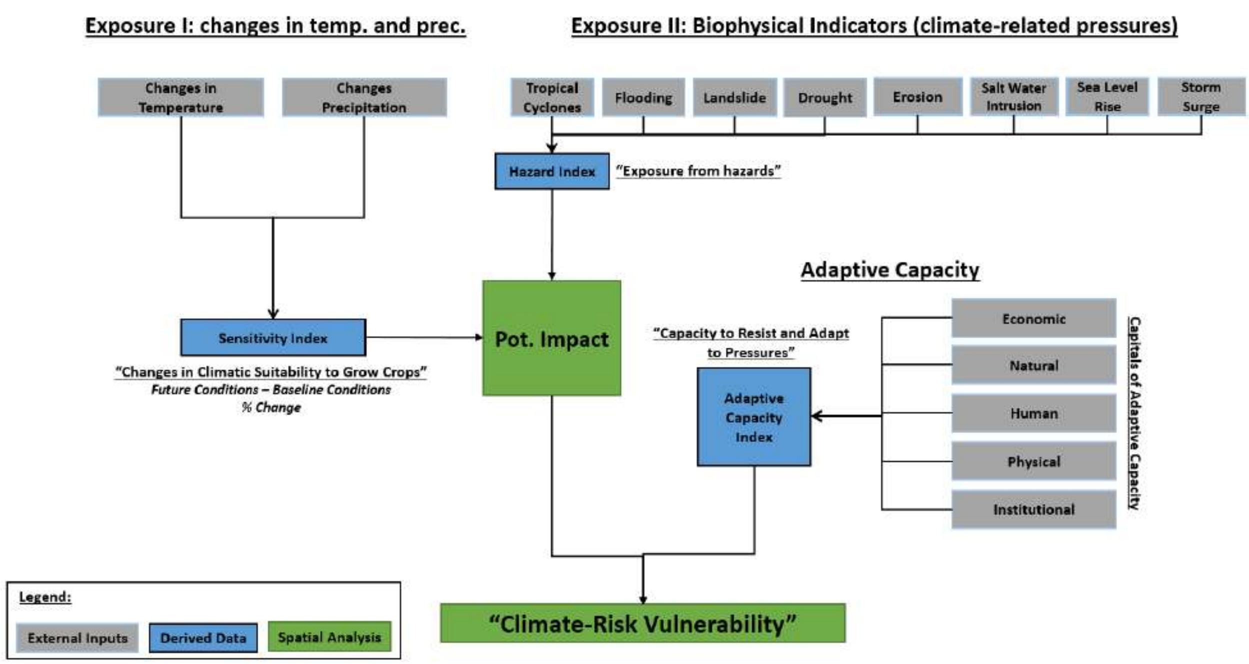

Figure 2: Climate Risk Vulnerability Assessment Framework.

$$f(Haz, Sens, AC) = \sum_{n=i}^{n} \frac{1}{2}\left(\left(Haz_{(w_h)} + Sens_{(w_s)}\right) + 1 - AC_{(w_a)}\right) \quad \textbf{Eq. 1}$$

Where: *Haz* = hazard index, *Sens* = sensitivity index ($_i$ = crop), and *AC* = adaptive capacity index. W_h = weight given for hazard, W_s = weight given for sensitivity, and W_a = weight given for adaptive capacity.

Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces

Recent Studies on Climate Change Vulnerability Assessment in the Philippines

Several vulnerability assessments have already been conducted in the Philippines agricultural sector. Table 1 summarizes the different components (sensitivity, exposure, and adaptive capacity), scale and resolution of already existing climate change vulnerability assessments in the Philippines. The climate change vulnerability assessments in the Philippines vary greatly in terms of the following: **1)** assessment of each components were highly variable, and impact of climate change where not explicitly analyzed. This means that most of the impacts that were attributed to climate change were based mainly on perceptions and less on empirical evidence; **2)** coverage is sparse. Studies have already been conducted at a single city or municipality; **3)** coverage was broad but resolution was coarse; and **4)** climate change was assessed using a single weather event (typhoon); and **5)** some are context specific (agriculture) while others are general. This can be useful for different objectives and institutions, but the context, component indicators, and analyses are of limited use if impacts of climate change will be assessed for the agricultural sector. Some are looking at short term climate variability or don't have any climate impact dimension in the analysis. In studies where vulnerability assessment was conducted at sub municipal and sub city scale, most of the data are based on perceptions, whereas studies conducted at regional level (inter-country comparison) the empirical data was aggregated at the coarse level. Some of the studies does not have any climate dimension in any of the components of vulnerability.

Table 1. Recent studies related to climate change vulnerability assessment covering Philippines. (dont forget to put those literature in the list of references)

Year Published	Scale	Sensitivity	Exposure	Adaptive Capacity	Citation
2016	Mabalacat City, Pampanga	Rainfall volume, Average typhoon wind speed, Plant growth stage	Affected production areas, Affected farmers, Damaged farmer equipment/houses/infra structure, Frequency of typhoons	Access to crop insurance, Access to typhoon forecasting information, Access to planting calendar bulletins	Mallari, 2016
2008	Sorsogon City, Sorsogon	The authors assumed that Sorsogon will experience strong tropical cyclones. Increase in rainfall was based from projected rainfall and temperature increase from PAGASA in year 2030 and 2050.		Socio-economic: Poverty incidence, Informality (Tenure), Literacy Rate, PO/CBO,MFI membership; Technology: Access to telecommunications, Access to electricity, Functional DRR Plan; Infrastructure: Household with safe water access, Paved	Mias-Mamonong and Flores, 2008

				road, Protective infrastructure (sea	
NA	Upper Marikina River Basin	Presence of rivers and streams, watershed conditions in terms of forest cover, Dependence on irrigation, Duration of drought	Extent of production areas affected wall, unsafe housing unit)by the last two occurrences of drought (in hectares), Quantity (MT) and value of yield losses (million pesos) due to drought in the last two occurrences, Extent of prime agricultural lands to SAFDZs affected (in hectares)	Small scale irrigation program, Crop diversification practices, Livelihood diversification, cloud seeding program.	Briones, NA
2015	Regional BIMP EAGA	Average high temperature, Hottest temperature, Hot days temperature, Heat wave duration, Consecutive dry days, Number of dry days, Wet day rainfall, 5-day rainfall	Percent floodplain, Multihazard economic loss risk, Multihazard frequency, Relative water stress index, Total population	Irrigation equipped area	ADB, 2015
2014	Five barangays (San Diego, Lumaniag, Binubusan, Matabungkay, Balibago) in Lian Batangas	Health of coastal habitats, Coastal integrity vis-à-vis flooding and erosion, and fisheries	Sea surface temperature, Sea surface height, and Relative wave exposure index	Health of coral communities, Health of seagrass meadows, Health of mangrove forests, Water quality, Habitat restoration efforts, Marine protected area, Human settlements, Economy, Education	Licuanan et al., 2015

EXPOSURE

A combination of natural hazard datasets has been used to estimate to which extent a different regions in the Philippines are under pressure from climate and hydro-meteorological risks. Most of these datasets refer to historical databases to evaluate the current potential risk because many climate hazards can be large scale singular events and projections of climate hazards to the year 2050 would add further layers of uncertainty. However, while it is not possible to attribute singular extreme events to progressing climate change, it is agreed that the likelihood of most extreme events is increasing under progressing climate change (IPCC 2012). The succeeding section below discusses the procedure to develop the hazard index, and a brief description of each hazard that was considered in the study.

Hazard Dataset

The development of a hazard index relies on spatial analysis of the weighted combination of different historical climate-related natural hazards in the Philippines using data (Table 1) that are open-sourced or developed by partner institutions, such as the Department of Agriculture (DA). Eight (8) hazards were identified for the Philippines, and these are typhoon, storm surge, flood, drought, erosion, landslide, saltwater intrusion and sea level rise. The selection of hazards was based on consultation with project partners, such as state universities and colleges (SUCs) and the System-Wide Climate Change Office in the Philippines. The hazard maps represent the current risk and exposure of crops, people and institutions, while some are likely scenarios such as sea level rise. Since each hazard has different degree, intensity and frequency, the potential damage also varies, especially across the three main islands of the Philippines, i.e., Luzon, Visayas, and Mindanao (herein referred as “island groups”), hence each of the hazards were weighed in each of the island groups. These island groups are unique in terms of exposure to hazards, rainfall pattern, landform, and crop distribution. For instance, the Luzon Island will have more areas planted with rice because of large basins and the abundance of flat terrains and also records the highest number of typhoons in the Philippines. Seven out of eight hazard dataset used in this study was from the output of the Adaptation and Mitigation Initiative in Agriculture (AMIA) phase 1 project of the Department of Agriculture and are described below:

Table 2. Source and description of each dataset.

Parameter	**Source**	**Unit of measurement, spatial and temporal resolution**
Typhoon	UNEP / UNISDR, 2013 (http://preview.grid.unep.ch/index.php?preview=data&events=cyclones&evcat=2&lang=eng)	1 kilometer pixel resolution. Estimate of tropical cyclone frequency based on Saffir-Simpson scale category 5 (> 252 km/h) from year 1970 to 2009.
Flooding	AMIA multi-hazard map / baseline data from Mines and Geosciences Bureau, Department of Environment and Natural Resources (MGB, DENR)	1:10,000 scale. Susceptibility of flood risk for Philippines from the past 10 years
Drought	AMIA multi-hazard map / baseline data from National Water Resources Board	Groundwater potential for the Philippines

Erosion	AMIA multi-hazard map / baseline data from Bureau of Soils and Water Management	1:10,000 scale. Soil erosion classified from low to high susceptibility
Landslide	AMIA multi-hazard maps / baseline data from MGB, DENR	1:10,000 scale. Landslide classified from low to high susceptibility
Storm Surge	AMIA multi-hazard maps / baseline data from Disaster Risk and Exposure Assessment for Mitigation, Department of Science and Technology (DREAM, DOST)	
Sea level rise	AMIA multi-hazard map	Assumption based on 5m sea level rise
Saltwater intrusion	AMIA multi-hazard map / baseline data from the NWRB	Groundwater potential for the Philippines

Developing Hazard Weights

A workshop has been conducted to identify appropriate weights per hazard for each island group. The SUC experts/focal persons were invited and were asked to score (1 is low and 5 is high probability/impact) hazard risk based from qualitative assessment using the following criteria 1) probability of occurrence, 2) impact of local household income, 3) impact to key natural resources to sustain productivity (refers to how key resources such as water quality and quantity, soil fertility, and biodiversity are affected), and 4) impact to food security of the country, and 5) impact to national economy. Table 3 summarizes the different weights for each island group in the Philippines. The criteria used also reflects the impact of hazards at different scales from local, landscape, and national level. A weighted sum was used to develop with the overall aggregated weight for hazards. For each municipality, the mean value of aggregate weight was computed. A subset of each province was created and values were normalized (0 to 1) per municipality. 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).

Table 3. Hazard scores per island group based from consultation with SUCs.

Hazards	**Island Group**		
	Luzon (%)	**Visayas (%)**	**Mindanao (%)**
Typhoon	20.00	18.21	16.95
Flood	19.05	16.40	15.25
Drought	14.25	16.17	16.95
Erosion	11.43	12.57	12.71

Landslide	8.57	10.72	14.41
Storm Surge	9.52	10.39	8.47
Sea Level Rise	5.71	8.33	5.08
Saltwater Intrusion	11.43	7.21	10.17

Figure 3 shows the degree of exposure to hazard for each of the target provinces. Typhoon, flood, and drought are consistently rated high across the three island groups and are considered the major driving factors of high hazard exposure vis-a-vis high hazard index. Although typhoon have the highest weight among all hazards (can trigger secondary hazards such as flood, landslide, and storm surge), its impact was mostly prominent in north Luzon, southeastern Luzon, and eastern Visayas regions in the Philippines. Since the hazard index is a composite of multiple hazards, higher values (darker colors) reflect several geographical overlaps of hazards (especially where typhoon, flood, and drought coincides), and wider geographical extent of each hazard layer.

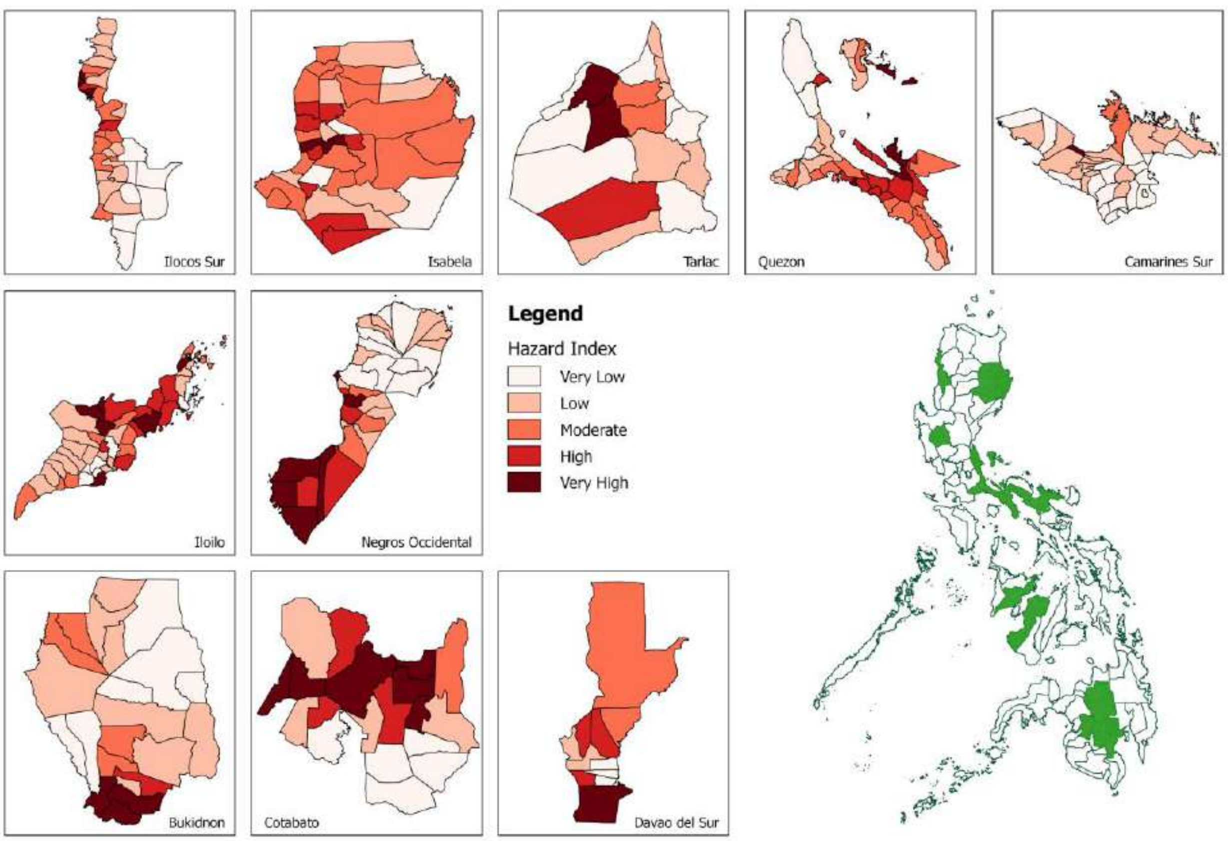

Figure 3. Hazard index for AMIA target provinces. Darker colors (hotspots) means higher incidence of hazards, and is driven by either extent or overlaps of hazards.

Climate-related Exposure across the 10 Provinces

Heat map (Figure 4) shows the degree of hazard incidence by province and indicates the province-specific climate risk that threatens the resilience of agri-fisheries communities. The analysis is based on the number of pixel counts by which indicates spatial coverage of each hazard for each province, except for typhoon which is based on mean frequency of typhoon events. This is to compare the degree of exposure across provinces. Higher incidence of hazards are observed in Luzon (Ilocos Sur, Isabela, Tarlac, Quezon, and Camarines Sur) and Visayas (Iloilo and Negros Occidental) island groups. Isabela and Camarines Sur are at high risk of typhoon events (historical data), since these provinces are located in areas considered as typhoon belt. Occurrence of flood is high in Tarlac, Isabela, and Negros Occidental because these provinces have large river basins and wide flood plains. On the other hand, Camarines Sur and Quezon are at high risk of sea level rise. In terms of potential drought, the map from AMIA1 indicates that higher spatial coverage are in the provinces of Isabela and Quezon. North Cotabato which experienced two consecutive drought in 2015 and 2016 is ranked 5th among the 10 provinces in terms of drought risk.

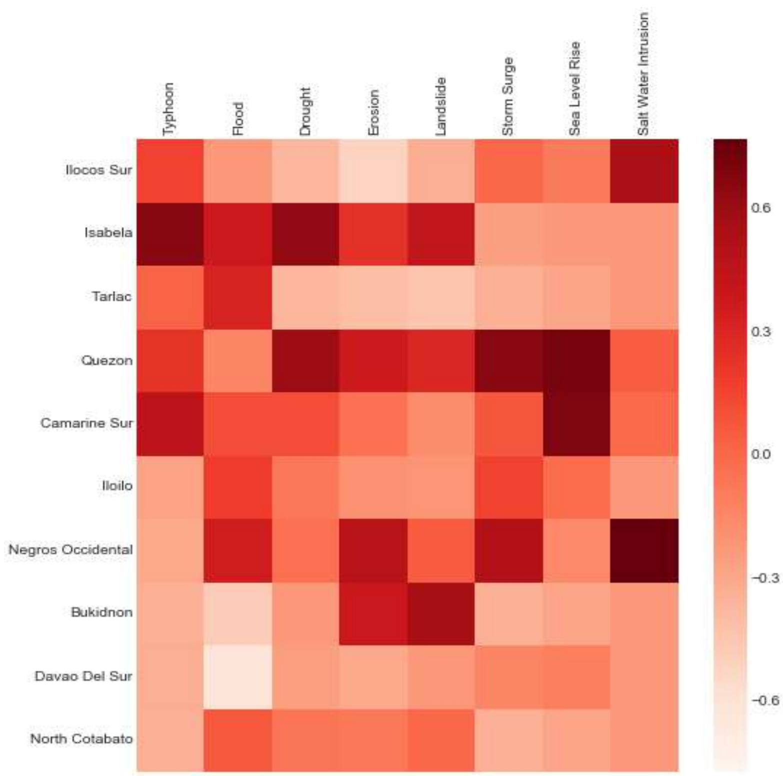

Figure 4. Degree of incidence of hazards per province.

Philippines' Exposure to Natural Hazards

Agricultural production in the Philippines, such as rice and maize, are highly vulnerable to typhoons as the typhoon season coincides with the growing period of these crops (fig. 5). The rice growing season, which typically ranges from June to October (based on peak of planting) also coincide with high incidence of typhoons. A single typhoon event can already cause billions (PHP) in damage to agriculture. In 2015, Typhoon Lando had caused damage to agriculture with an estimated total amount of Php5.9 billion. Among the affected provinces, Nueva Ecija suffered the most agricultural damage (Php3.5 billion) (Rappler, 2015. Data source from Department of Agriculture).

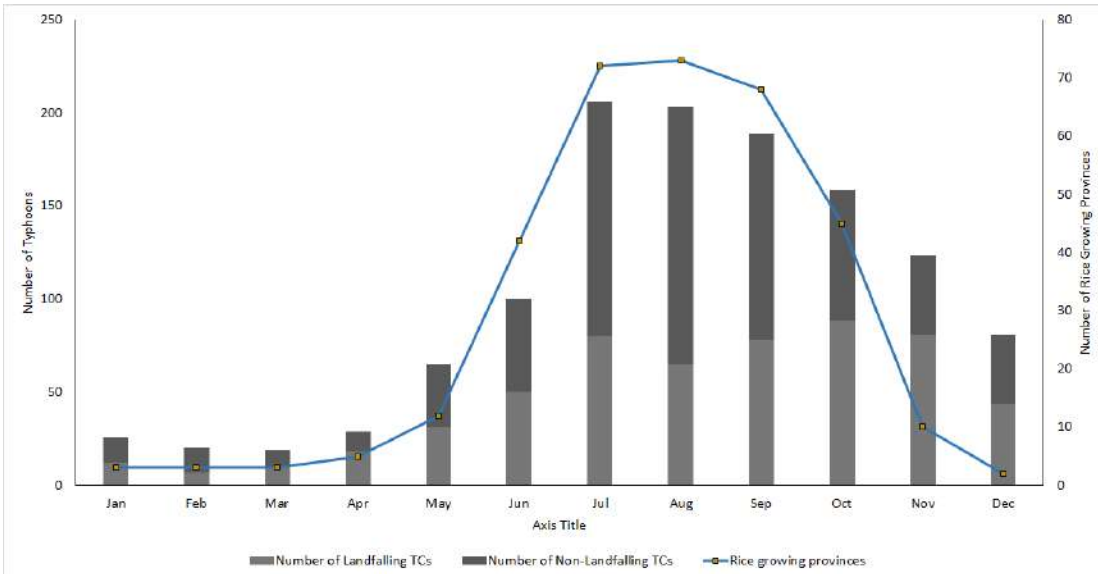

Figure 5. Monthly frequency of tropical cyclones entering the Philippine Area of Responsibility (PAR) from 1951-2013 (Cinco, et al. 2016) and estimated rice growing provinces in the Philippines (Laborte, et al. 2017)

The damage to crops, property, and livelihoods from typhoon, flood, and drought are increasingly becoming higher and costly, however, very few studies dealt with investigating its effect at different scales of governance (municipal, provincial, regional, and national). From 2000 to 2010, the total economic damage of typhoon, flood, and drought is estimated to be USD2,234.21 million in which the most affected crops are as follows: rice (USD 1.2 billion), maize (USD 461.50 million), and high value crops (HVC) (USD 244.82 million) Israel and Briones (2013). Moreover, there is an increasing trend of losses to agriculture (fig. 6) with an all-time high in year 2009, which is attributed to two typhoon events (Ketsana and Parma) which severely affected the agricultural areas in Regions 1, CAR, 2, 3, NCR, and 4A. The regions affected are considered the rice bowl of the Philippines. Damage to agricultural facilities was found out to be related to crop damage during typhoon, flood, and drought events (Israel and Briones, 2013). Some of this damage is avoidable and call for further training and resources for institutions, such as local government units, local NGOs, and Department of Agriculture Regional Offices, to be able to respond more efficiently and effectively during such events.

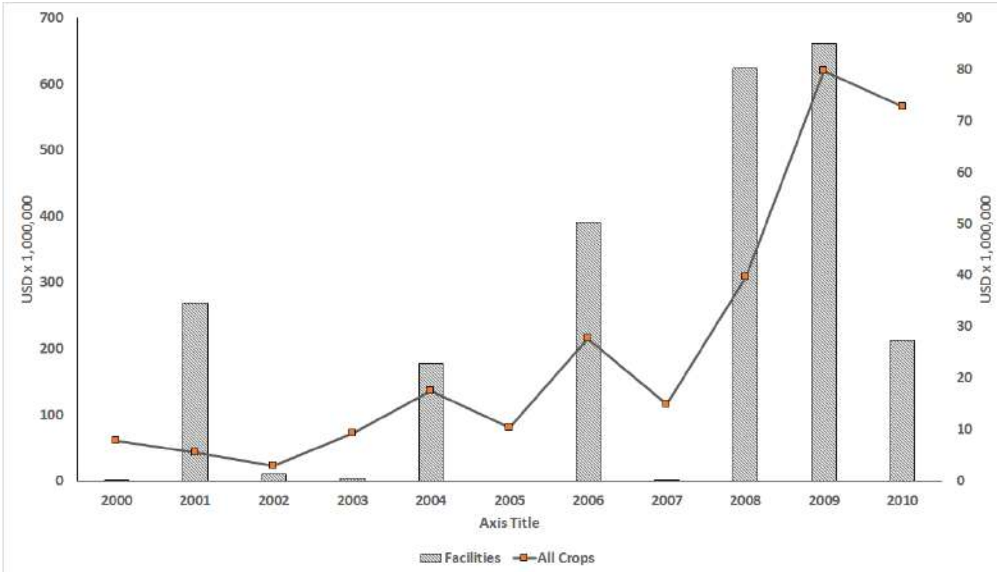

Figure 6. Crop damage trend from year 2000 to 2010. Line graph represent damage to all crops, and bar graph represent damage to agricultural facilities (Israel and Briones, 2013).

Typhoon

Typhoons are projected to globally increase in intensity due to progressive climate change over the coming decades (Webster et al. 2005, Emanuel et al. 2008). The vast majority (57%) of global typhoons occur in the Pacific ocean basin (NOAA 2013): The Philippines is the second most exposed country in the world to typhoons after China (NOAA 2010), receiving at least 15 typhoons (aggregate of tropical storms and typhoons) a year (PSA,2014). Northern Luzon, Southeastern Luzon and Eastern Visayas are the geographical regions with high incidence of typhoons and tropical storms (fig 7). With months of higher incidence of typhoon falling on the major cropping season in the Philippines, farmers are at high risk in terms of crop losses. The economic vulnerability of the agricultural sector to typhoons as the most damaging geophysical hazard was highlighted by FAO (2015) in their recent disaster analysis for the Philippines: *"Most of the production damage and losses [are] caused by typhoons/storms, amounting to USD 3.5 billion or 93 percent [for the agricultural sector]. The majority of the damage and losses in the agriculture sector were in the crop subsector with USD 3.1 billion [for the period 2006-2013]".*

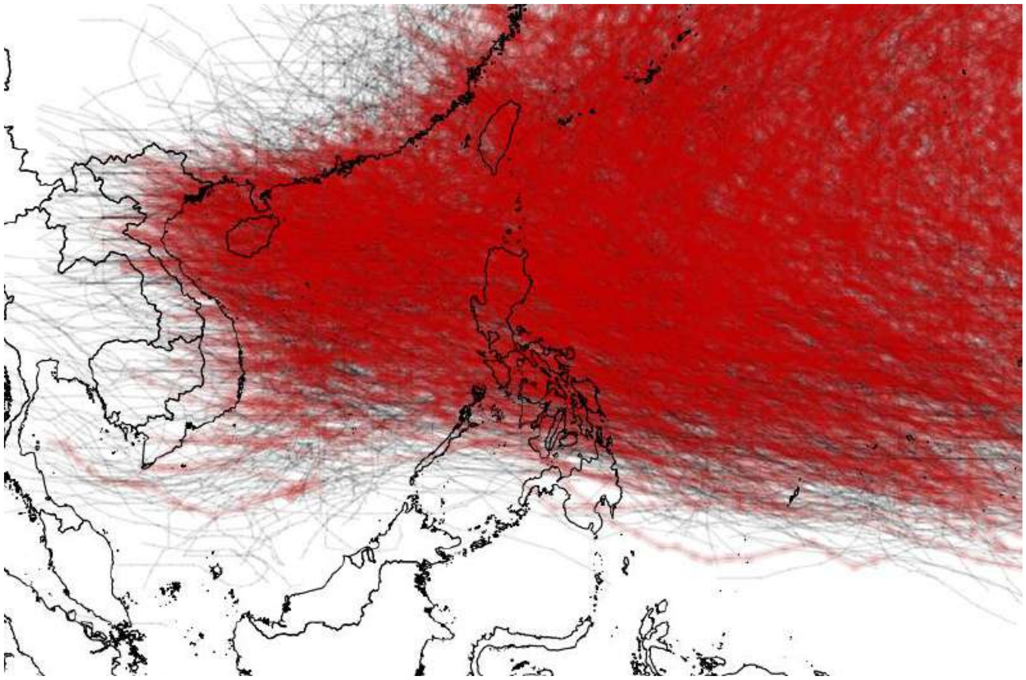

Figure 7. Typhoon incidence in the Philippines. Red lines are typhoon tracks with more than 160 kph wind speed.

Flood

Flooding is one of the major problems in the country, primarily during the monsoon season, and it is caused by either typhoon or enhanced southwest monsoon. An enhanced southwest monsoon is a weather system where a typhoon or low pressure area located outside of the mainland Philippines or outside the PAR enhances the southwest monsoon winds that brings heavy rainfall in Luzon and parts of the Visayas. Flood dataset was acquired from the multihazard AMIA dataset in shapefile format.

Drought

Drought has always an impact on agricultural, ecological and socio-economic spheres and causes serious environmental, social, and economic consequences worldwide. Drought is one of the most challenging hazards to monitor since it always has a slow onset and it is difficult to to observe and forecast quite well. The drought map was acquired from the AMIA 1 dataset. It is produced using the integration of groundwater potential from NWRB, incidence of drought from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), and air temperature.

Erosion

Erosion is a natural occurring process attributed into different factors such as soil properties, ground slope, vegetation/land cover, and the amount and intensity of rainfall (Montgomery, 2007). It is usually a slow and gradual process which involves movement of rocks and loosened soil on the Earth's surface from one place to another. In the coming years, the soil erosion rate is expected to increase due to more total rainfall and more frequent extreme events brought by climate change. In turn, an increase in erosion rate may lead to poor soil productivity and accelerated siltation of waterways and reservoirs (R.Lal, 2010).

Landslide

Landslide is one of the hazards which is naturally occurring event that may cause damage to properties, injuries and deaths, and adverse impacts on the environment. In 2011, Jadina stipulated in one of her studies in Southern Leyte that the frequent occurrence of landslide in region is associated with the presence of fault lines and heavy rainfall and not by human activities alone. Although seismicity can be the trigger factor of landslide, other biophysical components such as soil properties, steep slopes and vegetation/land cover are also considered major causal factors.

Storm Surge

A storm surge is an abnormal rise in the sea water level due to the presence of the storm and tropical cyclones also known as typhoons. Typically, storm surge happens in the coastal regions where water is pushed towards the shore by strong winds which can lead to flooding (figure 8). In the Philippines, Typhoon Haiyan hit Tacloban in 2013 and was responsible for one among the deadliest storm surge in the last 50 years with an estimate of more than 7000 fatalities recorded by the Philippine government organization known as National Operational Assessment of Hazards (NOAH).

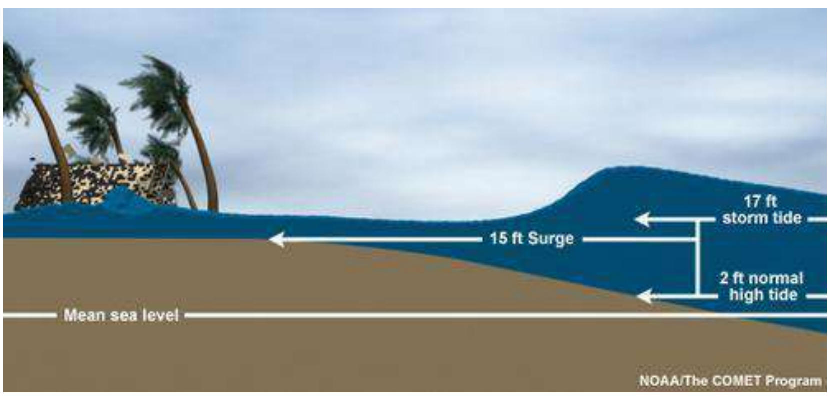

Figure 8. Storm surge vs. storm tide and normal high tide

Sea Level Rise

Sea level rise refers to an increase in the volume of water in the world's ocean caused by global warming. According to NASA, two factors related to global warming identified were the added water from the melting land ice and the expansion of of sea water as it warms. There are two types of sea level rise: the global and the local sea level rise. Figure 9 shows the global change in sea level observed by the satellites from 1993 up to present. The global rate of change is at an increasing trend of 3.4 millimeters per year (NASA, 2017). Saxena in 2016 observed that both globally and locally, sea levels are going up. However, she mentioned that there is a big difference among regions in terms of the rate of rising. Because just like the surface of the Earth, the surface of the ocean is not also flat, meaning the sea surface is not changing at the same rate globally.

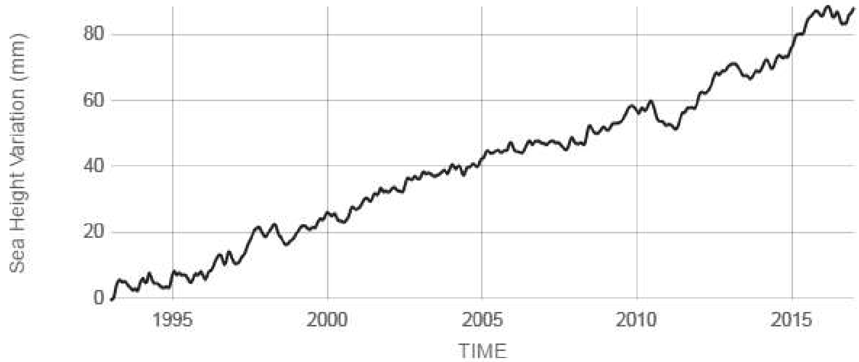

Figure 9. Global sea level observations by satellites showing the rate of change in mm/yr
Source: (climate.nasa.gov)

Saltwater Intrusion

Saltwater intrusion is defined as the movement of the saline water towards the freshwater aquifers that can lead to contamination of drinking water, as well as decrease in freshwater storage in the aquifers. Along coastal areas, saltwater intrusion naturally occur and found in the zone of dispersion or transition zone, where the freshwater and saltwater is diffused to keep it at a neutral level (USGS). Common mechanisms which causes saltwater intrusions are groundwater extraction, deepening of canals and drainage networks, and other human activities that lower groundwater levels and reduce freshwater flow to coastal waters.

SENSITIVITY

The crop sensitivity was assessed by changes in climatic suitability of crops by the year 2050 in comparison with the baseline crop suitability. The Maximum entropy (Maxent) model was used because of its robustness (able to show most important variable that affects crop distribution) and adaptability (model is based on locally observed data) to any local context. Analyzing crop suitability involved a two step process. The first step is to assess the baseline (current climate condition) crop suitability which is based on the condition that a species is predicted to occur at a particular location if it approximately matches the environmental condition where it is observed. The second step is to predict the location of a species on a particular time slice if it matches the environmental condition where it is observed in the baseline condition.

Crop Selection and Presence Data Collection

A series of workshops was conducted to identify the crops that will be analyzed for climate suitability. This was done by the SUCs in collaboration with the DA-Regional Field Offices. The list of crops for sensitivity analysis are shows in table 4. The main criteria for selecting the crops are based on two factors: 1) crops are important for food security, and 2) crops are important sources of cash. The crops were classified into grains (rice and maize), vegetables (squash, tomato, and eggplant), livestock forage (napier), and integrated farming (cacao, coffee, rubber, mango, and banana). It is also important to emphasize that we chose forages as proxy for livestock, but we did not run the sensitivity analysis because of insufficient points across the regions. Point data for crop occurrences were collected using a participatory mapping approach with partner state universities and colleges, agricultural technicians and staff from local government units - agricultural department, provincial government - agricultural department, and the Department of Agriculture - regional field offices to locate existing crop presence data in each of the municipalities. The mapping exercise was designed to rapidly collect data from the field. A map was provided with features that can assist in locating the occurrence of crops, such as road networks, river network, digital elevation model, municipal and barangay (smallest administrative boundary where decisions and actions are made) boundaries. A fishnet was also included in the map which shows a grid feature representing the climatic resolution of the environmental variables. The participants from the workshop identifies different crops that occur for each grid of the fishnet. A protocol was followed that for each crop occurrence, aside from personal knowledge, it should also be based from existing reports. We accepted multiple occurrence from different crops, but not from the same crop. This is to reduce biases and model overfitting, where multiple presence from the same crop overlays within a single grid. Finally, we ask them to document the yield and categorically annotate the crop occurrences with high, moderate, and low yield based from national yield averages reported by the Philippine Statistics Authority. These annotated information on the analog map was georeferenced and digitized to convert into a GIS database. Some of the points for rice (IRRI, 2013) and corn (DA-RFO 2 Municipality of Isabela) were extracted from the MODIS-derived rice map of IRRI (IRRI, 2013) and corn survey from DA-RFO region 2, respectively. A total of 17, 170 points was used to model crop distribution across 11 crops.

Table 4. List of crops as suggested by regional partners for sensitivity analysis.

Province	Rice	Corn	Tomato	Eggplant	Squash	Napier	Cacao	Coffee	Rubber	Mango	Banana
Ilocos Sur	x	x	x			x				x	
Isabela	x	x		x	x	x				x	
Tarlac	x	x	x			x				x	
Quezon	x	x		x	x	x	x	x			
Camarines Sur	x	x	x	x		x				x	
Iloilo	x	x		x		x	x				
Negros Occidental	x	x			x	x	x	x			
Bukidnon	x	x	x			x	x	x			
North Cotabato	x	x	x			x	x		x		x
Davao del Sur	x	x	x	x		x	x		x		x
Total presence data	**4840**	**5466**	**694**	**1034**	**486**	**192**	**1181**	**340**	**890**	**748**	**1299**

Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces

Environmental Layers

Baseline Conditions: A set of selected 20 bioclimatic variables was chosen to assess climate suitability of crops and it is described in table 5. For baseline conditions, the Wordclim dataset (available at Worldclim.org) (Hijman, xxxx) was used. Bio 20 (Number of consecutive dry days), processed by the International Center for Tropical Agriculture (CIAT), was added to the Worldclim dataset and it is found to be one of the major driving factors of crop distribution of certain crops. The described bioclimatic factors are relevant to understand species responses to climate change (O'Donnell, M and Ignizio, D., 2012).

Table 5. Bioclimatic variables used in crop distribution modeling

Parameters	**Description (**O'Donnell, M and Ignizio, D., 2012**)**
Temperature Related	
Bio_1 - Annual mean temperature	Annual mean temperature derived from the average monthly temperature.
Bio_2 - Mean diurnal range	The mean of the monthly temperature ranges (monthly maximum minus monthly minimum).
Bio_3 - Isothermality	Oscillation in day-to-night temperatures.
Bio_4 - Temperature seasonality	The amount of temperature variation over a given year based on standard deviation of monthly temperature averages.
Bio_5 - Maximum temperature of warmest month	The maximum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal).
Bio_6 - Minimum temperature of coldest month	The minimum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal).
Bio_7 - Temperature annual range	A measure of temperature variation over a given period.
Bio_8 - Mean temperature of wettest quarter	This quarterly index approximates mean temperatures that prevail during the wettest season.
Bio_9 - Mean temperature of driest quarter	This quarterly index approximates mean temperatures that prevail during the driest quarter.
Bio_10 - Mean temperature of warmest quarter	This quarterly index approximates mean temperatures that prevail during the warmest quarter.
Bio_11 - Mean temperature of coldest quarter	This quarterly index approximates mean temperatures that prevail during the coldest quarter.
Precipitation Related	
Bio_12 - Annual precipitation	This is the sum of all total monthly precipitation values.

Bio_13 - Precipitation of wettest month	This index identifies the total precipitation that prevails during the wettest month.
Bio_14 - Precipitation of driest month	This index identifies the total precipitation that prevails during the driest month.
Bio_15 - Precipitation seasonality	This is a measure of the variation in monthly precipitation totals over the course of the year. This index is the ratio of the standard deviation of the monthly total precipitation to the mean monthly total precipitation and is expressed as percentage.
Bio_16 - Precipitation of wettest quarter	This quarterly index approximates total precipitation that prevails during the wettest quarter.
Bio_17 - Precipitation of driest quarter	This quarterly index approximates total precipitation that prevails during the driest quarter.
Bio_18 - Precipitation of warmest quarter	This quarterly index approximates total precipitation that prevails during the warmest quarter.
Bio_19 - Precipitation of coldest quarter	This quarterly index approximates total precipitation that prevails during the coldest quarter.
Bio_20 - Number of consecutive dry days	Consistent number considered as dry days.

Future Conditions: Global circulation models (GCMs) are presently an important tool to represent future climate condition. The GCMs were spatially downscaled by CIAT using spatial statistical downscaling techniques (CIAT, 2017) to produce the 1 kilometer resolution bioclimatic variables. The description of the methodology is available at https://ccafs.cgiar.org/spatial-downscaling-methods. Spatial downscaling is necessary to create high resolution climate surfaces from coarse resolution output of GCMs. The GCMs used in this study are already based on Coupled Model Intercomparison Project "CMIP5" Global Circulation Models (GCMs) and already corresponding to the Representative Concentration Pathways (RCPs) with four time periods (year 2030, 2050, 2070, and 2080) based from IPCC Assessment Report 5(IPCC, 2015). So far, RCPs are the most recent and policy relevant scenarios. To analyze climate change crop suitability, an ensemble of the 33 GCMs was used based on the Representative Concentration Pathway (RCP) scenario 8.5 from IPCC Assessment Report 5 and a time period of year 2050. Scenario 8.5 was used because of the observed trends in greenhouse gas emissions.

Model Implementation

Maxent model is a species or crop distribution model commonly used to estimate most suitable areas for a species or crop based on probability in geographic areas where the distribution of crops is scarce (Burgman, 2002). Climate and climate change suitability of crops was assessed using a two step process: First, the model was run and assessed for baseline conditions. We employ two ways to assess the performance of the mode; 1) value of the "Area under curve" or AUC if greater than 85%, and 2) visual inspection where a crop is reported to be present. For instance, for Cacao and Coffee, we should not expect a higher prediction in Luzon, because the majority of those crops is present in Visayas and Mindanao study sites. Then we should also expect a higher suitability in Mindanao. Second, if those criteria for step 1 was satisfied, then we run it for future conditions. Before we run each instance of Maxent, we filter geographic records of presence data. We remove points that are within a specified distance from each other using a script available in GitHub (https://github.com/lpalao/point_distance_filter/blob/master/point_distance_filter.py) to reduce point spatial autocorrelation due to high point density which can affect model performance (over fit). Figure 10 below are the sampling distances before and after filtering was applied.

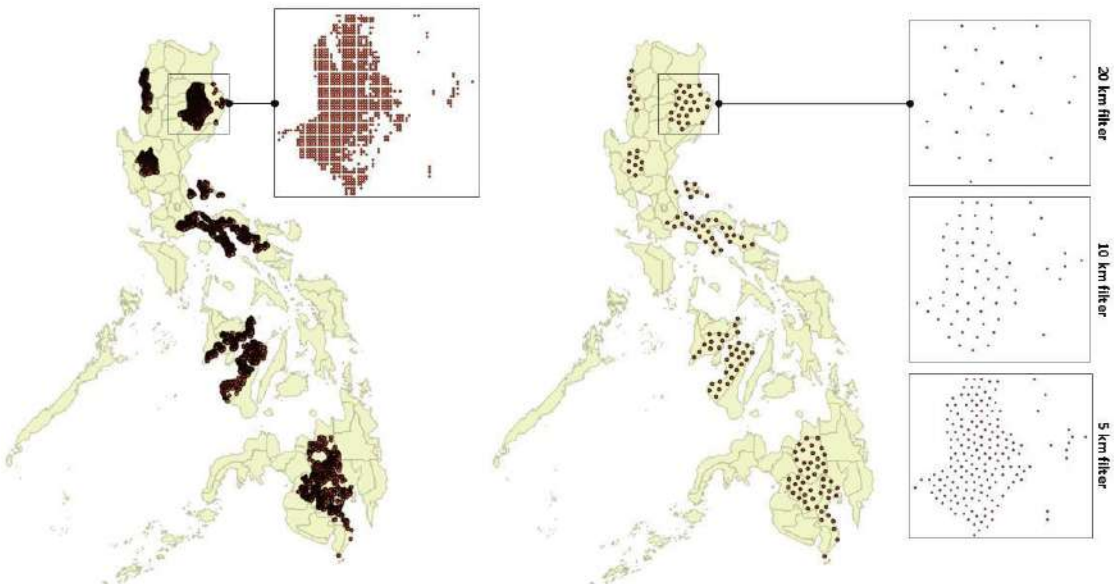

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Figure 10. Shows the filtering of points based on distance. **a)** Rice crop presence points collected by the regional partners, and **b)** Rice crop presence points filtered with a distance of 20 kilometers.

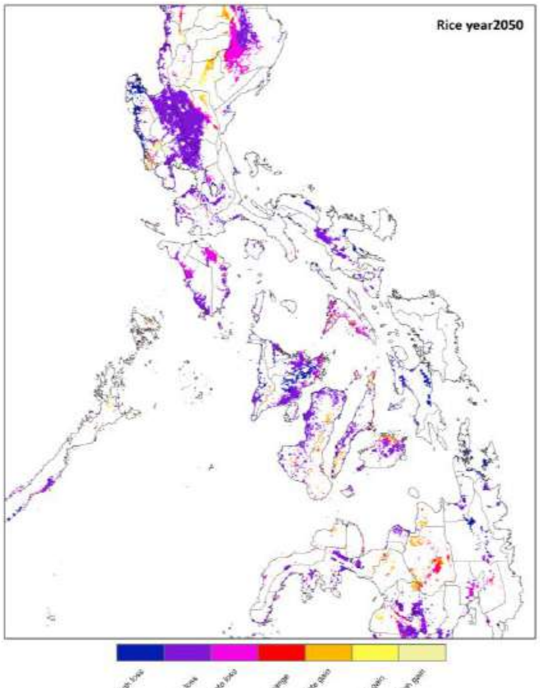
The difference (expressed as percentage) in future and baseline suitability determines the climate change crop suitability, and reflects the degree of crop sensitivity to changing environmental conditions. Higher change in a negative direction reflects higher impact of climate change. An index was developed from -1.0 to 1.0 for CRVA. An index range from 0.25 to 1.0 indicates a loss in suitability, while -0.25 to -1.0 indicates a gain in suitability (table 6).

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

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	

The map shows (fig 11) shows the changes in climatic suitability of different crops and commodity systems in the Philippines due to climate change by year 2050 through climate modeling and use of species distribution model. Higher losses (90%) are observed in most of the lowland areas (0-500 meters ASL) due to changing temperature and precipitation regimes. On the other hand, there is an observed shift in climatic suitability in higher altitudes as shown in Bukidnon and Davao del Sur in Mindanao where there are increasing areas becoming climatically suitable, while some areas have maintained climatic suitability. It is misleading to conclude that crops in geographic areas that will experience a decrease in climate suitability will not anymore survive, however, a reduction in yield is expected in high impact areas of agricultural management continues business as usual. Since climate is something that farmers cannot control, an improved crop production/farming practices system that promotes health soil and efficient use of water is vital as a means of climate change adaptation. As reported by Iizumi and Ramankutty (2015), in the absence of fatal weather events, the major variations in crop production would be affected by mean climate conditions. Maize crop simulation in Isabela province under climate change shows 7% to 13% reductions in growing cycles (effect of expansion in dry months) and 17% to 41% reductions in mean yields (water stress and rising temperatures) (Tongson, et al., 2017). This is because, most of the crops included in the list are managed by farmers to some degree, and changes in cultural management might alleviate climate pressures. Climate change may also have an effect on the distribution of pests and diseases and can put more pressure to crop performance (i.e., yield). This emphasizes the need for improved crop management, responsive research and development initiatives, and better provision for infrastructure (irrigation) and technology to cope with the increasing pressures of climate change to agricultural productivity.



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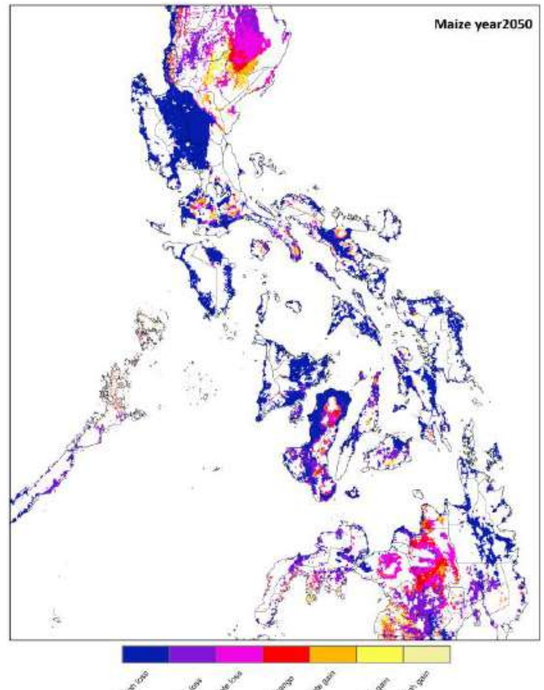

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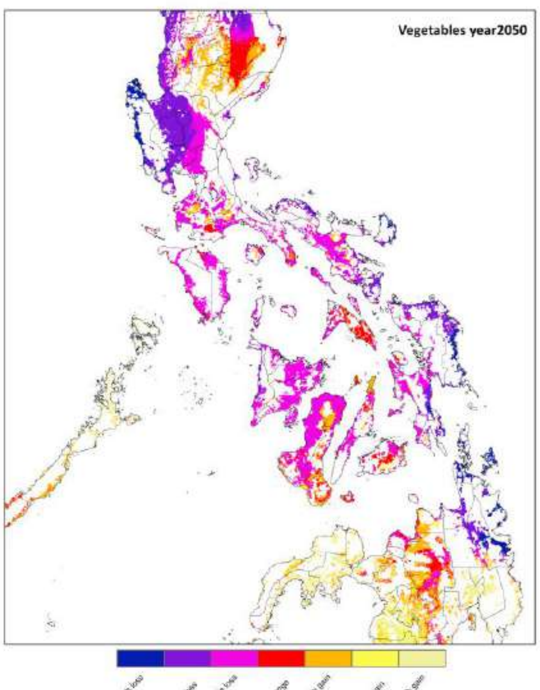

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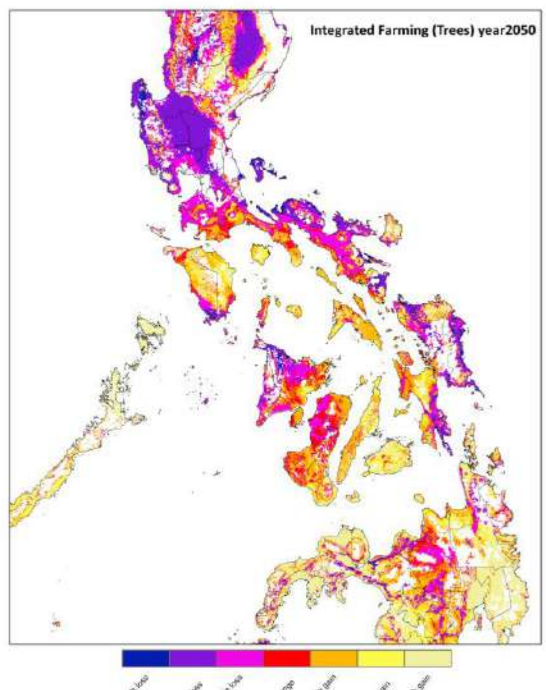

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Figure 11. Maps indicating changes in climatic suitability of crops/commodities: **a)** Rice, **b)** Maize, **c)** Vegetables, and **d)** Integrated farming.

The climatic variables that determines the suitability of the crops are the following: temperature related (temperature annual range, isothermality) and precipitation related (annual precipitation, precipitation of driest quarter, and precipitation of warmest quarter) (fig. 12). According to Peng, 2004, they observed a decreasing trend by 10% in rice yield during dry season for every 1°C in mean night time temperature. This confirms that isothermality is one of the critical factor in crop suitability of rice. Ramakrishnan et al., 2011, reported varying degree of yield loss with different temperature regimes in India. Furthermore, as reported by Iizumi and Ramankutty (2015), the accumulated rainfall during the crop duration has high correlation with planted area. Hence, available of precipitation during dry season (driest quarter) and temperature regimes have a strong negative effect on crop distribution and growth. This only shows that the critical variables predicted by the model conforms to existing literatures on the impact of climate change on crops.

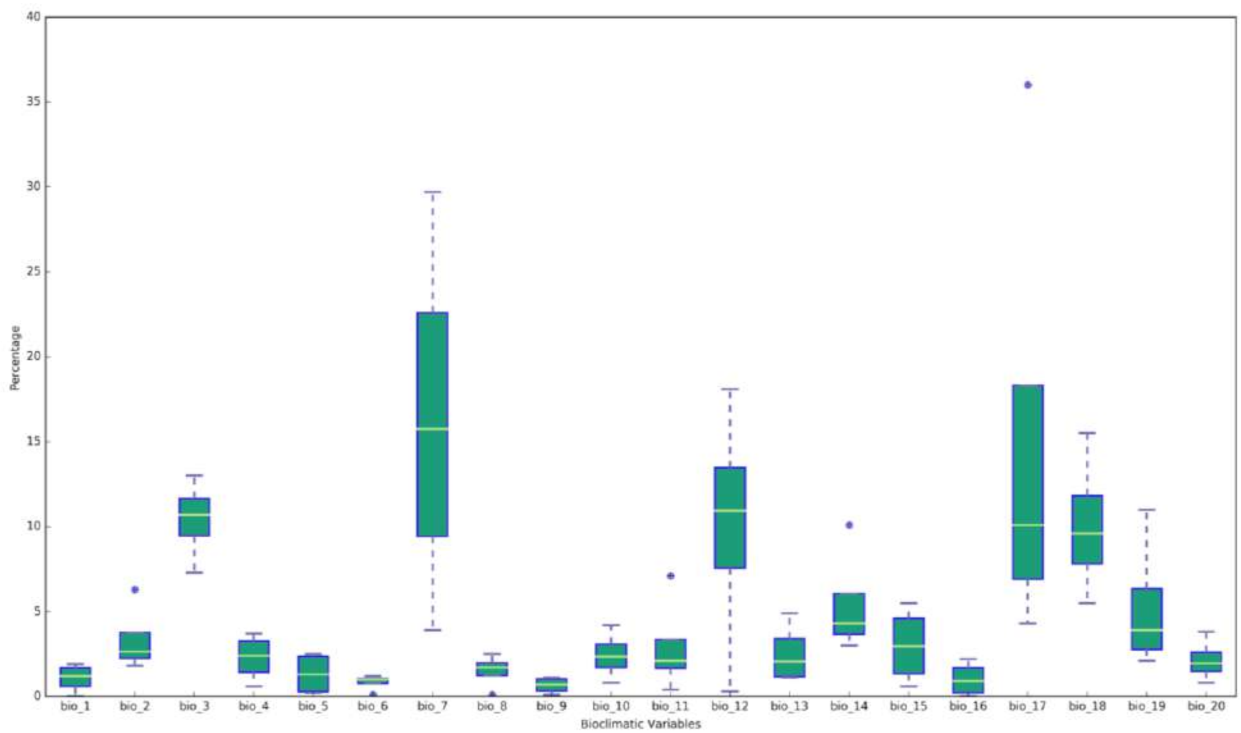

Figure 12. Variable contribution of bioclimatic variables for each crop distribution

According to Martin Parry and Al Gore (IPCC, 2007), "Climate change will generally reduce production potential and increase the risk of hunger. Where crops are grown near their maximum threshold temperatures and where dry land, non-irrigated agriculture predominates, the challenge of climate change could be overwhelming especially for subsistence farmers.

The impacts of global climate change are already felt in the Philippines particularly in the inland valleys and upland ecosystems. Frequent occurrences of devastating droughts and floods, warming temperatures, and increasing weather variability were among the local manifestations. Rice, the country's major staple crop, has experienced a decrease in its production potential due to water and heat stress. For instance, as cited by Lansigan et al. (2000), typhoons, floods, and droughts caused 82.4% of the total rice (Oryza sativa L.) losses from 1970 to 1990. Unreliable weather patterns such as the onset of the wet season and unpredictable rainfall are already causing losses (Foley et al., 2009). For instance, the 2016 El Niño resulted to insufficient rainfall, hence, few farming activities have been undertaken in other areas of the country particularly in Ilocos, Western Visayas, Zamboanga Peninsula, Misamis Occidental, Davao Region, SOCCSKSARGEN, and Autonomous Region of Muslim Mindanao. According to "The Performance of Philippine Agriculture" report by Philippine Statistics Authority (PSA) there is an 11 percent reduction in production from the same period in 2014 (IFRC, 2016).

The changes of the atmospheric composition and global climate will also affect the location of crops and their pests and diseases. The impact will be in the form of crop loss leading to decline in economic productivity. The continuous change of levels of CO2, ozone and UV-B will influence disease by transforming the host physiology and resistance (Chakraborty et al., 2000). Moreover, the changes in temperature, rainfall and occurrence of extreme events will determine pest and disease prevalence (Pautasso et al., 2012; Valeroso et al. 2002 as cited in Lasco et al. 2004). According to FAO (2016), the 2016 El Niño season pest infestation affected 1,704 farmers in Region III, with armyworm damaging 1,060 hectares of HVCs whereas rat infestation affected Region XII (South Cotabato, Sarangani, North Cotabato, and Sultan Kudarat) and Region XV (Maguindanao). The Department of Agriculture estimates that 181,687 farmers have been affected by the drought. The 54 percent are rice farmers, 38 percent are corn farmers, and 8 percent are high value crop (HVC) farmers. In total, 224,834 hectares of land area were affected and 96 percent has been directly affected by El Niño-associated drought. The majority affected are rice areas (96%) followed by corn (34%).

CLIMATE RISKS IN THE PHILIPPINES

Based from the ensemble of nine (9) GCM models for high emission scenario, the Philippines is expected to have warmer temperatures in most parts of the country, especially the low lying areas. Maximum temperatures will be prominent in Northern Luzon and Central Luzon, and some parts of Mindanao, which party explains the high loses of suitability in these areas, especially rice and maize. Number of dry periods are also expected to increase by 10%-15% in areas of central to norther Luzon. These scenarios are critical in growth and performance of crops. This analysis have not taken into account damaged caused by climate extreme events, such as El Niño, La Niña, cyclones, and pest and diseases outbreak.

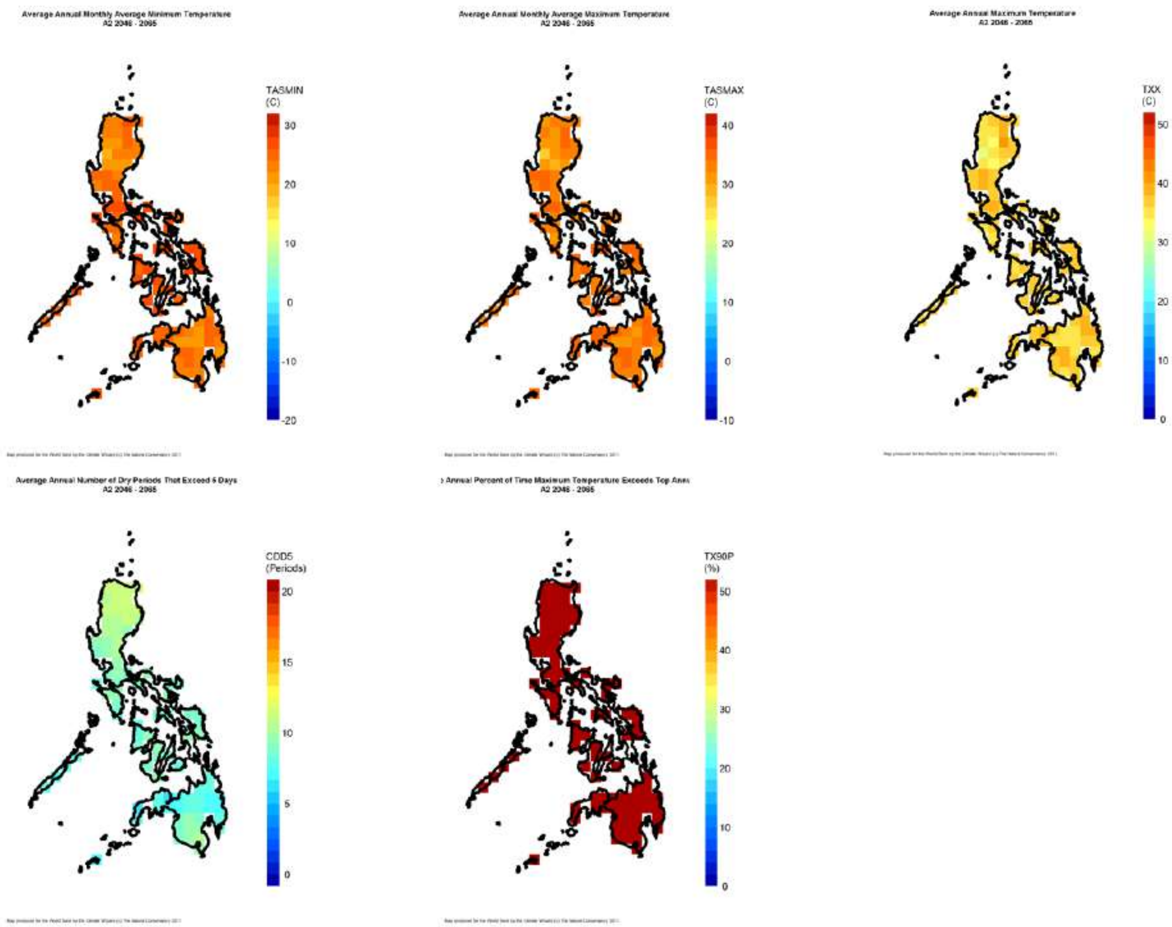

Figure 13. Map of projected temperature and precipitation regimes by midcentury: from top left to bottom center: average annual monthly average minimum temperature, average annual monthly average maximum temperature, average annual maximum temperature, average annual number of dry periods that exceeds 5 days, and annual percent of time maximum temperature exceed the baseline maximum temperature

ADAPTIVE CAPACITY

Adaptive capacity forms one of the three pillars of the vulnerability assessment in addition to exposure and sensitivity to climate change (Figure 1). At the same time it is also one of the three components when measuring resilience, in addition to absorptive coping capacity and transformative capacity (figure 14). Both are integrated concepts in a coupled human-environment system (Lei et al. 2014). In the following we define Adaptive capacity according to the IPCC (2014): “Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.” Due to the country-wide scale, this vulnerability assessment takes thus a broader approach to adaptive capacity than more in-depth resilience assessments.

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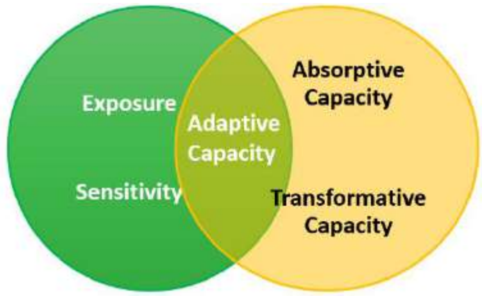
Vulnerability & Resilience



Vulnerability	**Resilience**
Components: Exposure, Sensitivity, Adaptive Capacity	Components: Absorptive Capacity, Adaptive Capacity, Transformative Capacity
"Passive": What stressors are regions/societies exposed to?	"Active" : Capacities to respond to stressors or changing conditions

Figure 14. Concepts of vulnerability and resilience (Source: IPCC 2014).

The adaptive capacity index for this vulnerability assessment is compiled by a set of proxies: none of them alone can give a reliable statement of the current level of adaptive capacity alone, but as an ensemble considering different capitals they become a more powerful tool to understand how well and with which tangible and intangible assets a population can cope with climate change and variability. This methodology aims to compile information on a set of different capitals, such as economic, natural, human, physical, and institutional capital. There are many indicators that could form a strong adaptive capacity index, but data availability was a driving factor in establishing the final index for the Philippines. This vulnerability assessment is aiming to provide a high resolution analysis on municipality level as this is where most socio-economic data can be derived. However, often key indicators are only available on national or province level. Hence, the list of indicators in table 1 is not restrictive but further socio-economic data can be added to have a better understanding to what extent is the population able to cope with climate change and related risks.

Indicator Identification Process

In order to develop the adaptive capacity index a multi-step approach of using official and local datasets, statistical analysis as well as integrating feedback and weights by experts to select relevant variables was followed (figure 15).

As a first step it was critical to get an understanding on current indicators that are associated with adaptive capacity and then identify the indicators that can best describe a capacity to cope with climate change in the Philippines. The selection of potential indicators is based on own elaboration and various literature sources e.g. Adger (2006), Daw et al. (2009), Cinner et al. (2011), Defiesta & Rapera (2014), Speranza et al. (2014), Baca et al. (2014), Cruz-Garcia et al. (2016).

A wide secondary data collection identified sources that were able to provide some of the needed indicators on municipality level. Foremost the National Competitiveness Council (NCC) provided an extensive up-to-date database, but also the Philippines Statistics Authority and previous DA projects were consulted. Furthermore was data from the International Water Management Institute and the National Mapping and Resource Information Authority derived to calculate indicators for the natural capital component.

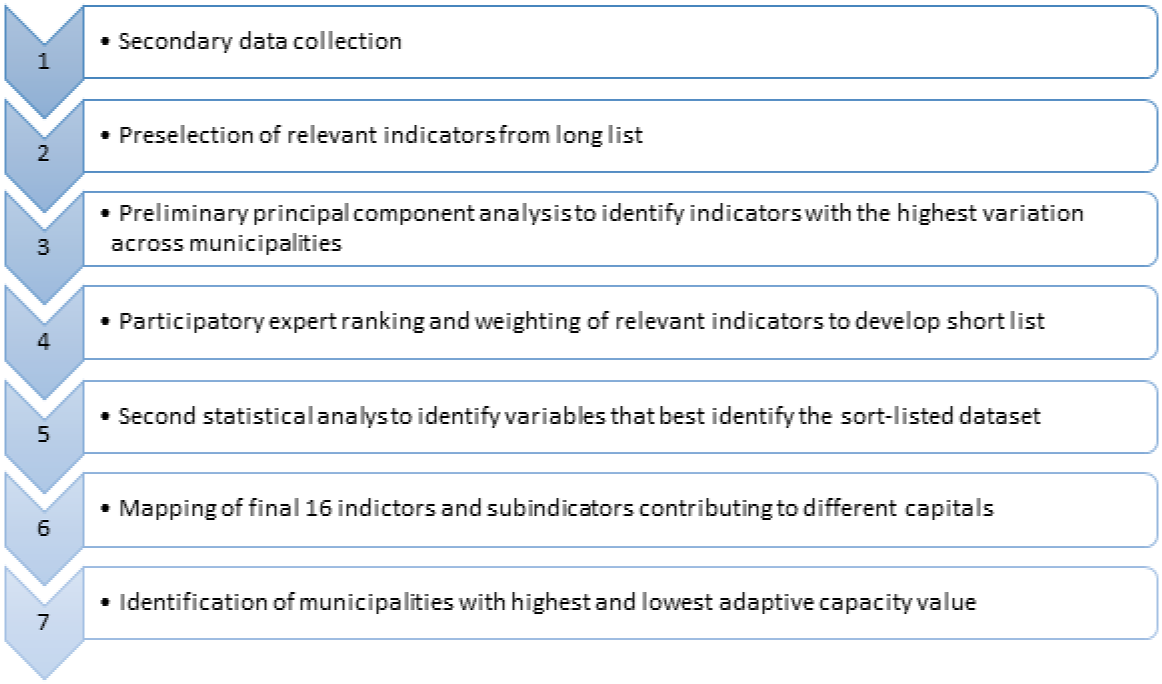


Figure 15. Indicator selection process

Principal Component Analysis (PCA), recursive feature elimination and Random Forest were applied to explore the geographic variances, correlation, and feature importance of data across municipalities and indicators. PCA is a subfield of machine learning which is used to reduce dimensionality of the dataset, remove noises, while retaining most important features or information of the dataset. Results suggested that the indicators best describing the dataset where i) inflation, ii) agricultural minimum wage (plantation and non-plantation), iii) number of local citizens with Philhealth and iv) total road network (see figure 16, data derived from NCC 2015). The shortlisted indicators were validated with experts during the participatory workshops and further indicators were included to complete a more balanced representation of all adaptive capacity capitals.

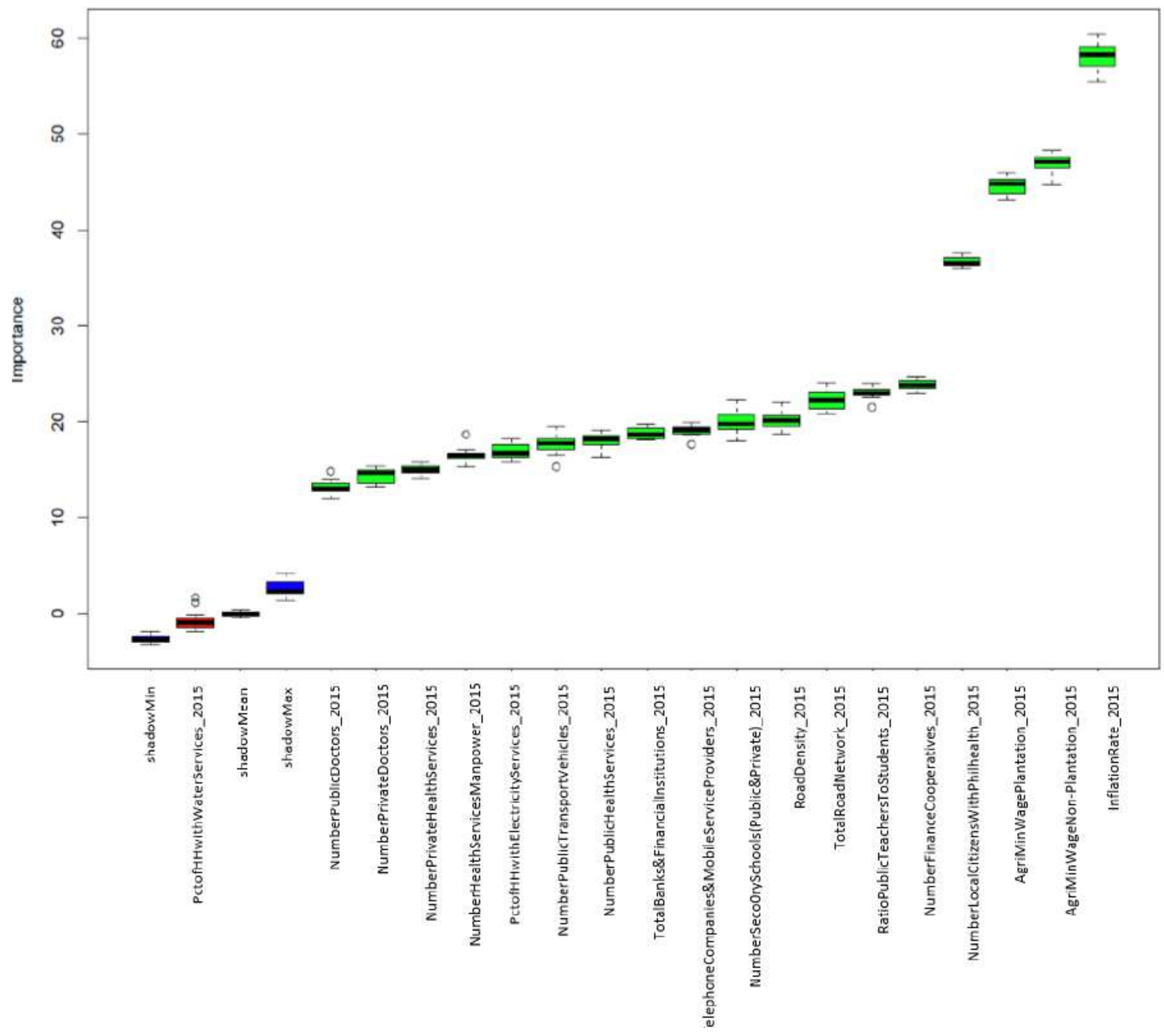


Figure 16. Recursive feature elimination after normalization of values of selected adaptive capacity variables (data sourced from NCC 2015).

Experts from different DA agencies, National Economic Development Authority (NEDA), United Nations Food and Agriculture Organization (UN-FAO), Non-Government Organizations (NGOs), and Academe were invited to an expert workshop. They were grouped into 2 clusters and ask to score each of the indicators according to importance. Each group discussed and decided for a common value/rate for each indicator. They were provided with a scale of 1-5, where 5 represented the highest/most important value. Only those indicators that got scored 4 and 5 were considered. Some of the similar variables, e.g. under health and education were lumped into a single variable and was given a high score as suggested by experts.

In addition to identifying the final list of indicators describing adaptive capacity, the relative importance of the three different components of the vulnerability assessment were discussed during the workshop. As a result, the experts suggested overall vulnerability assessment weights as "Sensitivity (15%)", "Hazards (15%)", and attributed the highest importance in defining vulnerability to "Adaptive Capacity with (70%)".

The values of the 16 indicators (table 7) were integrated in the shapefile municipal boundaries. Each of the indicators were normalized and were treated with equal weights. The sum of the 16 indicators provided the final adaptive capacity index. Five equal breaks were developed to establish the thresholds: 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).

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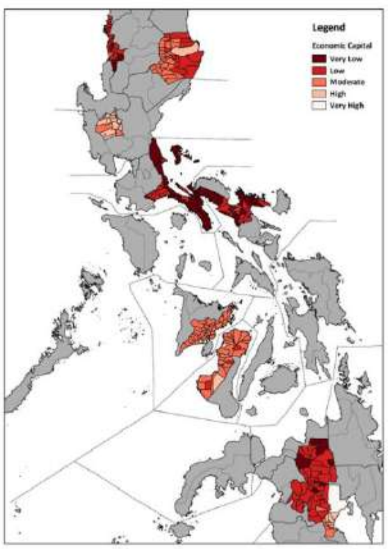
Table 7: Selected list of indicators and sub-indicators

Attribute Capital	**Indicator**	**Sub-indicator**	**Source**
Economic Capital	1. Poverty		Philippine Statistics Authority (2012)
	2.Inflation Rate		National Competitive Council (2015)
	3.Minimum wage (agriculture	Ag. minimum wage non-plantation, ag minimum wage plantation	National Competitive Council (2015)
	4.Financial Institutions and Cooperative	Total banks & financial institutions, Number of finance cooperatives	National Competitive Council (2015)
Natural Capital	5.% of area irrigated		International Water Management Institute ()
	6.% of closed forest and mangrove forest		National Mapping and Resource Information Authority
Human Capital	7.Health	Ratio to population: Public health services, Private doctors, Private health services, Health services manpower, Public doctors, Local citizens with Philhealth	National Competitive Council (2015)
	8.Education	Number of secondary schools (public and private), ratio of public school teachers to students	National Competitive Council (2015)
Physical Capital	9.Infrastructure investment		National Competitive Council (2015)
	10.Infrastructure Network		National Competitive Council (2015)
	11.Access to services	% of households with access to electricity services, % of households with access to water services	National Competitive Council (2015)
	12. Number of Public Transport		National Competitive Council (2015)
	13.Telephone Companies and Mobile Services		National Competitive Council (2015)
Institutional Capital	14.Number of DA officers		DA FPOPD (2017)
	15.Buffer stocks		DA FPODP (2017)

	16.Presence of Disaster Risk Reduction Management Plan (DRRMP)		National Competitive Council (2015)

Adaptive Capacity Results

Results are available for each indicator and sub-indicator, so a strength of this vulnerability assessment is not just being able to identify areas with a low adaptive capacity as a priority but that specific capitals and separate indicators can be explored and targeted. The following presents spatial analysis of all 5 capitals (fig. 17 a-e) as well as the aggregated (fig. 17f) overall adaptive capacity index. It can be seen that most cities across the study sites have higher adaptive capacity. This is particularly true since cities tend to have high economic activity and higher access to health and education.



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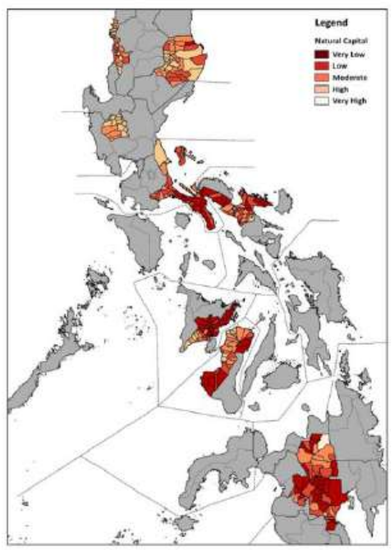

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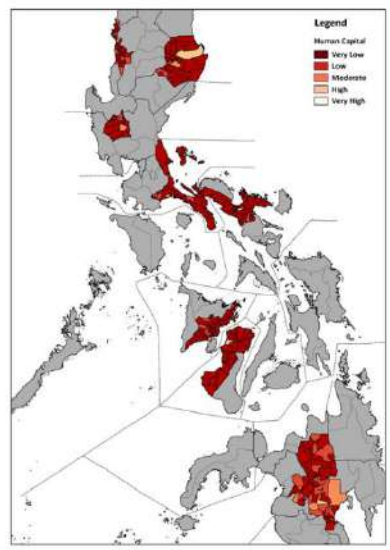

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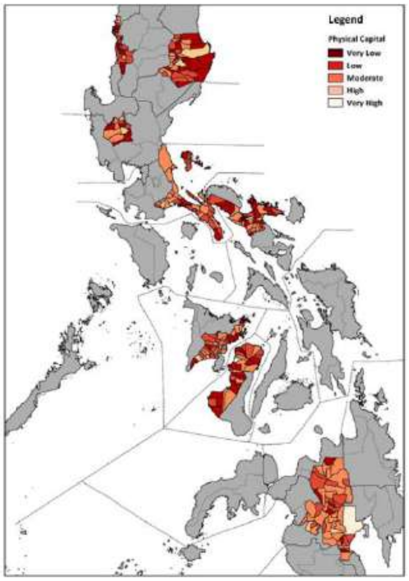

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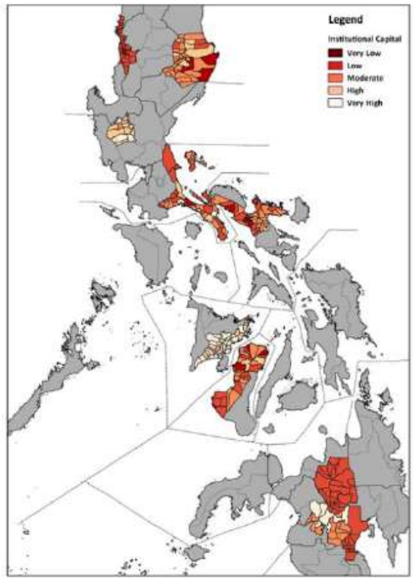

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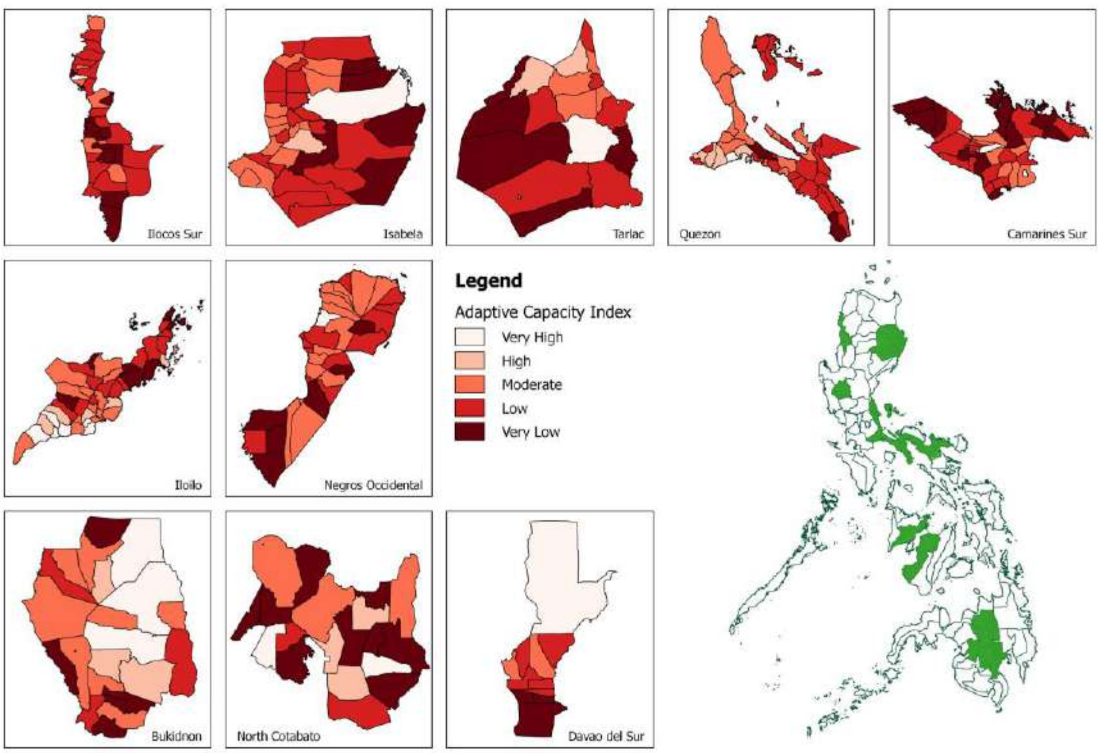

f

Figure 17. Adaptive capacity capitals for the 10 provinces across Philippines. a) Economic capital; b) Natural capital; c) Human capital; d) Physical capital; e) Institutional capital; and f) aggregated adaptive capacity index.

OVERALL VULNERABILITY INDEX

The final climate risk vulnerability map (fig. 18) for the year 2050 is an integration of the exposure, sensitivity and adaptive capacity components. The weighting of each of these indicators was discussed during expert workshops and resulted in 15% for exposure, 15% for sensitivity and 70% for adaptive. Each crop was assessed for vulnerability using the equation 1.1. Different classes of vulnerability by municipality (moderate to very high vulnerability) is shown in table 8.

Each of the ten target regions show municipalities that are particularly vulnerable to climate risks. As this assessment focuses on the agricultural sector, urban areas appear throughout the country as comparatively less vulnerable than rural areas. The results were validated during several workshops with all participating SUCs, RFOs, AMIA partner institutions and other stakeholders.

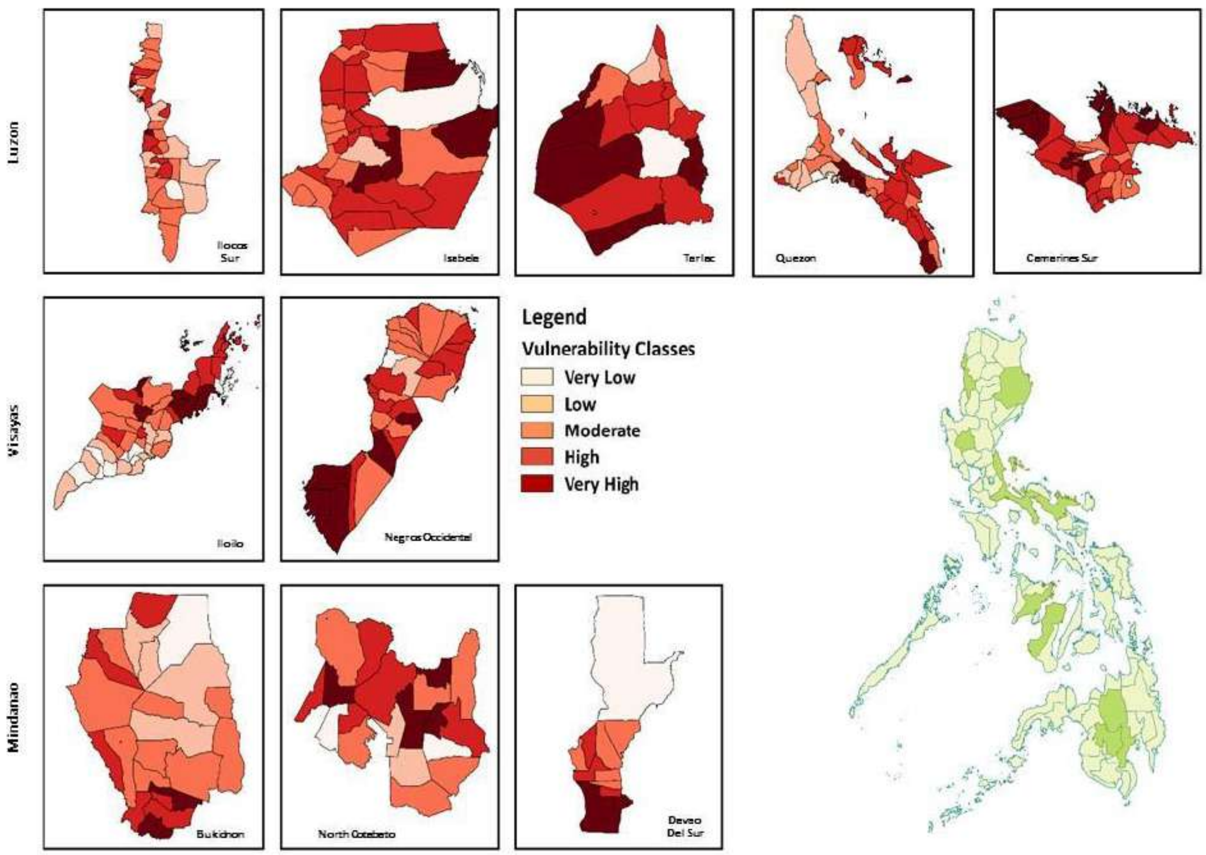

Figure 18. Vulnerability map in 10 provinces in the Philippines

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Table 8. Vulnerability classification by municipality

	Classes		
Province	**Very High Vulnerability**	**High Vulnerability**	**Moderate Vulnerability**
Ilocos Sur	Santa Catalina, San Esteban	San Vicente, Santa, Santiago, Santo Domingo, Galimuyod, Banayoyo, Nagbukel, Salcedo	San Juan, Santa Lucia, Santa Cruz, Santa Maria, Suyo, Tagudin, Sugpon, Caoayan, Cabugao, Burgos, Bantay, Alilem, San Ildefonso, Gregorio Del Pilar, Lidlidda, Magsinggal
Isabela	Palanan, Maconacon, Divilacan, Angadanan, Benito Soliven	San Isidro, San Guillermo, Reina Mercedes, Ramon, Naguilian, Quirino, Quezon, Jones, Luna, Dinapigue, Echague, Santa Maria, Gamu, San Pablo, Cabatuan, Burgos, Santo Tomas, Delfin Albano, Mallig,	San Agustin, Roxas, Cordon, Aurora, Alicia, Cabagan, Tumauini, San Mateo, San Manuel, San Mariano, Santiago City
Tarlac	Bamban, La Paz, Mayantoc, San Jose, San Clemente	Gerona, Concepcion, Capas, Ramos, Victoria, Paniqui, San Manuel, Santa Ignacia	Anao, Camiling, Pura
Quezon	Unisan, San Francisco, Jomalig, Atimonan, Padre Burgos	San Narciso, Tagkawayan, San Antonio, Panukulan, Patnanungan, Plaridel, Quezon, Lopez, Macalelon, General Luna, Catanauan, Guinyangan, Agdangan, Burdeos, Calauag, Mulanay	Tayabas, San Andres, Sampaloc, Perez, Pitogo, Polillo, Infanta, Mauban, Dolores, Gumaca, Alabat, Buenavista
Camarines Sur	Ragay, Tinambac, Siruma, Minalabac, Milaor, Pamplona, Garchitorena, Del Gallego, Canaman, Lupi	Sipocot, Sagnay, San Fernando, Presentacion, Nabua, Pasacao, Ocampo, Lagonoy, Goa, Gainza, Caramoan, Libmanan, Balatan, Bato, Bula, Cabusao, Magarao	San Jose, Tigaon, Pili, Iriga City, Baao, Bombon, Buhi, Calabanga, Camaligan
Iloilo	San Rafael, Duenas, Bingawan, Barotac Viejo, Ajuy	Lemery, Maasin, Sara, Estancia, Carles, Calinog, Batad, Banate, Balasan, San Dionisio, Mina	Lambunao, Janiuay, Dumangas, Dingle, Cabatuan, Badiangan, Alimodian, Anilao, San Enrique, New Lucena, Passi City
Negros Occidental	Himamaylan City, Hinobaan, Cauayan, Pulupandan, Sipalay City, Moises Padilla, Candoni	Manapla, Ilog, La Castellana, Escalante City, Bago City, Binalbagan, Calatrava, Salvador Benedicto, Valladolid, Pontevedra, San Enrique, Toboso	Hinigaran, Kabankalan City, Isabela, La Carlota City, Enrique B. Magalona, Cadiz City, Victorias City, Sagay City, San Carlos City, Silay City, Talisay City
Bukidnon	Damulog, Kitaotao	Malitbog, Kalilangan, Kadingilan, Dangcagan, Kibawe	Pangantucan, Quezon, Maramag, Lantapan, Libona, San Fernando, Don Carlos, Cabanglasan, Takalag

North Cotabato	Libungan, Matalam, President Roxas	Magpet, Carmen, Pigkawayan, Aleosan, Banisilan	Makilala, Alamada, Pikit, Antipas, Tulunan, Arakan
Davao del Sur	Malalag, Kiblawan	Bansalan, Sulop, Matanao	Magsaysay, Hagonoy, Digos City, Padada, Santa Cruz

Given the nature of data collection and availability, currently the vulnerability is displayed on a high, municipality-level resolution. However, climate risks and vulnerability of communities and ecosystem services do not have administrative boundaries. Thus the created municipality-level maps can be used to take the analysis a step further and assess vulnerability to climate change and sensitivity on a landscape dimension. In this context, a landscape/multi-sectoral approach would provide a more appropriate lens, based on a more holistic (systemic) risk analysis, which will bridge processes that occur at the household level with wider socio-economic and environmental landscape dynamics. Since analysis of weights for each component of vulnerability are highly subjective, a sensitivity analysis was undertaken in one province per island group to explore the impact of varying proportions of weights to the overall vulnerability classes. Some of the weight proportions are based on literatures. Careful evaluation should be undertaken when comparing weights, since other literatures will have different spatial scale, time resolution, and type of vulnerability being assessed. The different weight proportions shown in table 9 was used in the provinces of Tarlac (Luzon), Iloilo (Visayas), and Bukidnon (Mindanao).

Table 9. Weights used to assess vulnerability assessment

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

We tested it in the three provinces of the AMIA sites, i.e., Tarlac, Iloilo, and Bukidnon (fig. 19 a-c) and the results shows consistent detection of highly vulnerable municipalities. For instance, Damulog and Kitaotao in Bukidnon, Banate in Iloilo, and La Paz in Tarlac always comes up as highly vulnerable municipalities using different weights for sensitivity, hazards, and adaptive capacity. This shows that the characteristic of vulnerability, in terms of component and indicators are not too sensitive to varying weight proportions. However, the reference weights of 15-15-70 is used in the final maps.

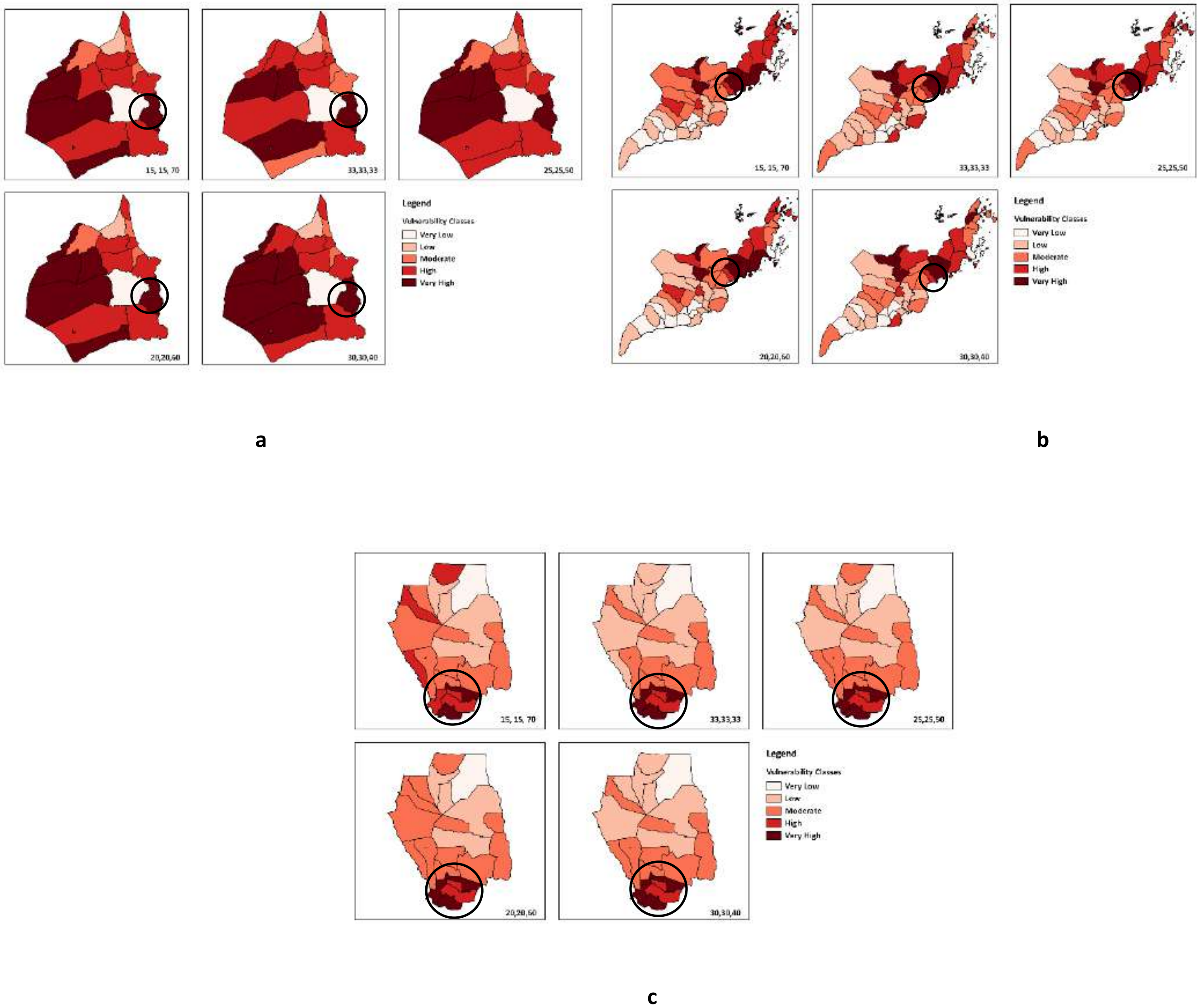
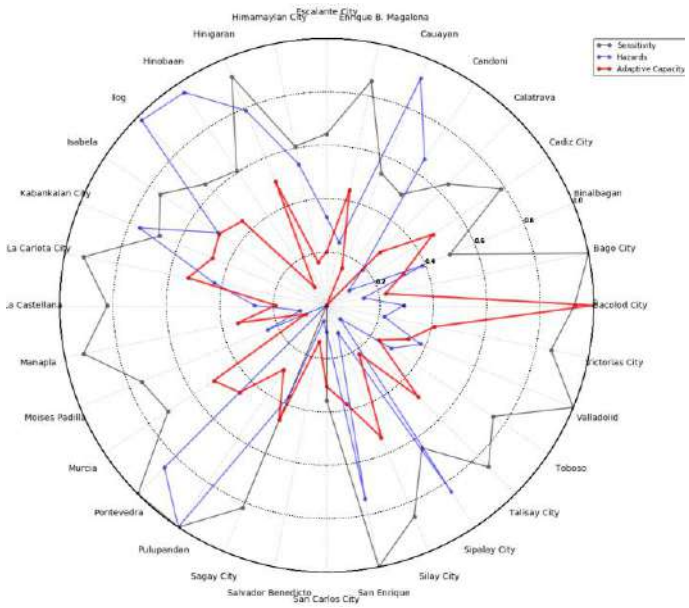


Figure 19. Vulnerability maps for the three provinces using different weight proportions for each component. **a)** Tarlac, **b)** Iloilo, and **c)** Bukidnon.

Vulnerabilities per Municipality

Figure 19 shows the three components of vulnerability and how it affects the analysis as demonstrated in the province of Bukidnon and Camarines Sur. Given that adaptive capacity was given higher weights, the lack of it determines the vulnerability. Lower vulnerability is identified in cities, where typically they rank high among the 5 capitals of adaptive capacity. High vulnerability was observed in municipalities where there is a divergence of high exposure to hazards, high loss of climate suitability in the future, and low adaptive capacity. The Radar graph shows the influence of each of the three components in vulnerability assessment. This information generally shows what is driving the vulnerability of each municipality. For instance, the municipalities of Hinobaan and Pulupudan in Negros Occidental (fig. 20-a), and Kitaotao and Kadingilan in Bukidnon (fig. 20-b)was considered as very high vulnerability because it is characterized with high incidence of hazards, most of the crops are at risk to climate change, and at the same time adaptive capacity was very low.



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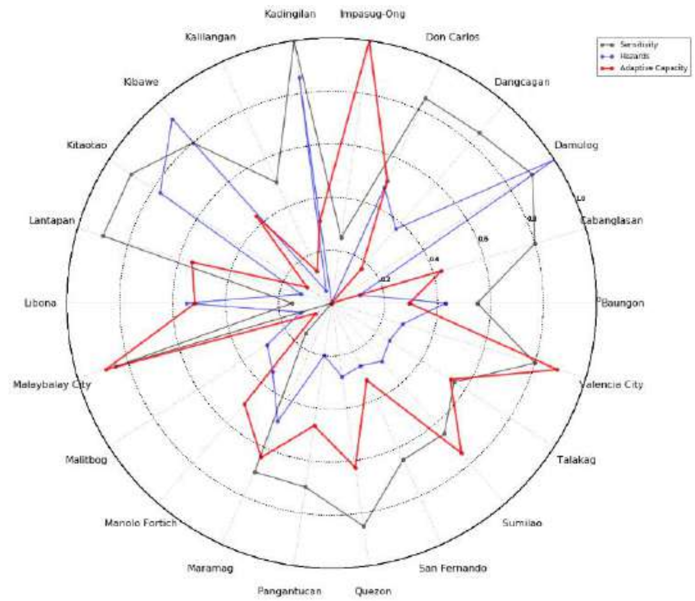
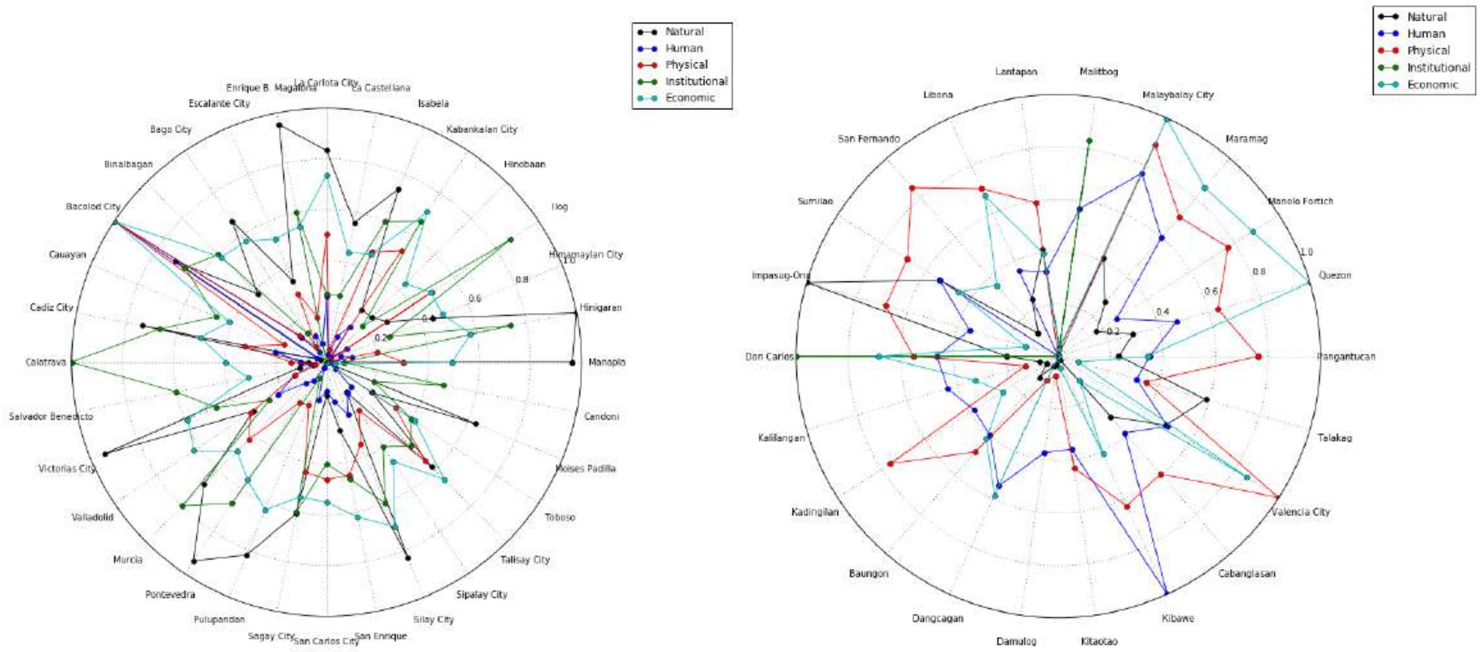


b

Figure. 20. Different dimensions of vulnerability. a) Negros Occidental and b) Bukidnon. Other radar graph for each of the other provinces are in the Annex A.

An in-depth analysis of adaptive capacity capitals which is useful for geographic targeting to build resilience can be done as a derivative of the vulnerability assessment. Fig. 21 shows the strength and weakness of across capitals per municipality in Bukidnon province. It will be essential if an intervention would like to improve a particular, or a combination of capitals for each municipality classified as high to very high vulnerability.

Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces



a **b**

Figure 21. Analysis of adaptive capacity capitals for the province of a) Negros Occidental, and b) Bukidnon.

RECOMMENDATIONS

Typhoon early warning systems are in place in the Philippines and are essential to protect the lives and livelihoods (as productive assets, livestock and sometimes crops can be protected in the few days/hours before the storm makes landfall). Many weather facilities from government and private organizations have been established that provides real to near real-time weather information (i.e, weather condition, typhoon/cyclone updates, and 5 day weather forecast) for free of charge. One of these organizations is the Weather Philippines Foundation which have approximately 800 weather stations in the Philippines and provides critical weather information that is being used by local government units (https://weatherph.org/all-aws/). The information generated is an essential tool for farmer advisories and anticipating extreme climate conditions.

Response mechanisms, such as systems of rapid seed multiplication for post-typhoon agriculture were also recently introduced by the government of the Philippines. However, in addition to focusing on recovering efforts, a landscape resilience and preparedness approach that enhances the communities' ability to protect crops and surrounding ecosystems from being damaged by typhoons in the first place, would strengthen and complement the already existing initiatives. To achieve this landscape resilience, capacities of local communities, sub-national and national technicians in identifying areas at risk as well as site-specific adaptation options need to be developed. This will enable a response to the need for well-targeted and site-specific adaptation measures in the agricultural sector as highlighted in the National Climate Change Action Plan (2011-2028), a roadmap for adaptation planning in the Philippines. Appropriate policy strategies - including adaptation and risk reduction strategies specifically for the agricultural sector - will be necessary in order to provide the crucial institutional enabling environment to build resilience in the Philippines.

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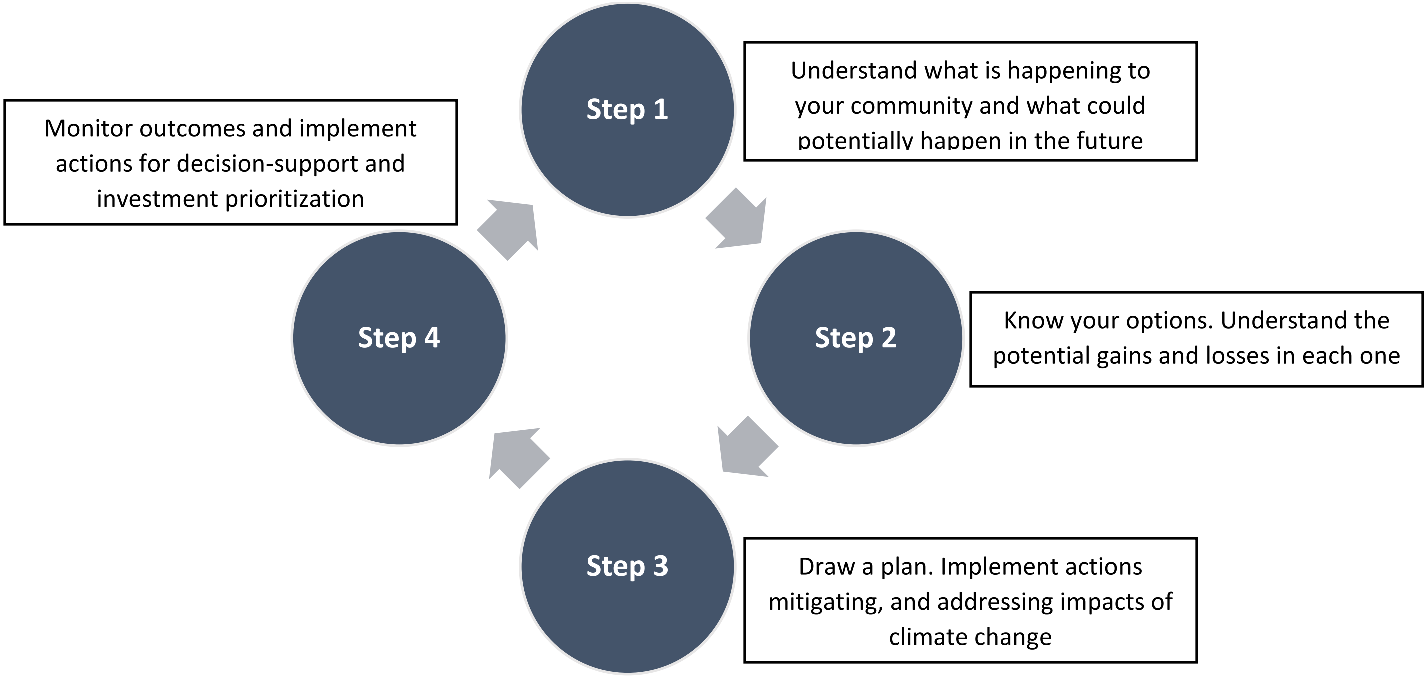
The result of the CRVA study will directly contribute to the Department of Agriculture's projects, programs, and interventions strategy in terms of planning and prioritization to step-up the efforts in identified areas to improve the capacity of communities, especially farmers, to cope with the impact of climate change and hazards. The CRVA also complements the Philippines Country Profile (Dikitanan, 2017) which highlight the different climate resilient/smart practices of communities in the Philippines. Prioritized CRA practices responding to the CRVA for trialing and out-scaling will need to be tailored to site-specific crop- and community-needs and their trade-offs will need to be assessed. The below list are based from the prioritized practices from the Philippines' Country Profile (Dikitanan, 2017) and IIRR (2015) that were assessed for various indicators of CRA smartness, e.g. yield, income, water, soil, risk/information, energy, carbon, and nutrient:

- Biodynamics/Organic
- Maize-banana crop diversification
- Sloping Agricultural Land Technology (SALT)
- Small Water Impounding Project (SWIP)
- Climate Smart Variety, adative crop calendar
- Short duration and/or drought tolerant varieties
- Rice-rice-mungbean rotation
- Post-rice legume systems
- System of rice intensification (SRI)
- Mango Integrated Pest Management (IPM)
- Rice-tomato rotation
- Rice-maize rotation
- Climate Smart Variety
- Organic
- Coconut-based integrated farming
- Rainwater harvesting
- Alternate Wetting and Drying (AWD)
- Climate Smart Variety
- Crop rotation, zero tillage
- Crop rotation, integrated nutrient management
- Intercropping
- Rice-duck farming
- Climate Smart Variety

These considered CRA practices are important in climate change adaptation, greenhouse gas emission reduction, and food security. One of these practices should be introduced in climate smart villages to ensure that the practice is sustainable, productive, and economically viable.

The CRVA is a first step in building climate resilient agricultural communities to understand the potential impact of climate change in each municipality. DA-Regional Field Offices have already chosen a municipality where they will select a farming community to implement CRA actions and help build climate resilience in the food system. In the selected vulnerable communities, the DA-RFOs have the options to either implement actions for 1) hazard mitigation, such as improved access by farmers to high quality seeds, 2) coping capacity enhancement, such as giving farmers assistance to improve their land use to climate smart practices, 3) improved irrigation services, and so forth. The main idea is that, knowing the drivers of vulnerability allows for a more targeted actions.

Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces



CONCLUSION

Agricultural vulnerability to climate change was assessed and mapped in 10 provinces in the Philippines using modeling and statistical analysis of climate impacts, climate variability, and socio-economic variables. The analyses focused on key commodities in the Philippines, such as rice, maize/corn, vegetables, and trees. Some commodities were not yet included due to limited availability of data. It is important to understand that the results are based on modeling results, which have inherent uncertainties and limitation, such as the climate models, crop distribution model, and socio-economic variables used. In the Philippines, the municipal resolution was used because authors believed this is where significant decision making and planning takes place, especially in the agricultural sector. With inherent uncertainties, any planning and development initiative using the output of this research should be made with consideration of local conditions. However, with all these limitations, the results presented in this paper are in broad agreement with existing literatures on climate change impacts as well as realities in terms of vulnerability.

The CRVA output can be used to inform and guide decision makers from government agencies, extension staff, and private sectors on geographic areas that are in most need of interventions, and what package of interventions are needed for each geographical area. It also opens door for cross sectoral collaboration between different government agencies and private sectors. There are demands to scale-up the assessment to a landscape level vulnerability assessment, and this will be done in the extension phase of AMIA (AMIA2++). Impacts of climate change has been quantified using crop distribution models using baseline and future scenarios. These climate crop suitability scenarios are not just an important component of CRVA, but is essential in preparing research interventions in terms of improving agricultural practices and crop management to cope with climate change. The result of CRVA is now being used to apply for bigger funding from international donors to help Philippines adapt to climate change. Access to funds is vital in improving agriculture, to ensure that small-holder farmers can improve their coping capacity. Furthermore, it is used by the Department of Agriculture for planning and prioritising interventions in the Philippines.

A national workshop was organized and were attended by main DA officials, Bureau of Soils and Water Management officials, DA-RFUs, and partner SUCs. Then we presented the details how each component were assessed and developed. The overall vulnerability map was also presented during the workshop. Overall, the DA-RFUs, as the main user of the CRVA output, have already chosen vulnerable sites (municipalities) where CRA actions will be implemented. A simple step-by-step user guide on how to validate maps was developed and shared with partner SUC. It is outlined in Annex B.

ACKNOWLEDGEMENT

Many thanks to all AMIA project team of each state universities and colleges in 10 regions in the Philippines for their invaluable support to the project. We also want to thank the Depart of Agriculture – Regional Field Units AMIA focal person for the assistance and coordination of the project within the region.

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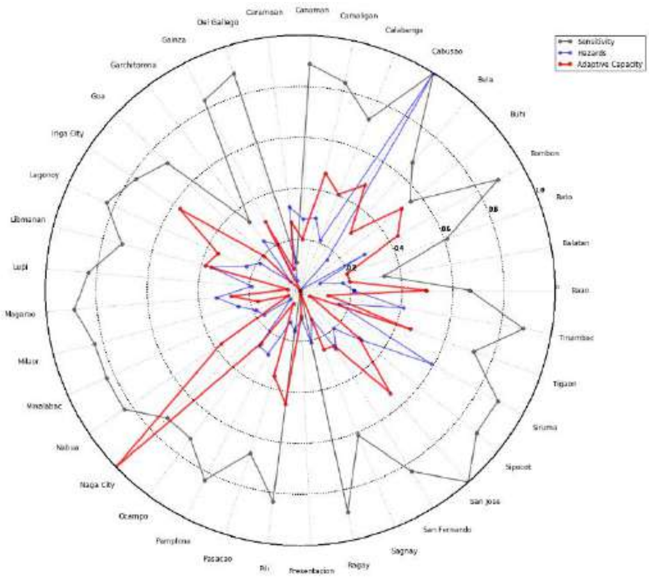
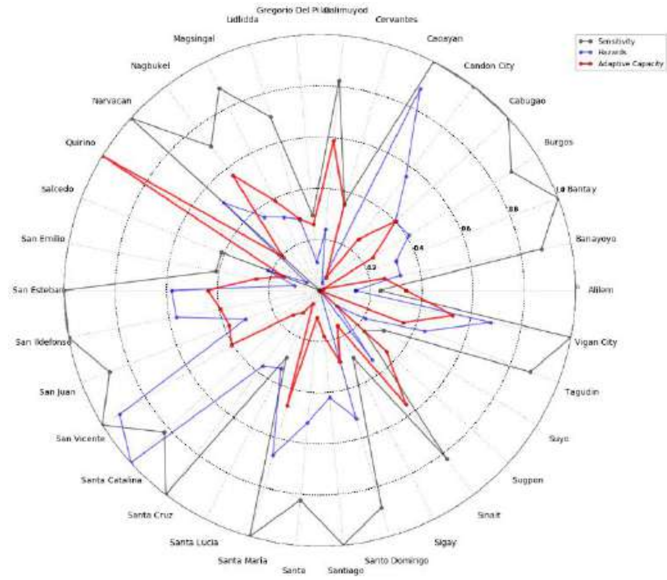
Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces

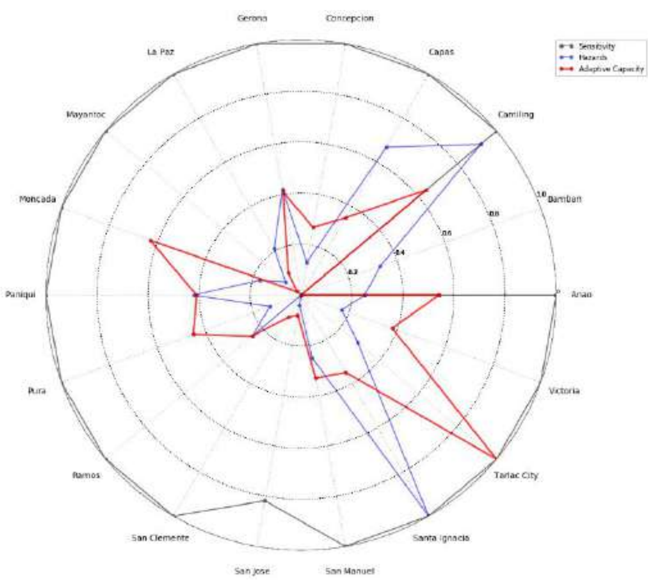
Annex A. Radar Graph of Vulnerability for all provinces covered by AMIA2 in Luzon



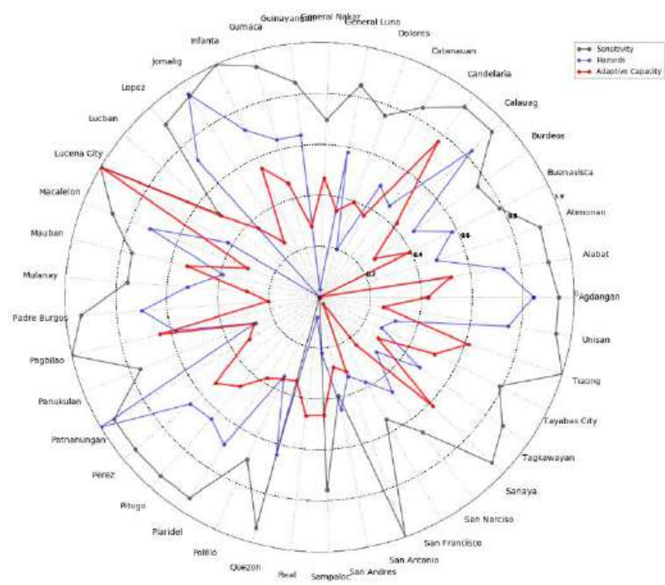
Ilocos Sur



Isabela

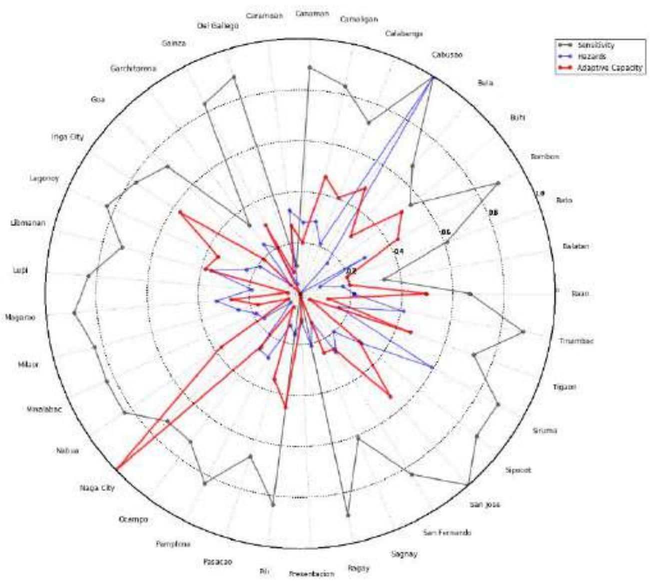


Tarlac

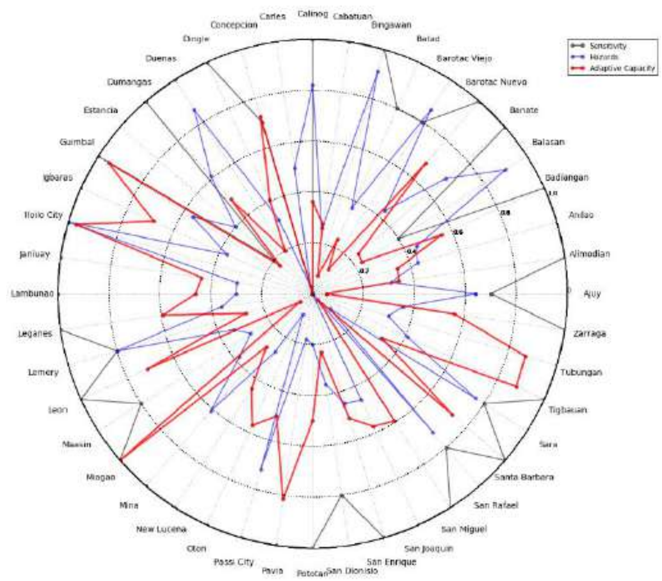


Quezon

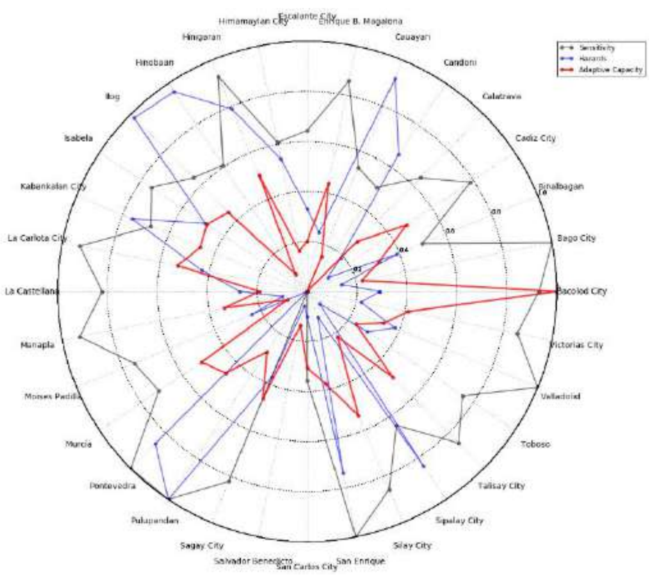
Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces



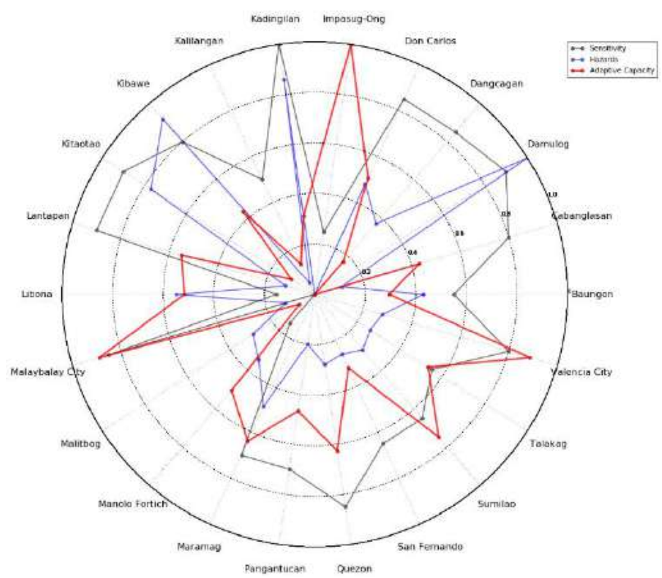
Camarines Sur



Iloilo

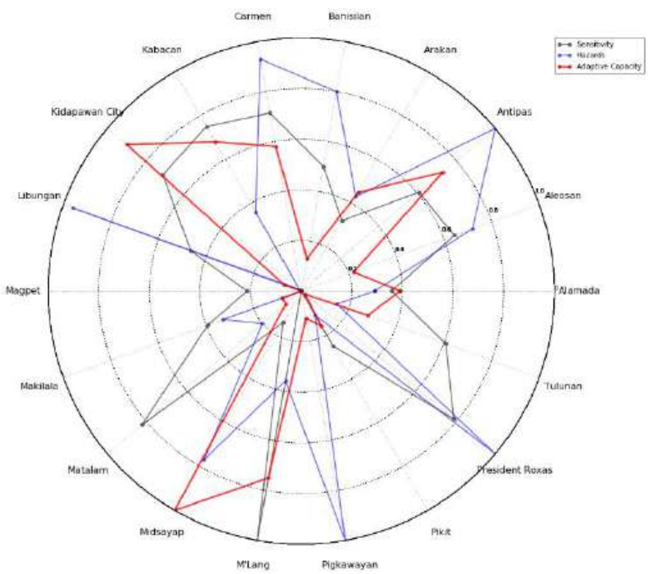


Negros Occidental

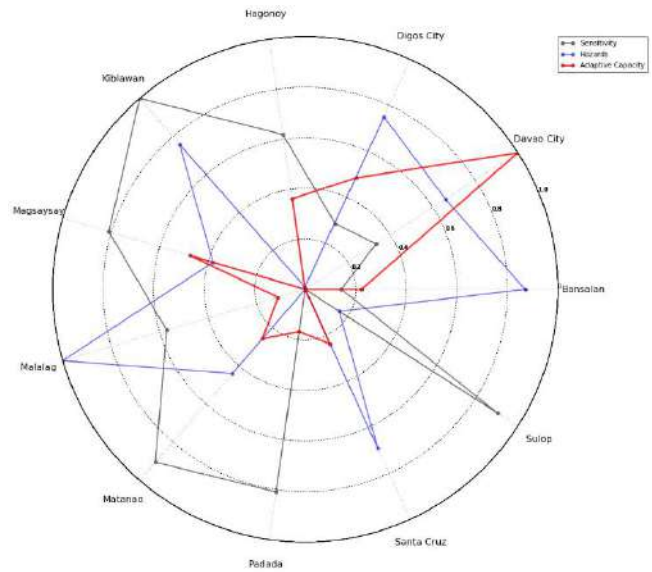


Bukidnon

Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces



North Cotabato



Davao Del Sur

Annex 1: CRVA Methodological Guidelines and Result for the 10 provinces

Annex B: Step by step guide in validating the maps thru participatory workshops

Validation of CRVA results

Objective:

Vulnerability map produced from the CRVA needs to be validated to establish the validity and accuracy of the assessment done in each municipality.

Procedure

I. Validate the point data for crop location by conducting a geolocate validation (visual)

- Show the map to the local resource person
- The map consists of point data for the crop occurrence in a specific area
- The local resource person needs to confirm the occurrence of a specific crop within a grid cell equivalent to a square kilometer
- Provide basic reference such as rivers, roads, elevation and admin boundary

Procedure

II. Validation of Hazard Index

- Explain how the hazard index was developed for each island group based on the combination of weights assigned to each of the Eight (8) climate related hazards identified for the Philippines
- Validate the results based on the presence, incidence and damage/intensity of each of the climate related hazard
  - Validate the areas identified with higher index value
  - Validate the areas with wide geographic extent of the hazard
  - Validate the areas with higher geographical overlap of the hazards

Procedure

III. Validation of the Adaptive Capacity Index based from the integration of the Five (5) capitals: Economic, Natural, Human, Physical, and Institutional

- Discuss how the adaptive capacity was developed
- Show the table comprising the Five (5) capitals
- Validate the set of proxy parameters and indicators of the Five (5) capitals based on the availability of the data

Procedure

IV. Validation of vulnerability maps

- Check the presence, incidence and damage/intensity of each of the climate related hazard
- Discuss the weights given for each dimension (sensitivity, hazard, and adaptive capacity)
- Validate the status of the Five (5) capitals for each municipality

Annex 3

Investment Briefs of Climate-Resilient Agri-Fisheries Practices

Annex 3a – Investment Briefs for Climate-Resilient Climate-Resilient Varieties (CRV)

Climate-Resilient Agriculture Practices Investment Prioritization

Investment Prioritization for Region 2: Climate Resilient Rice Varieties (CRV): Planting of NSIC Rc 216 or 222/152 (1st Cropping) and PSB Rc 18 (2nd cropping)

Overview

Isabela is a first class province and the richest and progressive province in Cagayan Valley Region (Region 2). It has a total land area of 1,241,493 of which 42% of the area is covered by agriculture. The province is popularly known also as the Regional Trade and Industrial Center of Northeastern Luzon. It is the country's top corn producer with a physical area of 235,998 ha and second in census in rice production with physical area of 235,998 hectares and 339, 605 hectares respectively. However, due to the poor infrastructural development and its geographical location, Northern Isabela is particularly vulnerable to climate change. From 2003-2011,nine (9) super typhoons hit the whole province of Isabela that caused large damage to the agricultural industry and human lives. In 2016, the Province of Isabela was heavily devastated by typhoon Lawin with ₱2.5 billion recorded cost of damage in the agriculture sector.

Prioritized CRA Practice

NSIC Rc 216 or 222 is a short maturing variety planted during the cropping period May/June-August/September while PSB RC I8 is being grown from November/December-February-March. A longer maturing variety, PSB RC 18 is a lowland rice variety which is drought and heat tolerant, resistant to major diseases, insects, pests, high rice recovery and good grain quality. Its maturity is 123 days after seeding with a height of 102 cm, long grain size, and 65.34 % milling recovery. It reaches a maximum yield of 8.1 tons/ha with an average yield of 5.1 tons/ha. The variety can recover from or withstand submergence during floods or too much rain.

PSB RC 18 was identified by the Office of the Municipal Agriculture in San Mateo, Isabela as an effective climate resilient agricultural practice. During the field visits, the local farmers recognized this rice variety as having good growth performance in the last 10 years.

According to the farmers, the use of Climate Resilient Variety of rice with crop calendar practice was prioritized and adapted as it can avoid or minimize the unpredictable risks to their crops due to the changing climate conditions.

Data Gathering and Methodology

Focus group discussions (FGD)and key informant interview schedule were employed to gather primary data from the Municipalities of San Mateo, Cabagan, Sta. Maria, San Pablo, Delfin Albano, and Sto. Tomas. With the assistance and recommendations of the Local Government Units (LGUs) visited, the team have identified 17 farmers (with average age of 53) practicing the use of Climate Resilient Varieties (CSV)of rice namely; NSIC RC 216/222 (early maturing) during the first cropping (May/June-August/September) and PSB RC 18, a Climate Smart Variety, during the second cropping season (November/December-February/March). Five (5) conventional farming practitioners were interviewed in order to compare the current CRA and the old (conventional)farming practice. The data gathered analyzed using the Cost-Benefit Analysis (CBA) online tool developed by the International Center for Tropical Agriculture (CIAT).

Results

The results of analysis indicate that the Net present Value (NPV)) of the practice is **US$** 10,483.42 and its Internal Rate of Return (IRR) is 40.05%, The Social Net Present Value (SNPV) is **US$** 28,850.37 while the Social Internal Rate of Return (SIRR) is 93.40%The Initial Investment is **US$** 7,500 with a payback period of three (3) year.

In the aggregate analysis, the table shows that the Private Net Present Values (PNPV) of the practice is **US$** 6,077,933.9, while the aggregate Social Net Present Value (SNPV) is **US$** 12,662.311.08.

The Scenario of analysis indicates that the current price of ₱16/kg of rice will decrease in 20% after 10 years of adoption of the CRA practice.

CBA tool summary Farm (1 ha) results	**Net present value (NPV)**	**Internal Rate of Return (IRR)**	**Payback Period**	**Initial Investment**	**Social NPV**	**Social IRR**	**Scenario in the analysis (10 years)**	
Unit	**US$**	**%**	**Year/s**	**US$**	**US$**	**%**	**Before**	**After**
Value	10,483.42	40.05%	3	7500	28,850.37	93.40%	Current price of Php 16.00 per kilogram of rice	20% decrease in price
Aggregate analysis CBA tool summary	Total harvested area (ha)	Current adoption rate	Adoption rate	Aggregated private NPV	Aggregated Social NPV			
	523,031	1%	30%	6,077,933.9	12,662.311.08		Period	

Recommendations

The use of the two (2) Climate Resilient Rice Varieties (CSV)as a CRA Practice should be promoted and adopted by other farmers.

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Annex 3b – Investment Briefs for Adaptive Crop Diversification/Rotation (ACDR)



Climate-Resilient Agriculture Practices Investment Prioritization

Investment Prioritization for Region 2: Adaptive Crop Diversification/Rotation (ACDR): Rice-Rice-Mungbean

Overview

Isabela is a first class and the richest and progressive Province in Cagayan Valley Region (Region 2). It has a total land area of 1,241,493 of which 42% of the area is covered by agriculture. The province is popularly known also as the Regional Trade and Industrial Center of Northeastern Luzon. It is the country's top corn producer with a physical area of 235,998 ha and second in census in rice production with physical area of 235,998 hectares and 339, 605 hectares respectively. However, due to the poor infrastructural development and its geographical location, Northern Isabela is particularly vulnerable to climate change. From 2003-2011, nine (9) super typhoons hit the whole province of Isabela that caused large damage to the agricultural industry and human lives. In 2016, the Province of Isabela was heavily devastated by typhoon Lawin with ₱ 2.5 billion recorded cost of damage in the agriculture sector.

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Prioritized CRA Practice

In the Municipality of San Mateo, the local government noticed a marked decline in the rice harvest yield, which was traced to the depletion of organic materials brought about by chemical intensive use of agro chemicals. Subsequently, the decrease in yields meant dwindling incomes for the farmers. To reverse the trend, the municipal government introduced a different cropping pattern involving rice and mungbean production.

Planting of rice-rice-mungbean is a major farm practice in the town of San Mateo. This cropping pattern has been institutionalized as a primary alternative farming system because of its benefits in terms of income generation and climate change adaptation strategy since mungbean is a drought-tolerant crop. Mungbean is dubbed as "black gold" by the farmers of San Mateo, Isabela. The Municipality is known as the "mungo capital" of the Philippines. Planting mungbean is done immediately after the harvesting of rice at the end of the month of March which is the onset of the dry season month.

Aside from mungbean production of which an additional income is ensured, mungbean is also beneficial when it comes to soil fertility. It enhances the quality of soil that lessens the use of farm inputs like synthetic fertilizer for the next planting season of rice. With this, some municipalities in Isabela are now emulating this practice as an evidently good intervention to increase family income

Data Gathering and Methodology

Focus group discussions (FGD)and key informant interview schedule were employed to gather primary data from the Municipality of San Mateo. With the assistance and recommendations of the Local Government Units (LGUs) visited, the team have identified 4 farmers (with average age of 50) practicing rice-rice mungbean crop pattern. Also, due to the absence of conventional practitioners four (4) old conventional practices from the same group of respondents were interviewed to complete the data needed for the CBA tool. The data gathered were analysed using the Cost-Benefit Analysis (CBA) online tool developed by the International Center for Tropical Agriculture (CIAT).

Results

The results of analysis indicate that the Net present Value (NPV)) of the practice is **US$** 16,230.92 and its Internal Rate of Return (IRR) is 50.14%,The Social Net Present Value (SNPV) is **US$** 29,597.87 while the Social Internal Rate of Return (SIRR) is 103.73%. The Initial Investment is **US$** 7500 with a payback period of three (3) years.

In the Aggregate analysis, the table shows that the Private Net Present Values (PNPV) is **US$** 5,396, 810.52, while the Aggregate Social Net Present Value (SNPV) is **US$** 9,173,017.12.

CBA tool summary Farm (1 ha) results	Net present value (NPV)	Internal Rate of Return (IRR)	Payback Period	Initial Invest-ment	Social NPV	Social IRR	Scenario in the analysis in 10 years	
Unit	**US$**	**%**	**Year/s**	**US$**	**US$**	**%**	**Before**	**After**
Value	16,230.92	50.14%	3	7500	29,597.87	103.73%	With ₱16 price of per kilogram of rice With ₱60 per kilogram of mungbean	20% decrease in price 20% decrease in price
Aggregate analysis CBA tool summary	Total harvested area (ha)	Current adoption rate	Adoption rate	Aggregated Private NPV	Aggregated Social NPV			
	523,031	1%	30%	5,396.810.52	9,173,017.12		Period	

The Scenario of analysis indicates that the current price of ₱16/kg of rice will decrease in 20% likewise in ₱60/kg of mungbean after 10 years of adoption of the CRA practice.

Recommendations

Based from the results, the practice is highly profitable and thus, should be adopted. As such, widespread Information, Education and Communication (IEC) activities on this CRA practice should be undertaken.

References

1. Best Practices in Local Governance2007 Munggo: The Black Gold of San Mateo, San Mateo, Isabela, Philippines.
2. Philrice 2014: Chief Lauds Isabela farmers.
3. Philippine Crop Insurance Corporation (PCIC).
4. Official website: Isabela Province.

Annex 3c – Investment Briefs for Integrated Farming System (IFS)

Climate-Resilient Agriculture Practices Investment Prioritization

Investment Prioritization for Region 2: Integrated Farming System (IFS)

Overview

Isabela is a first class and the richest and progressive Province in Cagayan Valley Region (Region 2). It has a total land area of 1,241,493 of which 42% of the area is covered by agriculture. The province is popularly known also as the Regional Trade and Industrial Center of Northeastern Luzon. It is the country's top corn producer with a physical area of 235,998 ha and second in census in rice production with physical area of 235,998 hectares and 339, 605 hectares respectively. However, due to the poor infrastructural development and its geographical location, Northern Isabela is particularly vulnerable to climate change. From 2003-2011,nine (9) super typhoons hit the whole province of Isabela that caused large damageto the agricultural industry and human lives. In 2016, the Province of Isabela was heavily devastated by typhoon Lawin with ₱2.5 billion recorded cost of damage in the agriculture sector.

Prioritized CRA Practice

Integrated farming is a whole management system which aims to deliver more sustainable agriculture that includes crop, livestock, fish, tree crops, plantation crops and etc. Basically, it refers to agricultural systems that integrate livestock and crop production.

Integrated farming system has been prioritized due to its numerous benefits and advantages in terms of productivity per unit area, profitability, potentially and sustainability, balance of food, income rounds the year, adoption of new technology, increasing input efficiency and etc. *(www.agriinfo.in; My Agriculture Information Bank)*

Integrated farming system practice was identified by the assistance of the Office of the Municipal Agriculture (MAO) of the two municipalities. During the field visits, the local farmer leaders recognized this practice as a resilient practice due to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.

Data Gathering and Methodology

Focus group discussions (FGD)and key informant interview schedule were employed to gather primary data from the Municipality of Delfin Albano and Cabagan, With the assistance and recommendations of the Local Government Units (LGUs) visited, the team have identified 5 farmers practicing integrated farming. Five (5) conventional farming practitioners were interviewed in order to compare the current CRA and the old (conventional) farming practice. The data gathered were analyzed using the Cost-Benefit Analysis (CBA) (*not the CBA software developed by the CIAT).* In this study, sensitivity analysis have not included or considered due to

Results

The results of analysis indicate that the Net present Value (NPV)) of the practice is PhP **110,829** and its Internal Rate of Return (IRR) is **118%**, The Social Net Present Value (SNPV) is Php **124,128.73** while the Social Internal Rate of Return (SIRR) is 132%. The Initial Investment is PhP **607,790.78** with a payback period of three (1) year.

Also, using the CBA trade-offs, the team have also analysed and produced the profitability of conventional practice in comparison for the prioritized CRA practice.

The result of conventional practice indicates that the Net Present Value (NPV) is PhP **8300** and its Internal Rate of Return (IRR) is **110%**. The Social Net Present Value (SNPV) is **PhP 9296** while the Social Internal Rate of Return (SIRR) is **123%** with a 1 year payback period.

Recommendations

This practice should be promoted and adopted by other farmers.

References

1. www.agriinfo.in: My Agriculture Information Bank, 2015
2. Philrice 2014: Chief Lauds Isabela farmers.
3. Official website: Isabela Province

CBA tool summary Farm (3 ha) results	Net present value (NPV)	Internal Rate of Return (IRR)	Payback Period	Initial Investment	Social NPV	Social IRR
Unit	₱	%	Year/s	₱	₱	%
Value	110,829	118%	1	607,790.78	124,128.73	132%
Conventional Practice	₱ 8300	110%	1	81,244	₱9296	123%

Annex 2

Profile of Local Government Units (LGUs) in Isabela

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Annex 4

Crop Cultural Practices

CULTURAL PRACTICES

1. ***Squash*** (*Cucurbita moscahata* Duch.)

Squash or "Kalabasa" is a viny, creeping and trailing crop producing fruits and considered to be one of the most producing fruits and considered to be one of the most delicious vegetables. It is the most commonly and regular grown among the cucurbits due to its rich source of vitamin A, phosphorous and calcium. Squash is a tender tendril-bearing and viny-like plant belonging to the family Cucurbitaceae of gourd family. It has a
very course, prostrate or climbing annual, herbaceous vine, reaching a length of 4 meters and flowering throughout the year.

Squash can be grown in both wet and dry season. It has been reported that environment can have a marked effort development and quality of the fruit. The optimum monthly average temperature for food growth is from 18 to 27 ˚C. likewise, warm temperature and low relative humidity favour good fruit-setting development and quality of the fruit.

It thrives on many types of soil but it grows well on organic-rich medium often found on compost or refuse heaps. A soil Ph range of 5.6 to 6.5 is recommended. It can be grown in minimum tillage. Clear area dig holes at appropriate distances. In open field, distance of 2 to 3 meters between hills is recommended.

2. ***Eggplant*** *(Sulanum melongena)*

Eggplants vary greatly in size, from pea-sized to that of a melon, and appear white green, pink, red or purple in color. They are heat loving plants that benefit from a long growing season, have a somewhat meat-like texture when cooked, and are pickled and canned as well. Important in many vegetarian cuisines, eggplant is a good source of vitamins, minerals and fiber. It is also subject to several insect pests and diseases. For eating, pick fruit early as maturity increases bitterness. Ideal growth is between 75-85F with night temperature above 65F.

Eggplants like a warm soil temperature of 70F for best growth. They need high fertility soils to produce well, but avoid excess nitrogen.

3. ***Tilapia***

Tilapias belong to the family Cichlidae. Three genera are well-known namely *Oreochromis, Tilapia* and *Sarothredon* of which Nile Tilapia belong to genus Oreochromis. This species is naturally distributed in Palestine, the Nile river as well as most part of African river and lakes. It was intoroduced in the Philippines in 1972. Its rising popularity is due to their hardiness, resistance to disease, ease to breeding, reasonable growth rate, good taste and tolerance to a wide range of environmental conditions including temperature and salinity.

Tilapia cannot tolerate a temperature below 10 ˚C. Temperature at mid-20s, however, could still supress growth. All tilapias can tolerate high water temperature. However, too much handling at high temperature could result in high mortality. Most of tilapias are relatively euryhaline (can tolerate a wide range of salinities). Tilapias are extremely hardy fish and can withstand adverse water conditions. However, good water management is the key to successful fingerlings and food fish production. The water quality should be monitored regularly to find out the condition of the fish.

Table 1.Environmental conditions favourable for Tilapia growth

Parameter	Level	Comments
Temperature	25 – 30 ˚C	Optimum for reproduction and growth
DO (mg/L)	3	Minimum for optimum growth
Salinity (ppt)	10 - 15	Favor growth
pH	6.5 - 9	Optimum for primary reproduction
CO_2 (mg/L)	20	
Total Ammonia (mg/L)	0.02 – 0.5	
Turbidity	30 - 35	Silt can damage
Water current	20	For intensive culture flow-trough system

Growth of tilapia is dependent on stocking rates, food supply and water quality. Males Grow faster by 10 – 20&% than females. The growth of fish will be drastically reduced if fingerlings production is not controlled. The growth of tilapia is directly related to the amount of food available in the pond.

4. **Mango** (*Mangifera indica*)

Mango usually begins to bear 3-4 years planting in the case of budded or grafted tress, or 5-6 years after planting in case of seedlings. Bearing normally continues for 40 or more years. Flowering usually begins after a period of dormancy due to cool and or dry weather. Mangoes have a tendency to be biennial bearing and may only produce good crop every 3-4 years. This is influenced by the climate and cultivar.

Climatic conditions for mango are distinct wet and dry seasons with at least four to five months or dry period with a 21 to 30 degree celsius. Soil characteristics of mango; sandy loam, relatively rich in organic matter, good drainage is very important. pH level of soil is from 6-7 and flat to slightly rolling terrain. the elevation not be higher than 600 meters above sea level but the most ideal for its growth is 400 meters.

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