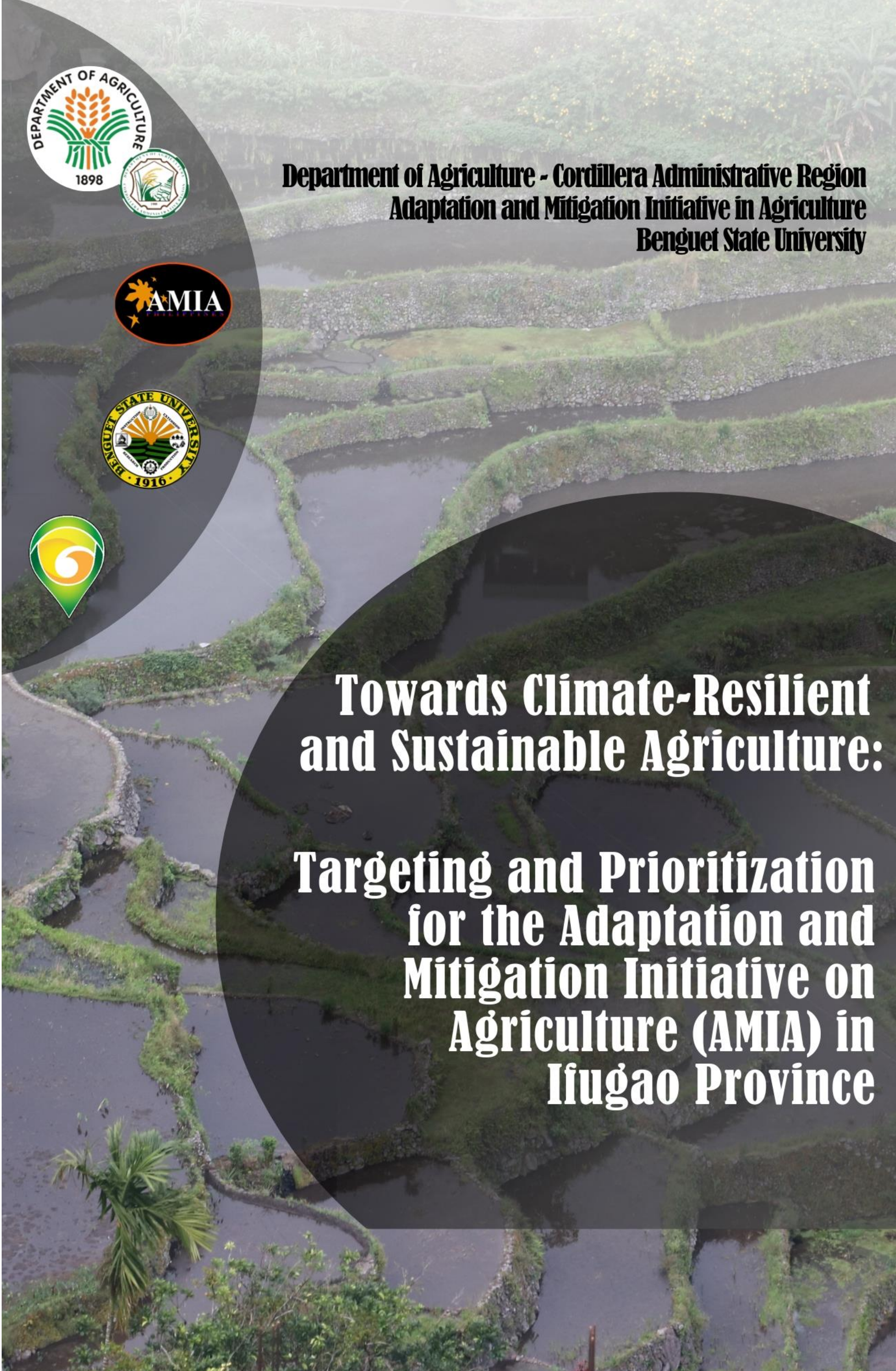

Department of Agriculture - Cordillera Administrative Region
Adaptation and Mitigation Initiative in Agriculture
Benguet State University

Towards Climate-Resilient and Sustainable Agriculture:

Targeting and Prioritization for the Adaptation and Mitigation Initiative on Agriculture (AMIA) in Ifugao Province

Towards Climate-Resilient and Sustainable Agriculture: Targeting and Prioritization for the Adaptation and Mitigation Initiative in Agriculture (AMIA) in Ifugao Province

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ABSTRACT

The negative impacts of climate change are currently being experienced globally, especially in the agriculture sector. Assessment of the climate risk vulnerability of rice, corn, and tomato in the 11 municipalities of Ifugao Province was implemented to identify areas to be prioritized in the implementation of adaptation measures that will improve the resiliency of agri-fishery communities. This study adopted the climate risk vulnerability assessment (CRVA) framework of the International Center for Tropical Agriculture (CIAT) which includes the evaluation of adaptive capacity and potential impact of climate change (exposure to hazard, and sensitivity) to identify the most vulnerable municipalities to climate risks. Maximum Entropy (MaxEnt), a presence-only machine learning model, uses the current occurrence of the crop with bioclimatic variables following the representative concentration pathway scenario (RCP) 8.5 in evaluating the current and future suitability of the selected crops. A synthesis of naturally occurring hazards (tropical cyclone, soil erosion, landslide, drought, and flood) was used to evaluate the extent of exposure of the different municipalities within the province of Ifugao under pressure from meteorological and hydrological disasters. Results of the CRVA of the selected crops revealed that by 2050, the agricultural sector of Hingyon and Mayoyao will be the most vulnerable. The municipality of Hingyon was chosen to be prioritized for heirloom rice production since it has very high vulnerability and at the same time high production. For conventional rice, Hingyon and Mayoyao have the highest vulnerability and produce conventional rice. Tomatoes, on the other hand, are being produced in the municipalities of Tinoc (high) and Hingyon (low to high) and are considered highly to very highly vulnerable to climate risk. In terms of prioritization of corn production in Ifugao province, the municipalities of Alfonso Lista (high) and Aguinaldo (moderate) are recommended since high production of corn in Alfonso Lista was observed with low vulnerability while Aguinaldo has high vulnerability and moderate corn production. Climate change adaptation and mitigation initiatives and projects should be implemented in these municipalities to reduce the possible negative impact in the agricultural sector of Ifugao province.

Keywords: Climate Change; Vulnerability; Rice; Corn; Tomato

I. Rationale

Climate change affects agriculture through a diversity of changes, these include changes in temperature, precipitation, and accelerating frequency of extreme weather events (e.g., floods, drought, etc.) (Arunanondchai et al. 2018) due to the shift in seasonal weather patterns. For instance, rainfall affects the suitability of agricultural land for different types of crops which in turn affect productivity. In addition, the risks of crop failures are already imposing great economic loss that threatens food security. These climatic variations are devastating, especially to subsistence farmers who are dependent on agriculture as their sustenance and livelihood. Many small-scale farmers have been affected and are continuously being affected by the damaging effects of drought, soil erosion, flooding, and salinization – caused by tropical cyclones, sea level rise, and saltwater intrusions in groundwater aquifers. To address the impacts of climate change, agricultural adaptation is an approach to managing potential risks.

Adaptation measures through strategic planning and identification and prioritizing of communities that are highly vulnerable to climate change are significant to combat the adverse impacts of climate change. Although farmers are already adapting by changing their cropping calendar and planting different varieties of the same crop, they need additional knowledge on adaptation interventions with the help of experts. Adaptation has become the most important area of research and assessment among climate change experts (Grothmann et al., 2005).

Vulnerability assessment is an effective approach to have a better understanding of major agricultural vulnerabilities to climate risks. This is fundamental in achieving more resilient farming systems, especially among poor rural households (Palao et al. 2017). Climate risk vulnerability assessment (CRVA) is the starting point of understanding where the risks and vulnerabilities lie as it identifies the geographical areas that are most vulnerable in terms of these climate-related hazards.

II. Review of Literature

Almost ten million Filipinos work in the agriculture sector which provides food for the population of more than one hundred nine million Filipinos. However, the effect of climate change on this sector is substantial (World Food Programme, 2021).

The Philippines is among the world's most disaster-prone countries. Floods, droughts, typhoons, landslides and mudslides, earthquakes, and volcanic eruptions are the commonly occurring hazards. Recent decades have witnessed an increase in damaging extreme events, such as heavy rainfall and tropical cyclone activity, and this trend is expected to continue under a changing climate (World Bank Group and Asian Development Bank, 2021).

Sensitivity, adaptive capacity, and exposure of natural and human systems to hazards brought about by climate change and its potential consequences are the three (3) key dimensions of vulnerability that were identified by the Intergovernmental Panel on Climate Change (IPCC, 2014). Vulnerability is generally depicted in negative terms, particularly, the inability to cope with adverse effects, the susceptibility to harm from exposure to stresses associated with environmental and social change, or the absence of capacity to adapt (Adger, 2006, McCarthy et al., 2001).

Sensitivity refers to the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. "*The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)*" while adaptive capacity refers to *"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"* (McCarthy et al., 2001). Exposure, on the other hand, is the character, magnitude, and rate of climate change and variation (Läderach et al., 2011)**.** Several biophysical indicators of exposure to climate change were factored in and summarized as hazards (Paquit et al., 2018).

Considering the foregoing dimensions, vulnerability assessment was developed to design and implement effective interventions, provide guidance, and support for adaptation planning, and justification for project implementation to create a more objective decision-making process. In addition, it promotes proactive adaptation in agriculture by identifying where the most vulnerable areas are located, what are the stressors, and how this might change in the future (Ford et al., 2010, Sherbinin et al. 2014).

Vulnerability assessment researches which were conducted focused on the development of CRVA methodology (Parker et al., 2019), and the application of a rapid participatory community-based climate change assessment instrument in different agro-ecosystems (Palao et al. 2017). Other CRVA researches conducted in the country are under the Adaptation and Mitigation Initiative in Agriculture (AMIA) program in the Philippines. These include Ilocos Sur, Isabela, Tarlac, Quezon, Camarines Sur, Iloilo, Bukidnon, Davao City, North Cotabato, and Negros Occidental (Palao et al., 2017)**,** in Bukidnon (Paquit et al., 2018), in Benguet (Supangco et al., 2022), and Mountain Province (Daipan et al., 2023)

The above-mentioned research identified and guided the decision makers such as government agencies, extension staff, and private sectors on the geographic areas that are in most need of interventions. These studies provided a great contribution to the selection of AMIA Village sites which served as a lighthouse for other communities to learn and emulate. In addition, technological and institutional innovations are introduced so that these villages may have access to climate-relevant support services.

III. Objectives

The main objective was to assess the climate risk vulnerability of the agriculture sector, particularly rice, corn, and tomato, as a basis for prioritizing climate adaptation and mitigation that includes technological interventions through geospatial and modeling tools in the different municipalities of Ifugao Province.

Specifically, it aimed to:

1. determine the sensitivity of rice (conventional and upland), hybrid corn, and tomato in Ifugao province;
2. analyze the exposure to climate-related hazards of the municipalities of Ifugao; and
3. assess the adaptive capacity of the municipalities of Ifugao.

IV. Procedure/Methodology

Study Site

Ifugao is one of the six (6) provinces in the Cordillera Administrative Region and is located in the southern portion of the region (Figure 1). It is a landlocked watershed province bounded by a mountain range to the north and west that tempers into uneven hills towards the south and the east (Valdez and Dumansi, 2020). The province is subdivided into 11 municipalities with 176 barangays. Its capital is the municipality of Lagawe, located in the mid of the province. Its highest elevation is 2,523 meter above sea level (masl). As of 2020, the total population is 207,498 which is 11.54% of the population of CAR (Philippine Statistics Authority, 2020). Agriculture is the main source of livelihood in the province. Moreover, the five (5) clusters of rice terraces designated as World Heritage Sites by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1995 can be found in this province. These sites with cultural importance were Batad and Bangaan Rice Terraces in Banaue, Mayoyao Rice Terrace in Mayoyao, Hungduan Rice Terraces in Hungduan, and Nagacadan Rice Terrace in Kiangan.

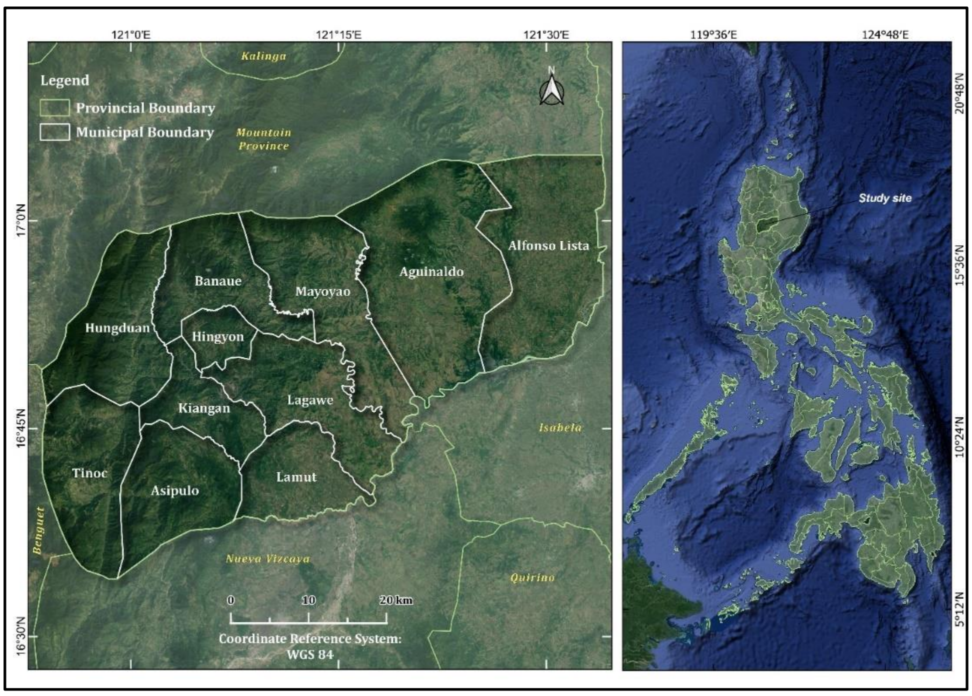

Figure 1. Geographical location of Ifugao Province.

Selected Crops

Rice and corn, which are the top two important crops in the Philippines, are being produced in almost all municipalities of Ifugao province. In 2020, 15,433 hectares (ha) were planted with rice with a yield of 49,413 metric tons (MT) while 28,462 ha were planted with corn with a yield of 109,783 MT. Irrigated rice production consists of 96.01% or 47,441 MT while rain-fed production covers 1,972 MT (3.99%) (PSA-CAR, 2022).

In 2020, the recorded total volume for tomato production in Ifugao province is 78.89 MT (PSA 2020). Rice, corn, and tomato were selected for the conduct of CRVA in Ifugao. Rice and corn are considered as the top two (2) most important crops in the Philippines given that rice is a staple food and corn is a good substitute for rice especially in poor or rural areas. Tomato, a high-value crop, was selected by the representatives of the Office of the Provincial Agriculturist and Municipal Agriculturists present during the participatory mapping. The selection of these crops was also based on the volume of yield and production are and in consultation with the Department of Agriculture-Regional Field Office- Cordillera Administrative Region (DA-RFO-CAR).

Data Collection and Analysis

The Adaptation and Mitigation Initiative in Agriculture (AMIA) Project, under the DA-RFO-CAR, was conducted to plan and implement strategies to support local communities in managing climate risks from extreme weather events to long-term climatic shifts. To establish climate-resilient agriculture (CRA) communities, CRVA is necessary to guide AMIA in targeting and planning. A CRVA would ensure that the AMIA investments are cost-effectively channeled to support the overall goals and outcomes and to address the inherent spatial and temporal variabilities within and across sites. The methodology was based on the CRVA framework developed by the *Centro Internacional de Agricultura Tropical* (CIAT) of Southeast Asia (Figure 2).

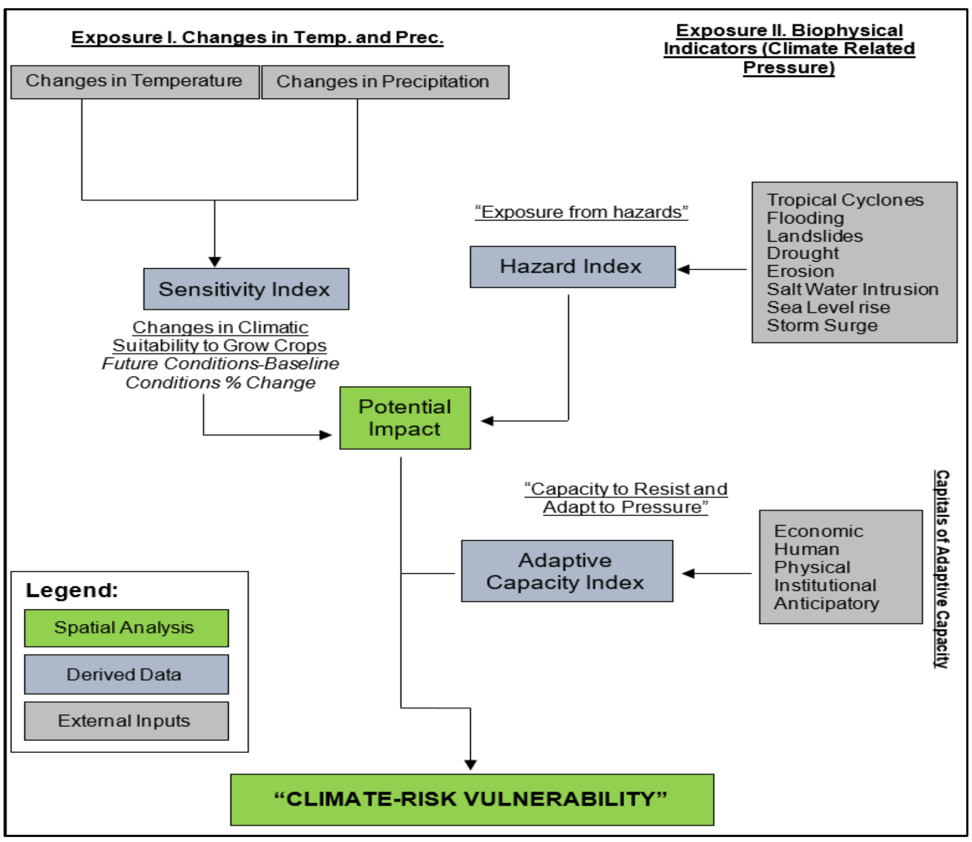

Figure 2. Climate risk vulnerability framework.
Source: Palao et. al., 2017

Three (3) components were used to assess the climate risk vulnerability of rice, corn, and tomato in Ifugao Province. The sensitivity index will identify the changes in the climatic suitability of a crop to grow, exposure to hazard identifies areas that are mostly exposed to climatic-related pressures, and lastly, the adaptive capacity index determines the ability of the municipalities in the province to resist and adapt to pressure.

Sensitivity Index

Although other factors could affect the suitability of a crop to grow in a certain location or a specific climatic condition, this study only focused on climate-related factors which are changes in temperature and changes in precipitation. The analysis of sensitivity was based on the projection of a high greenhouse gas emission scenario by 2050 (RCP 8.5 developed by the IPCC) which results in changes in temperature and precipitation. The procedure of assessing change in crop suitability requires two steps. The first step is to evaluate the baseline crop suitability using the assumption that a species exists in a specific site where environmental conditions are similar to where it was detected. If the environmental condition where the species is detected in the baseline condition matches, the second step is to predict the location of the species on a certain time slice (Apdohan et al., 2021).

Crop Occurrence Points

Since crop occurrence points were needed to identify the suitability of each crop, participatory mapping workshop with local experts that includes municipal agriculturists, agricultural technicians, and/or banner program coordinators of each municipality was done to locate the selected crops in their respective municipalities. Participatory mapping is the creation of maps by local communities, governments, NGOs or other stakeholders involved (Lienert, 2019). Participatory mapping was conducted to collect reliable data on crop occurrence and produce crop occurrence map.

The crop yield of each crop – rice (conventional and heirloom), corn, and tomato were annotated as high, moderate, or low yield using the existing data reports as a basis. Using the 1km-by-1km resolution grid maps, the participants documented the crop occurrences of each crop. These georeferenced crop occurrence data were then formatted in comma separated value (.csv) and were used for suitability analysis along with the bioclimatic variables with 1km^2 resolution.

Current Conditions

A total of 19 bioclimatic variables (Table 1) were selected to assess the climate suitability of the selected crops. These bioclimatic variables were acquired from WorlClim, a database of high spatial global and climate data. These bioclimatic variables, representing annual trends, seasonality, and extremes of the environment; accumulated from weather station data from 1961–1990, were derived from monthly temperature and rainfall values to produce biologically relevant variables (Hijman, et al., 2005). These are necessary to understand species' responses to climate change (O'Donnell and Ignizio, 2012). Climatic variables that are related to temperature are Bio 1 to Bio 11 while those related to precipitation are Bio 12 to Bio 19. The data is in raster format with 1km^2 resolution.

Table 1. The Bioclimatic variables used and their descriptions.

Code	Climatic variable	Description
Bio1	Annual Mean Temperature	Annual mean temperature derived from the average monthly temperature.
Bio2	Mean diurnal range	The mean of the monthly temperature ranges (monthly maximum minus monthly minimum).
Bio3	Isothermality (Bio2/Bio7)*(100)	Oscillation in day-to-night temperatures.
Bio4	Temperature seasonality	The amount of temperature variation over a given year based on standard deviation of monthly temperature averages
Bio5	Maximum temperature of warmest month	The maximum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal).
Bio6	Maximum temperature of coldest month	The minimum monthly temperature occurrence over a given year (time-series) or averaged span of years (normal). Variation over a given period.
Bio7	Temperature annual range (Bio5-Bio6)	A measure of temperature
Bio8	Mean temperature of wettest quarter	This quarterly index approximates mean temperatures that prevail during the wettest season.
Bio9	Mean temperature of driest quarter	This quarterly index approximates mean temperatures that prevail during the driest quarter.
Bio10	Mean temperature of warmest quarter	This quarterly index approximates mean temperatures that prevail during the warmest quarter.
Bio11	Mean temperature of coldest quarter	This quarterly index approximates mean temperatures that prevail during the coldest quarter.
Bio12	Annual precipitation	This is the sum of all total monthly precipitation values.
Bio13	Precipitation of wettest month	This index identifies the total precipitation that prevails during the wettest month.
Bio14	Precipitation of driest month	This index identifies the total precipitation that prevails during the driest month.
Bio15	Precipitation seasonality (Coefficient of variation)	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.

Code	Climatic variable	Description
Bio16	Precipitation of wettest quarter	This quarterly index approximates total precipitation that prevails during the wettest quarter.
Bio17	Precipitation of driest quarter	This quarterly index approximates total precipitation that prevails during the driest quarter.
Bio18	Precipitation of warmest quarter	This quarterly index approximates total precipitation that prevails during the warmest quarter.
Bio19	Precipitation of coldest quarter	This quarterly index approximates total precipitation that prevails during the coldest quarter.

Source: http://www.WorldClim.org

Future Conditions

According to Woodward (1987), plant distribution is primarily controlled by climate. In order to analyze the changes in crop suitability under climate change, crop distribution has to be modeled using future downscaled climate data (IPCC, 2001). The Representative Concentration Pathways (RCP) provide potential trajectories that project future changes in climate by assessing a series of different uncertainties. Four scenarios – RCP2.6, RCP4.5, RCP6, and RCP8.5 were developed based on their total radiative forcing (i.e. cumulative measure of human emissions of greenhouse gas (GHG) from all sources expressed in Watts per square meter) pathway and level by 2100 (van Vuuren et al., 2011). The scenario's storyline describes a heterogeneous world with a continuously increasing global population, resulting in a global population of 12 billion by 2100 (Riahi et al., 2011). Over the years, the GHG emissions and concentrations have considerably increased following the trend of the 8.5 scenario reaching a radiative forcing of 8.5 W/m^2 by the year 2050. RCP 8.5 is characterized by increasing greenhouse gas emissions, high rates of population growth, modest Gross domestic product (GDP) growth, and low rates of technological development and uptake (van Vuuren et al. 2011). It is considered as the most severe of the future scenarios documented in the IPCC Fifth Assessment Report (Field et al. 2014). Thus, for this study, RCP 8.5 was used as a basis for future projections of climate change by the year 2050.

Crop Distribution Modelling Tool

Maximum Entropy (MaxEnt) species distribution model Ver. 3.3.3k was used to create predictive maps of crop suitability based on the crop occurrence points and environmental layers. Maxent, a presence-only machine learning model, was recognized as an effective tool for modeling species geographic distribution based on environmental conditions of sites of known occurrence (Elith et al., 2006 and Phillips et al., 2006). The tool is commonly used to estimate the most suitable areas for crops based on the probability of geographic areas where the distribution of crops is scarce (Elith and Burgman, 2001). MaxEnt compared to other modeling tools produces impressive predictions of crop suitability (Phillips et al., 2008). This model makes use of a correlative model of the climatic conditions that meet the crop's environmental requirements and predicts the relative suitability of location (Davis et al., 2012). These environmental requirements were represented by bioclimatic variables (Table 1) which are combined to determine areas most suitable for a specific crop.

Sensitivity Analysis

Sensitivity is the degree to which a system is positively or negatively affected by climate-related stimulus (Läderach et al., 2011). Sensitivity is the change in the climatic suitability of an area to grow a crop. The climatic suitability of each crop was analyzed using QGIS, an open-source GIS software. The analysis involves a step-by-step process that involves the use of QGIS tools such as raster calculator, reclassification, and zonal statistics. The crop suitability of each crop was determined by subtracting the future from baseline suitability (expressed as percentage) (*Palao et al., 2017)*. This reflects the degree of crop sensitivity to changing environmental conditions.

Crop sensitivity formula:

$$\frac{\text{(Future Conditions-Current Conditions)}}{\text{Current Conditions}} * 100$$

To identify the suitability of each crop for the future, crop sensitivity was reclassified based on the sensitivity index formulated by CIAT. This index ranges from -1.0 to 1.0, where 0.25 to 1.0 indicates low suitability, while - 0.25 to -1.0 signifies gain in suitability. A value of zero implies no change in suitability (Table 2). The higher change in the negative direction reflects a higher impact caused by climate change (Palao et al., 2017).

Table 2. 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	
>-50 & <= -25 (High loss)	0.5	Loss
> -25 & <= -5 (Moderate loss)	0.25	
> -5 & <= 5 (No change)	0	No Change
> 5 & <= 25 (Moderate gain)	-0.25	
> 25 & <= 50 (High gain)	-0.5	Gain
> 50 (Very high gain)	-1.0	

Source: Palao et al., 2017

Hazard Index

Hazard is the nature and degree to which a system is exposed to significant climatic variations and extreme events (IPCC, 2014). In CRVA, the hazards considered are identified based on their known potential impact on the agricultural sector and characterized by their extent, magnitude, severity, duration, and variability (Bragais et al., 2020 and Parker et al., 2019).

Hazard Dataset

Eight (8) climatic hazards, namely tropical cyclones, flood, drought, soil erosion, landslide, sea level rise, storm surge, and salt water intrusion were identified to affect agricultural production in the Philippines, especially rice and maize, which are highly vulnerable to typhoons (Palao et al., 2017). Hazard datasets refer to historical databases to evaluate the current susceptibility of a hazard to occur in a geographic area (Bragais et al., 2020). These datasets were sourced from various mandated agencies such as the Mines and Geosciences Bureau of the Department of Environment and Natural Resources (MGB, DENR), National Water Resources Board, Bureau of Soils and Water Management (BSWM), and Disaster Risk and Exposure Assessment for Mitigation, Department of Science and Technology (DREAM, DOST) through the AMIA program. Different weights were assigned for each hazard and it varies in terms of degree, intensity, frequency, and potential damage. In this study, sea level rise, storm surge, and salt water intrusion were excluded since Ifugao is a landlocked province. The weights given for typhoon, flood, drought, erosion, and landslide were 27.29%, 25.99%, 19.44%, 15.59%, and 11.69%, respectively. These hazards are considered the major driving factors of high-hazard exposure. The identification and assigning of hazard weights were based on the result of workshops and consultations conducted by CIAT with local and national experts - state universities and colleges (SUCs) experts/focal persons and the DA-System Wide Climate Change Office in the Philippines

The hazard datasets of the province were converted into raster format for easy processing (Figure 3). Processing of these hazards was mostly done using QGIS software. The mean values of the tropical cyclone, flood, soil erosion, and landslide and sum values for drought in the different municipalities of Ifugao were determined using the zonal statistics function in QGIS. The mean and sum values were normalized in each municipality. Furthermore, hazard indices for each municipality were calculated by multiplying the normalized value of each hazard by its respective weights (Luzon) and getting the overall sum. The formula used is shown below:

$$H = \sum w_i h_i$$

where: i corresponds to each hazard,

w_i is the weight of the hazard i, and

h_i is the normalized value of hazard i

The hazard index was again normalized using the equation. Hazard index was classified into five (5) categories– 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).

Normalization formula:

$$hazidx\_norm = \frac{x - x_{min}}{x_{max} - x_{min}}$$

where: hazidx_norm is the normalized value of the hazard index and x is the value of a particular hazard.

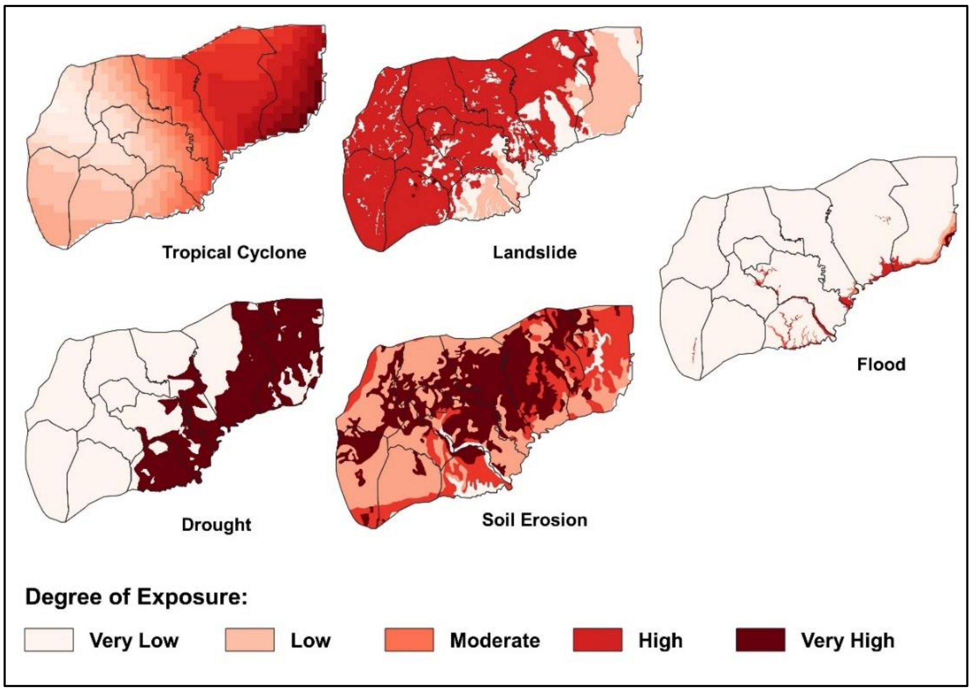

Figure 3. Raster hazard data clipped from the data provided by CIAT.

Adaptive Capacity Index

Aside from exposure and sensitivity, adaptive capacity (AC) is one of the three (3) components of CRVA. It is also one of the components in measuring resilience. Climate change does not equate to disaster itself, but it depends on how the risks are managed. Adaptation, in the climate change context, refers to *“adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”* (IPCC, 2001).

This study considered six (6) capitals to determine the adaptive capacity index of the eleven municipalities in Ifugao Province. These capitals include economic, human, physical, institutional, anticipatory, and natural. Each capital has various sets of indicators as shown in Table 4. The indicators for economic, human, physical, institutional, and anticipatory were derived from the available data (mostly from 2018) of the Cities and Municipalities Competitiveness Index (CMCI) of the Department of Trade and Industry (DTI). These were aggregated data from the respective local government units of the province and from the different mandated agencies. In addition, the data on natural indicators were extracted from the 2020 Land Use and Land Cover data produced by the National Mapping and Resource Information Authority (NAMRIA). Each indicator was normalized and summed up to get the index of each capital. The overall adaptive capacity index was then derived from the normalized value of the sum of all capital indices. Since the focus of this study is vulnerability, the AC index was inverted wherein a value of 1.0 implies low adaptive capacity and was used in determining vulnerability index. The capital indices, overall AC index, and inverted AC index of the different municipalities were integrated into the spatial data of Ifugao province that contains municipal boundaries. The value of the indices was classified into five (5) equal breaks: 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. List of capitals with their indicators.

Capital	Indicator
Economic	Classification
	Gross sales of registered firms
	Total capitalization of new business
	Number of approved business permits for new business applications
	Number of approved business renewals
	Number of occupancy permits approved
	Number of approved fire safety inspection
	Number of declared employees for new business applications
	Number of declared employees for business renewals
	Local inflation rate
	Cost of electricity - Commercial users and Industrial firms/customers
	Cost of water - Commercial users and Industrial firms/customers
	Price of diesel as of December 31, 2018
	Regional daily minimum wage rate agricultural plantation and non-plantation (amount in Peso) 2015
	Daily minimum wage rate - non-agricultural (Establishments with more than 10 workers)
	Cost of land in a central business district
	Cost of rent
	Number of universal/commercial banks
	Number of thrift and savings banks
	Number of rural banks
	Number of finance cooperatives
	Number of savings and loan associations with quasi-banking functions
	Number of pawnshops
	Number of money changers/foreign exchange dealers
	Number of remittance centers
	Number of microfinance institutions
	Total number of LGU recognized / registered business groups
	Total number of other business groups

Capital	Indicator
	Business tax collected by the LGU (in Php)
	Real property tax collected by the LGU (in Php)
	Total revenues of the LGU (in Php)
	Total LGU budget
Human	Capacity of public and private health services – Doctors
	Capacity of public and private health services – Nurses
	Capacity of public and private health services – Midwives
	Public and private secondary education - Number of Teachers
	Public and private secondary education - Number of Students
	Number of local citizens with PhilHealth registration
Physical	Existing road network asphalt (in km.)
	Total land area
	Percentage of households with water and electricity service
	Number of public and private secondary and tertiary schools
	Number of public and private - Clinics
	Number of public and private – Clinic Beds
	Number of public and private – Diagnostic Centers
	Number of public and private - Hospitals
	Number of public and private – Hospital Beds
	Public and private – Infrastructure for Evacuation
	Presence of drainage systems in LGU Center
	Presence of water and power source
	Presence of a sanitary landfill
	Practice of Waste Segregation
Institutional	Presence of comprehensive development plan
	Presence of the local investment incentives code
	Presence of the equivalent of an investment promotions unit
	Getting building and occupancy permits – Minutes
	Getting building and occupancy permits – Steps
	Getting Mayor's permit for new business applications – Minutes
	Getting Mayor's permit for new business applications – Steps
	Getting business renewal permits – Minutes
	Getting Business renewal permits – Steps
Anticipatory	Presence of the CLUP and DRRMP
	Presence of an office that implements the CLUP and DRRMP
	Presence of staff manning the office
	Presence of local E.O or ordinance that mandates the implementation of the CLUP and DRRMP
	Conduct of LGU-wide disaster drill

Capital	Indicator
	Date of latest LGU-wide disaster drill
	Presence of an early warning system that integrates professional responders and grassroots organization
	Total Budget for DRRMP
	Availability of local Geohazard Maps from DENR
	Availability of LGU Risk Profile from DSWD
Natural	Total area of open forest in hectare
	Total area of closed forest in hectare
	Total area of brushland and shrub land in hectare
	Total number of protected area

Source: CMCI – DTI and NAMRIA

Vulnerability Assessment

The results of the assessment of three components of vulnerability – the sensitivity index of each crop, exposure to hazard index, and adaptive capacity index were integrated to determine the climate risk vulnerability index (CRVI) of the different municipalities in Ifugao. These components were also given weights based on their relative importance, 70% was assigned for adaptive capacity and 15% each for sensitivity and exposure to hazards. These weights were used in calculating the CRVI as shown in the equation below:

$$f\,(\text{Haz, Sens, AC})= \Sigma_{n=i}^{n} \left(\left(\text{Haz}_{(wh)} + \text{Sens}_{(w_s)}\right)+1\text{-AC}_{w_a}\right)$$

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.

The assigned weights were based on the results of the consultations and workshops of local and national experts conducted by CIAT. Five (5) different scenarios/versions were created using different percentages for each component (Table 5) since the analysis of weights for each component of vulnerability is highly subjective. Although version 1 was used in this study, the four other scenarios were prepared to compare if the result would be consistent despite the changes in weights.

CRV maps of the rice, corn, and tomato in the province of Ifugao were produced using the CRVI. In these maps, municipalities were classified into five (5) classes, very low, low, moderate, high, and very high vulnerability. Finally, the crop occurrence data were overlaid to the CRV maps to easily identify the areas for prioritization of intervention.

Table 4. Weights used to assess vulnerability assessment.

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

V. Results and Discussion

Sensitivity Index

Current Crop Occurrences

The crop occurrence maps of heirloom and conventional rice, corn, and tomato are the results of the participatory mapping. These were based on the participants' knowledge and existing reports/data from their respective municipalities. Based on the result (Figure 4), most heirloom rice is produced in the mountainous municipalities of the province: Banaue, Hingyon, Hungduan, and Kiangan. Some production areas are also found in Aguinaldo, Asipulo, and Tinoc. Conventional rice production, on the other hand, is distributed throughout the province (Figure 5) with the municipality of Alfonso Lista being the top producer as compared with the municipalities of Banaue and Hungduan with the lowest production. The municipalities of Aguinaldo and Alfonso Lista have the highest corn production in the province as compared to other municipalities (Figure 6). Results also show that the municipality of Tinoc is the top producer of tomatoes (Figure 7) along with the municipalities of Banaue, Hingyon, Hungduan, and Kiangan. Few productions are areas are found in the municipalities of Aguinaldo, Lagawe, Lamut, and Mayoyao.

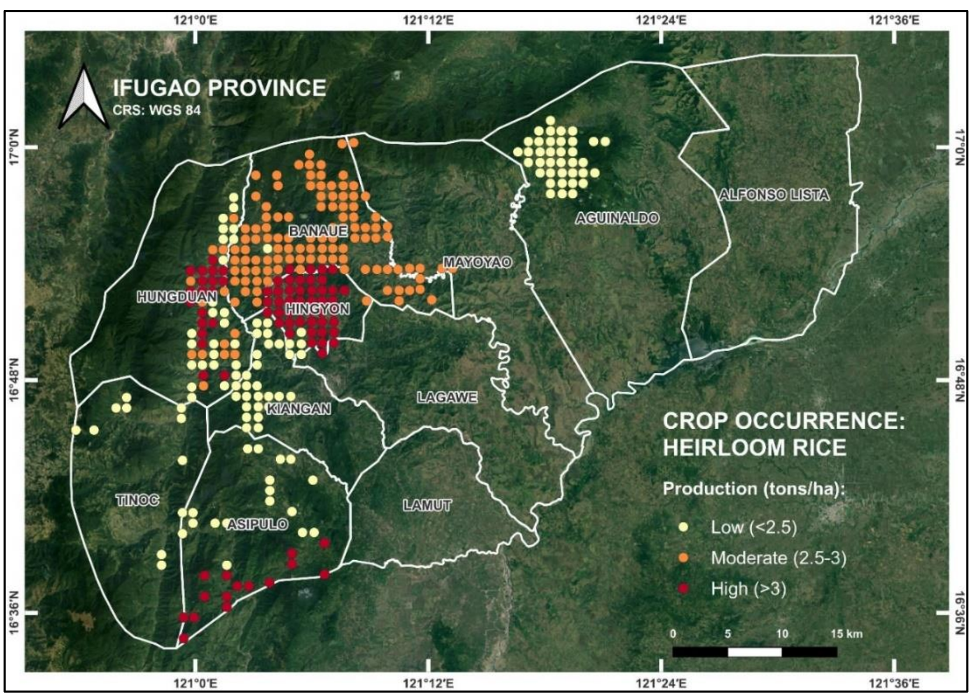

Figure 4. Crop occurrence map of heirloom rice in Ifugao.

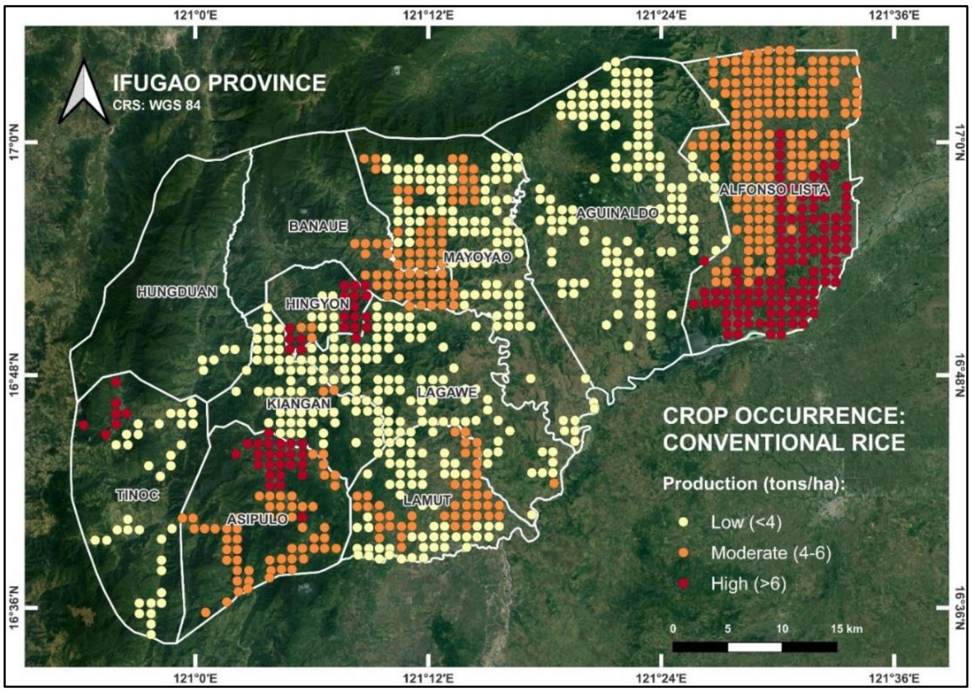

Figure 5. Crop occurrence map of conventional rice in Ifugao.

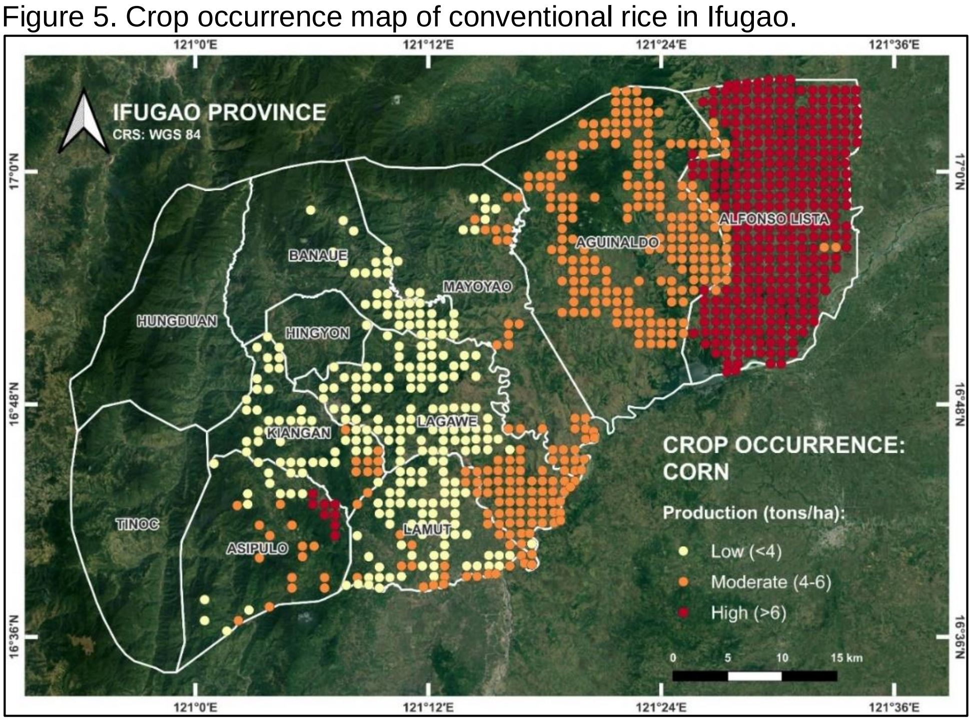

Figure 6. Crop occurrence map of corn in Ifugao.

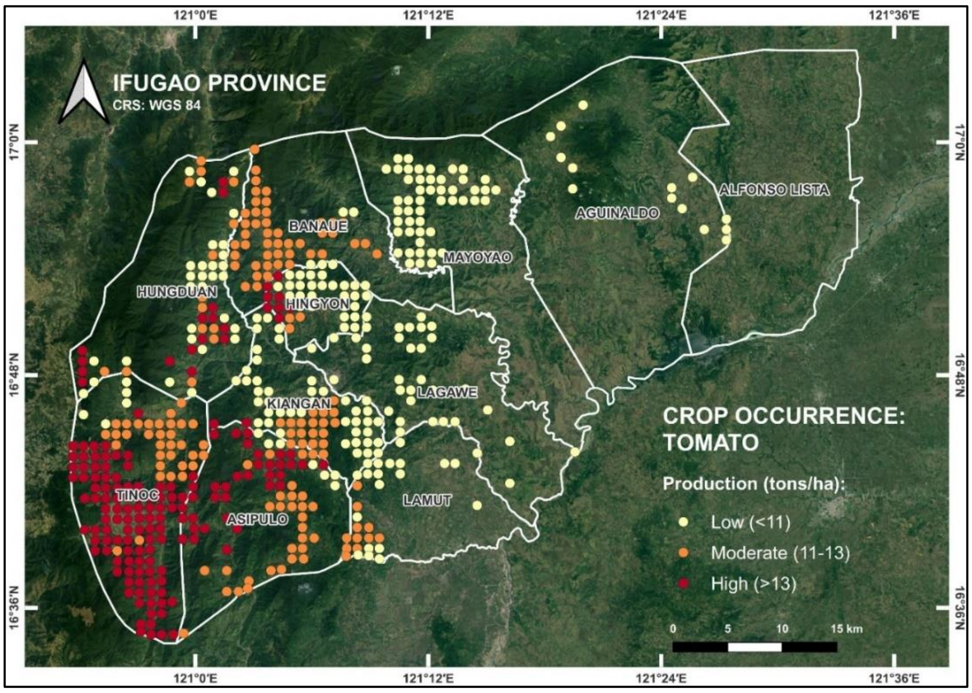

Figure 7. Crop occurrence map of tomato in Ifugao.

Crop Sensitivity

Heirloom Rice

Traditional agricultural systems are well adapted to the local ecosystems in growing heirloom rice varieties have been passed down through generations in the terraces of Cordilleras. One example is the famous Banaue Rice Terraces found in Banaue, Ifugao which is listed by UNESCO as one of the World Heritage Sites. These traditional agricultural systems, however, have been threatened by climate change (Sekine, 2021). The raster data shown in Figure 8 indicate the change in the current and future crop suitability of heirloom rice in all municipalities. The areas with lighter color are the most suitable areas in contrast with the areas with darker color which has lesser suitability. Also, based on the sensitivity analysis of heirloom rice production in Ifugao province (Figure 9), all municipalities are considered to have a loss in crop suitability. This finding is supported by the study conducted in Batad Rice Terraces, Banaue which revealed that rice in the area has a high sensitivity to climate change impacts that are aggravated by acidic soil pH, soil potassium deficiency, the perceived increase in the presence of pests, the high dependence on irrigation structure, agricultural unsuitability, and food import dependency (Ducusin et. al., 2019).

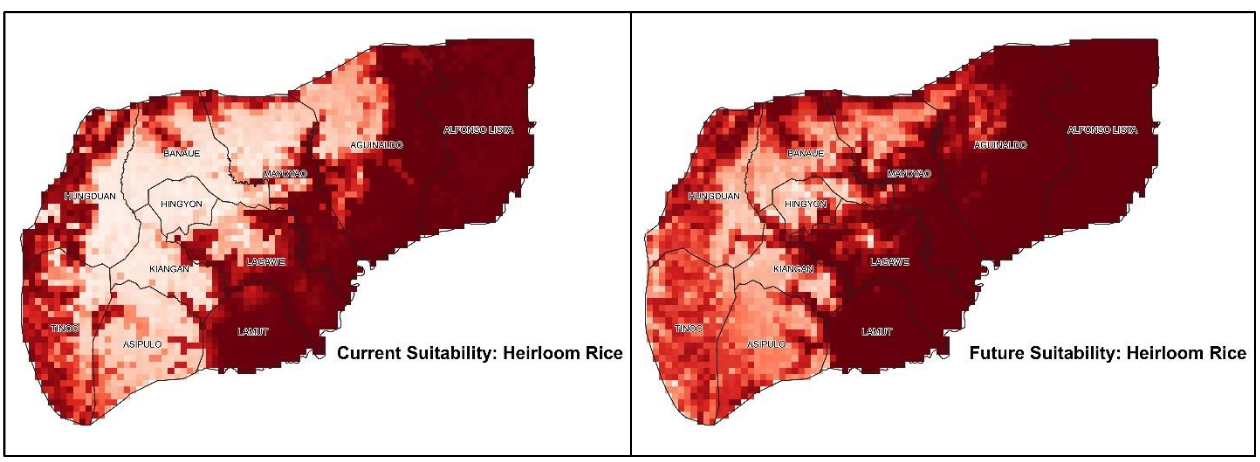

Figure 8. Baseline and projected crop suitability of heirloom rice in Ifugao.

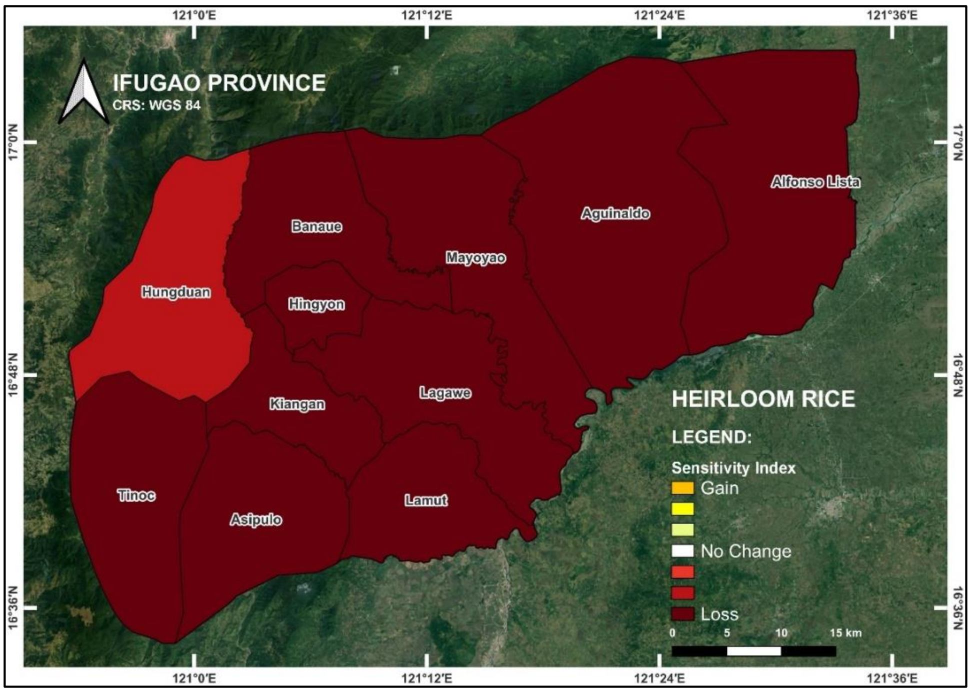

Figure 9. Sensitivity index of heirloom rice in Ifugao.

Conventional Rice

The province only contributed 10% or approximately 32,934 MT to the total production in the region (338,067 MT) (PSA, 2022). Based on the projected suitability map of conventional rice in the province, there will be a huge suitability loss in areas of lower elevation especially in the municipalities of Alfonso Lista, Aguinaldo, Lamut, Lagawe, and Mayoyao. The raw data of current and future suitability maps are shown in Figure 10. The sensitivity index map shows a loss in suitability across all municipalities in the province (Figure 11).

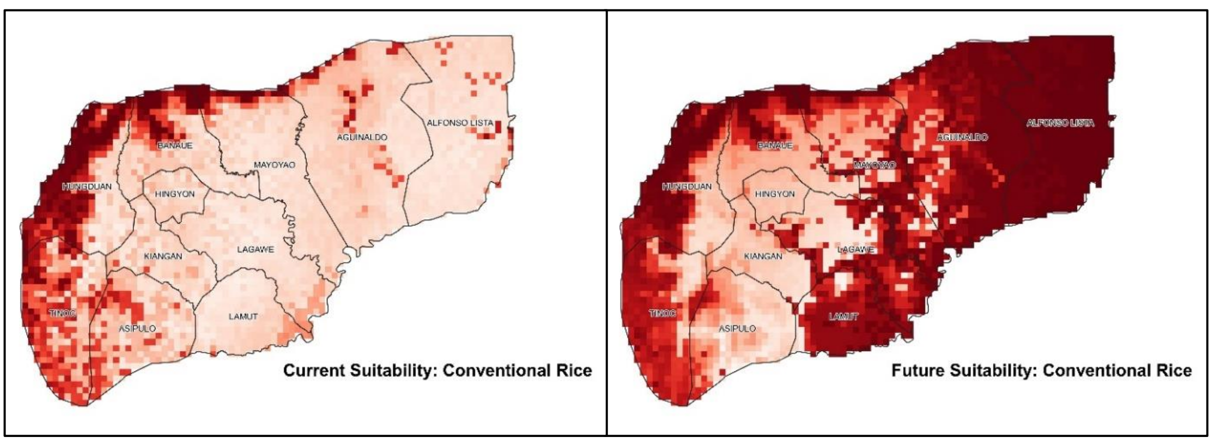

Figure 10. Baseline and projected crop suitability of conventional rice in Ifugao.

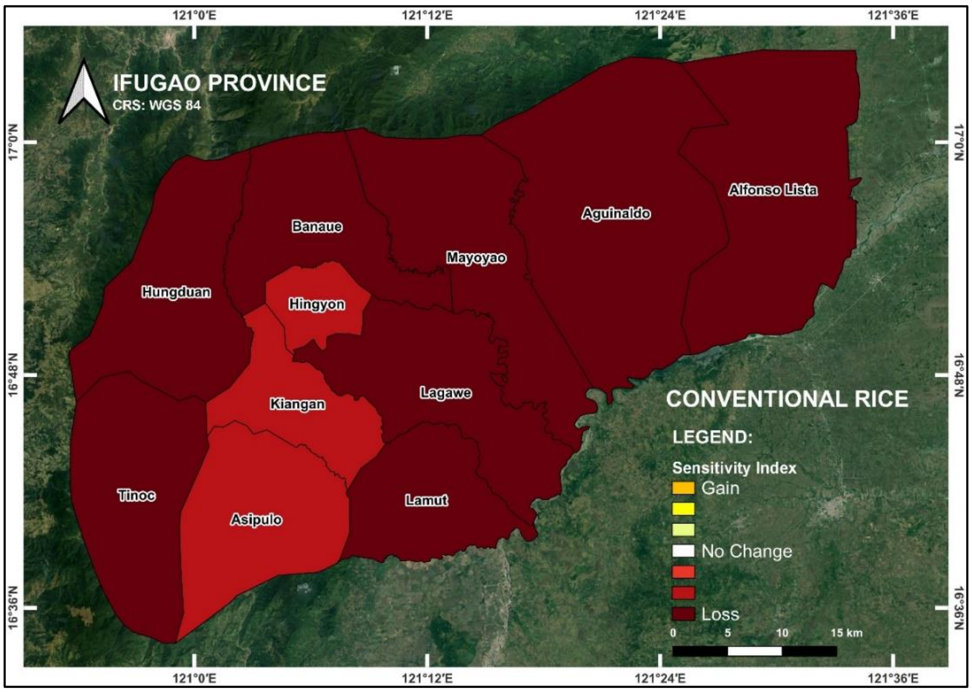

Figure 11. Sensitivity index of conventional rice in Ifugao.

Corn

Corn production in Ifugao province is primarily concentrated in the municipalities of Alfonso Lista, Aguinaldo, Lagawe, and Lamut. Figure 12 shows the crop suitability of corn in the province of Ifugao. Results of sensitivity shows that all municipalities will have a loss in suitability by the year 2050 in corn production in the Ifugao province (Figure 13). The World Meteorological Organization (WMO) reported that corn production would be more affected by the increase in air temperature, enhancing respiration and shortening the maturity period and thereby decreasing the yield. Moreover, the study of Jägermeyr et al (2021) revealed a 24% decrease in maize or corn yield globally by 2030 under a high gas emissions scenario (RCP 8.5).

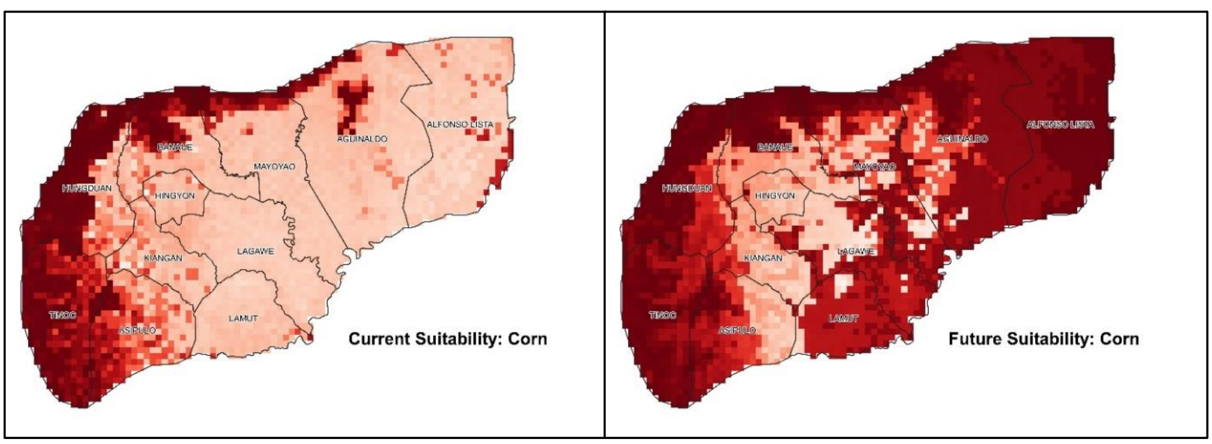

Figure 12. Baseline and projected crop suitability of corn in Ifugao.

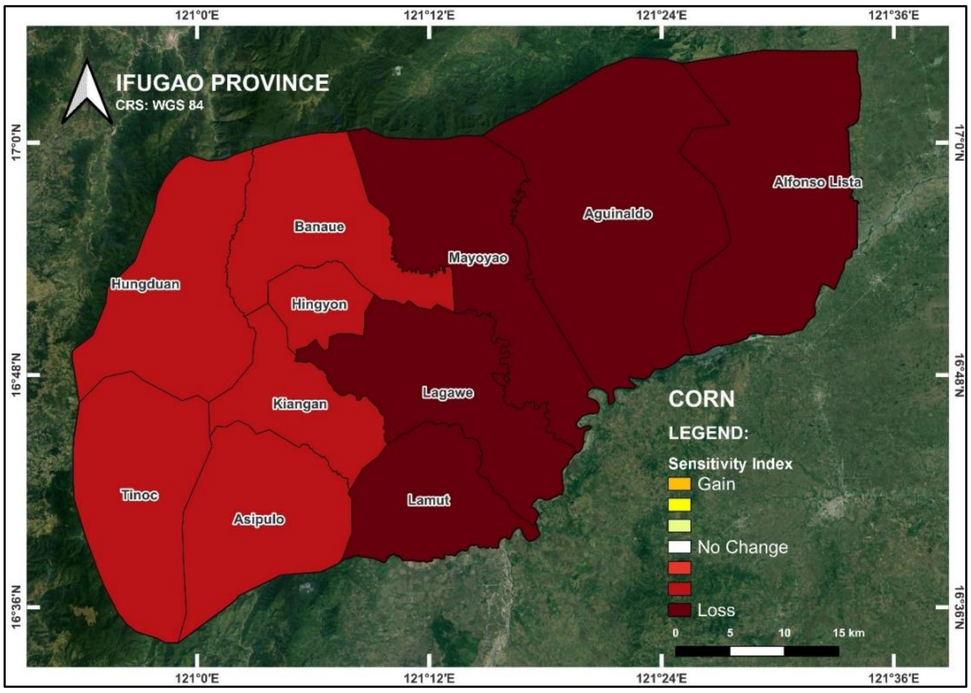

Figure 13. Sensitivity index of corn in Ifugao.

Tomato

Tomato is more suitable in areas with higher elevation as compared with the areas in lower elevation thus the municipalities in higher elevation have higher production than those in the lower elevation (Figure 14). The future suitability map, however, suggests that by the year 2050, there will be a huge loss in the suitability of tomatoes in terms of temperature and precipitation changes. The sensitivity analysis map (Figure 15) also shows the same result as there is a loss in suitability across all municipalities.

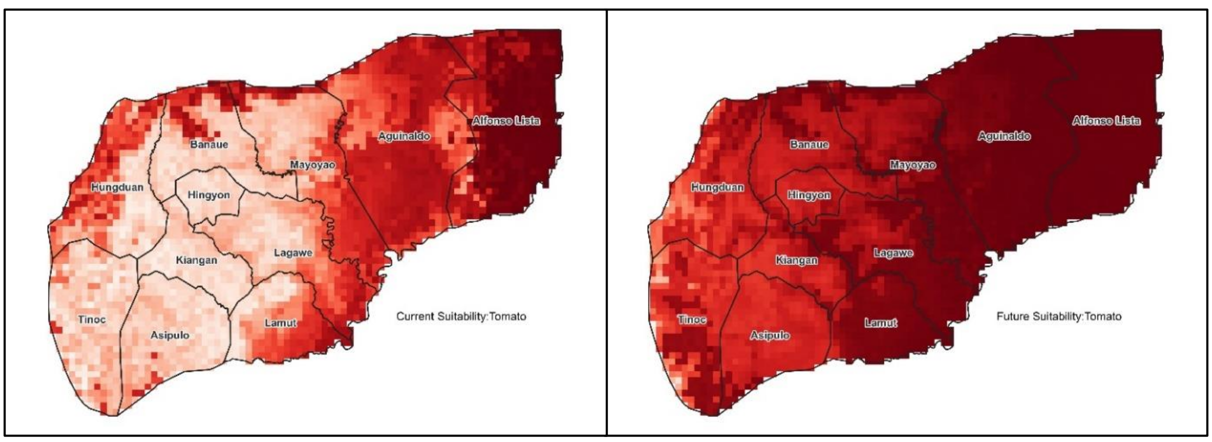

Figure 14. Baseline and projected crop suitability of tomato in Ifugao.

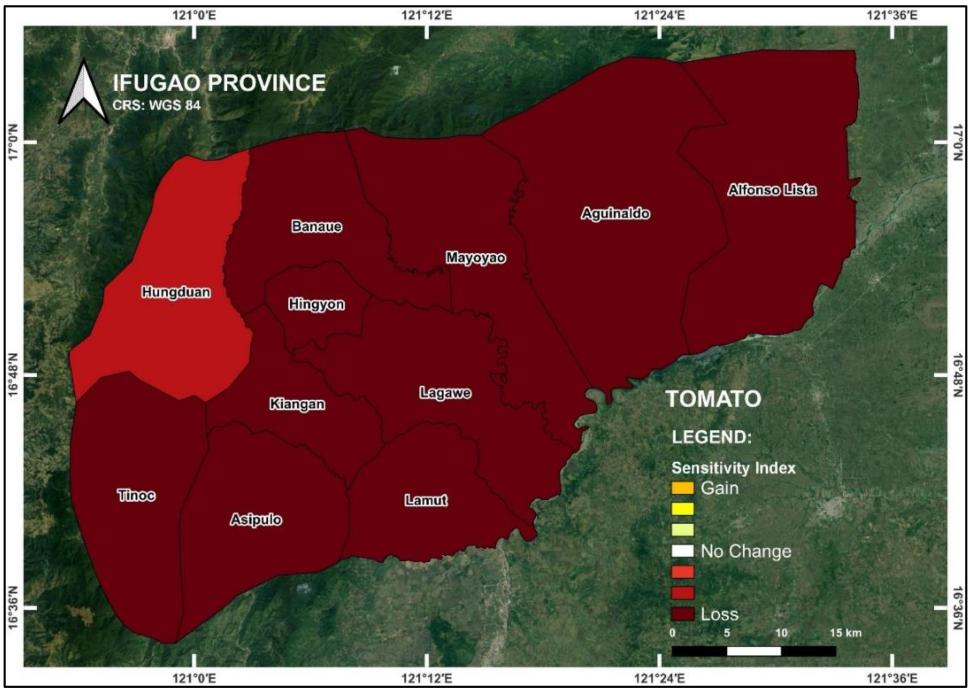

Figure 15. Sensitivity index of tomato in Ifugao.

Hazard Index

Tropical Cyclone

Tropical cyclones are the most destructive natural disaster globally. The Philippines experiences numerous typhoons because it is situated along the Pacific typhoon belt. The Philippine Area of Responsibility is visited by an average of 20 typhoons per year and half of these make landfall (Cinco et al., 2016). From 2001 – 2010, the country had a total of 171 typhoons with of which Luzon having the highest occurrence of this hazard was in Luzon, particularly in the Cagayan Valley, Ilocos Region, CAR, Central Luzon, and Bicol Region regions (Israel & Briones, 2013). Desquitado et al (2020) further reported that Luzon had the highest occurrences of typhoons from 1989 to 2016. According to Holden & Marshall (2018), Northern Luzon is one of the areas that is heavily affected by the risks of typhoons. The production of rice and corn in the Philippines is highly vulnerable to tropical cyclones since their high occurrence coincides with the growing period of these crops (Bragais et al., 2020). The results presented in Figure 16 show that Alfonso Lista and Aguinaldo which are located in lower elevations, have the highest exposure to tropical cyclones among the municipalities of Ifugao province, followed by Mayoyao. The municipalities of Banaue, Lagawe, Lamut, Asipulo, and Tinoc have low exposure while Hungduan, Hingyon, and Kiangan have very low exposure to tropical cyclones. While rain from tropical cyclone is an important source of irrigation to support crops, it can also bring destructive intense rainfall and strong wind and can induce hazards such as floods and landslides (Racoma et al., 2021). Heavy rains and strong wind disrupt the activities of lowland rice farmers and makes upland corn and highland vegetable growers vulnerable to strong winds and other climate-related hazards like soil erosion and landslides (Giles et al., 2019). In fact, it was reported that between 1970 to 2018 the province of Ifugao frequently experienced rice damage (13 to 14 times) caused by tropical cyclones (Yuen et al., 2022).

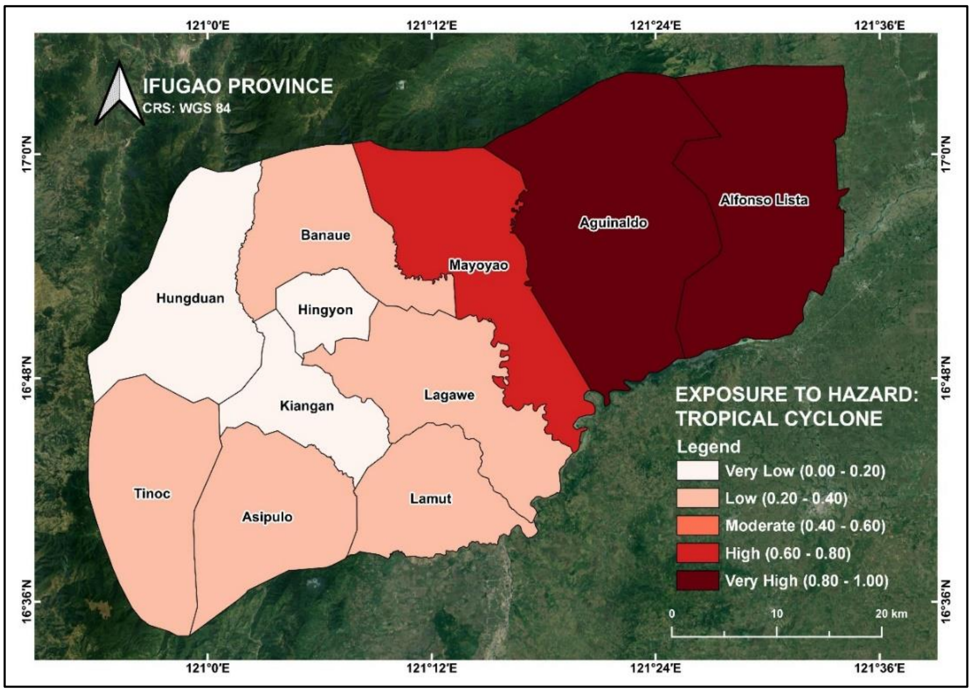

Figure 16. Tropical cyclone index of the different municipalities in Ifugao.

Flood

Floods are often brought about by tropical cyclones and heavy rainfall. This natural disaster is the leading cause of natural disaster deaths worldwide and is responsible for 6.8 million deaths in the 20th century (Doocy et al. 2013). According to the World Bank Group, (2011), heavy rainfall associated with typhoons and other weather systems may increase both in intensity and frequency over time under a changing climate and can exacerbate the incidence of flooding in existing flood-prone areas and introduce the risk of flooding to new areas. From 2000 to 2010, the total value of agricultural damage, by commodities, affected by typhoons, floods, and droughts in the Philippines amounted to a total of USD 2,234.21 million (Israel & Briones, 2013).

Based on the assessment of exposure to hazards, the municipality of Lamut is most exposed to flood (Figure 17). This is due to its geographical setting wherein the primary river, Lamut River, and its tributaries are located. It can be recalled that three barangays of Lamut were flooded in August 2022 which damaged 17 ha of vegetable gardens and rice fields. Reports revealed that the flood was triggered by heavy rains that caused Nayon River, one of the tributaries of Lamut River. to overflow (Quitasol, 2022). Moreover, according to the report of ReliefWeb (2022), in the same year, the province of Ifugao experienced heavy rains brought by the southeast monsoon that caused flash floods and landslides which affected the populace. This resulted in damage to properties including crops amounting to Php14,659,990.00.

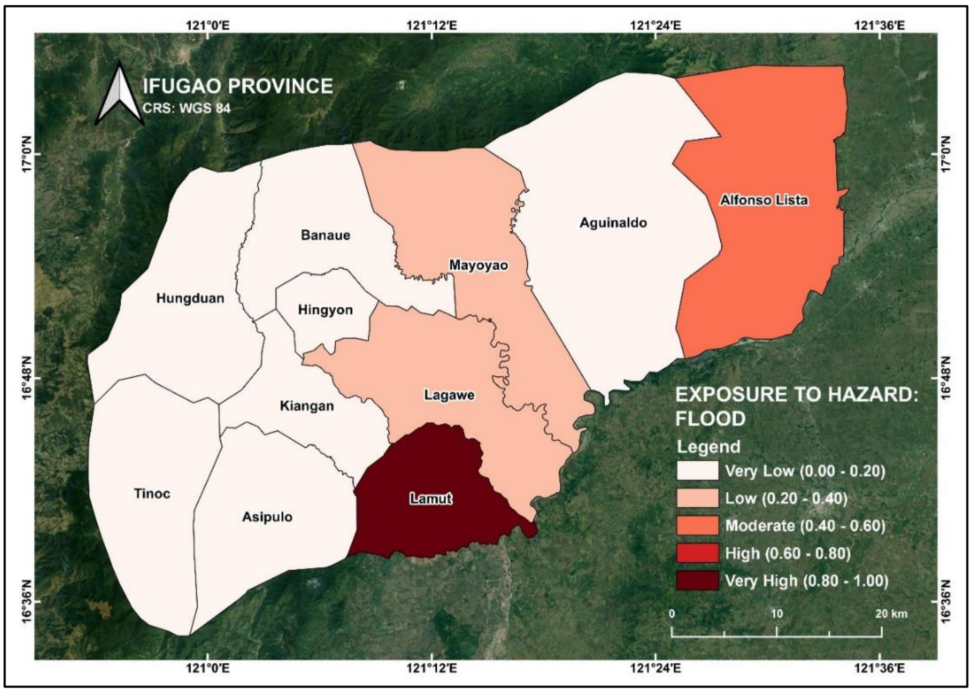

Figure 17. Flood index of the different municipalities in Ifugao.

Landslide

Landslides are a potentially hazardous natural disaster. It is the movement of a mass of rock, debris, or earth down a slope under the influence of gravity (Highland et al., 2008). It is one of the most common natural hazards in mountainous regions that can cause major damage to properties and at times, result in significant loss of human lives. It is often triggered by natural activities such as storms, heavy and prolonged rainfall, and earthquakes. They may be also caused by anthropogenic activities such as land use conversion and intensification. The Cordillera Administrative Region, like any mountainous area, is prone to landslides due to its rugged topography and soil properties. The elevation, slope angle, and slope aspect are considered important conditioning factors in landslide occurrence. Slope instability is high in higher elevations and a steeper slope means higher gravity and shear stress of the slope causing an increased probability of slope failure.

It was evident from the result shown in Figure 18 that the municipalities located in higher elevations including Banaue, Hingyon, Hungduan, Tinoc, and Asipulo have very high exposure to landslides followed by Kiangan and Mayoyao. Lagawe and Aguinaldo are moderately exposed whereas Lamut and Alfonso Lista have very low exposure to landslide.

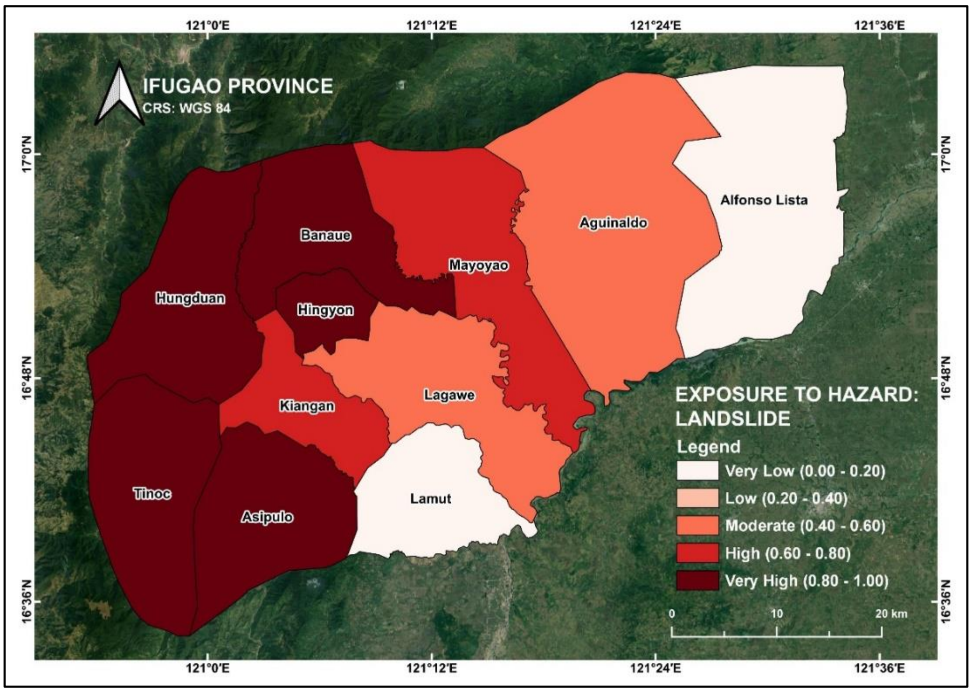

Figure 18. Landslide index of the different municipalities in Ifugao.

Soil Erosion

Soil erosion is defined as the movement and transport of the upper layer of soil by various agents including water and wind which makes climate the key factor (Bullock, 2005). Also, human activities such as land use conversion, deforestation, unsustainable farming practices, and poor land and water management have caused the quality of soil to decline, thus contributing to soil degradation. In the province of Ifugao, Aguinaldo, Mayoyao, and Hingyon are very highly exposed to soil erosion followed by Lagawe while the rest of the municipalities have very low to moderate exposure as shown in Figure 19.

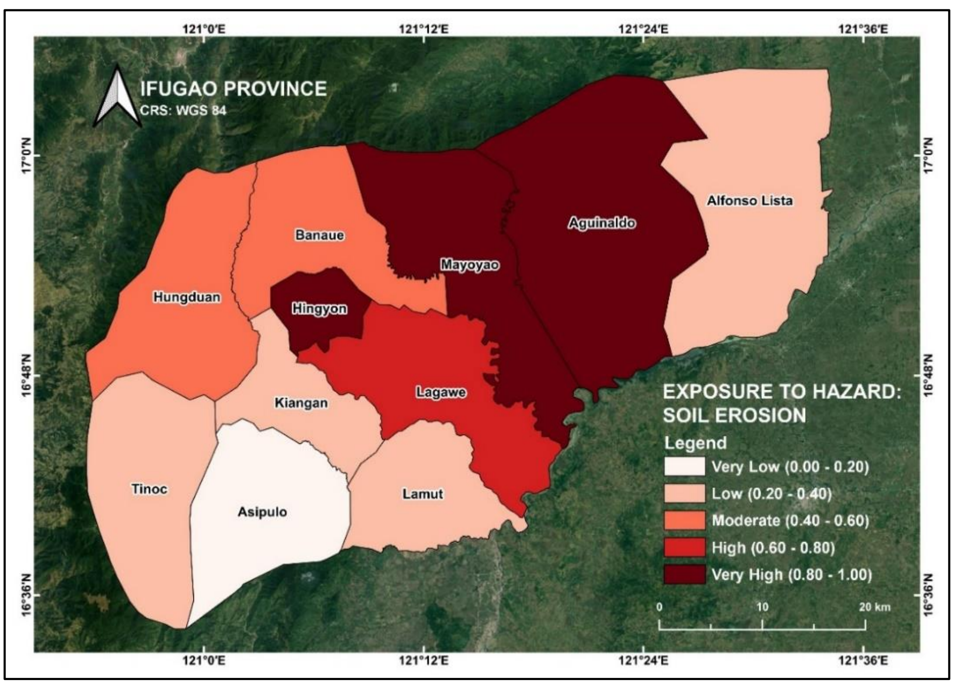

Figure 19. Soil erosion index of the different municipalities in Ifugao.

Drought

The World Bank Group (2011) reported that prolonged droughts are associated with the El Niño phenomenon and these natural events will likely intensify in the future in the Philippines. In the province of Ifugao, Alfonso Lista and Aguinaldo have the highest exposure to drought followed by Lamut with moderate exposure. Mayoyao and Lagawe have low exposure while the rest have very low exposure. It can be noticed in Figure 20 that areas in the lower elevation are more exposed to drought as compared to those municipalities located in higher elevation. Drought and/or floods that occur during a crop's vegetative stages result in significantly lower farm incomes thus reducing the household or farm's ability to build resilience (Giles et al., 2019) or at the very least, improve its adaptive capacity.

The severity of droughts in Luzon is strongly tied to the El Niño Southern Oscillation (ENSO) which has a strong modulating effect on rainfall patterns in the Philippines (Giles et al., 2019). ENSO has become increasingly unpredictable, such that Luzon is experiencing dry conditions during usually wet La Niña events while Mindanao has excessive rains during usually dry El Niño events (Yumul et al., 2009).

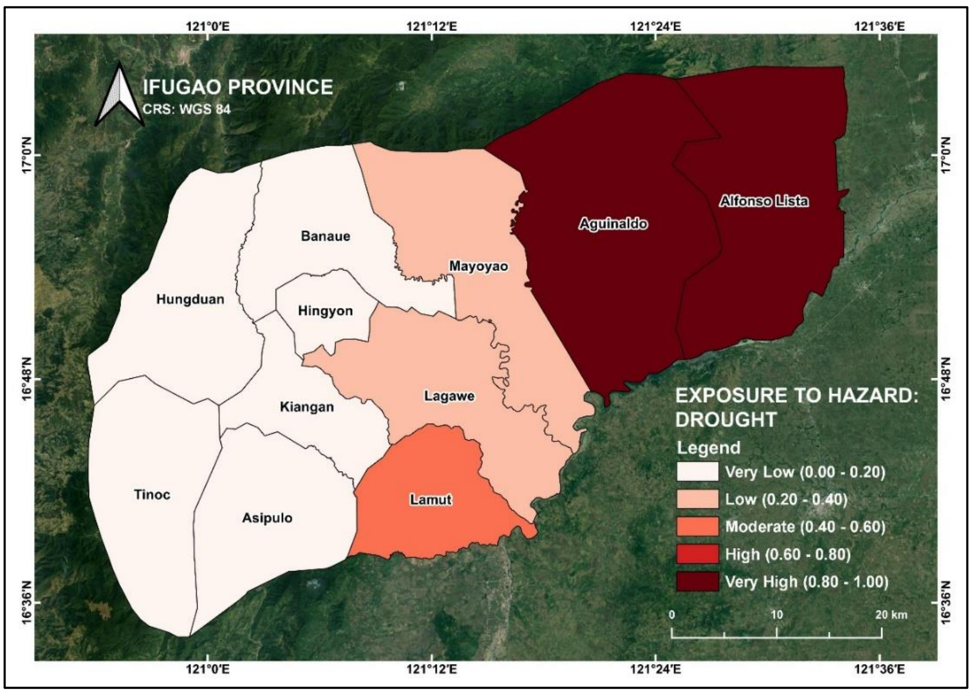

Figure 20. Drought index of the different municipalities in Ifugao.

Overall Hazard Index

The hazard index of the municipalities in Ifugao province was determined based on the combination of five (5) climate-related hazards which considered the relative "impact potential" of each hazard using the assigned hazard weights. The result revealed that the municipalities of Alfonso Lista and Aguinaldo are most exposed to climate-related with high and very high exposure to tropical cyclone, drought, and soil erosion (Figure 21). These were followed by Mayoyao as this municipality is the most exposed to soil erosion and highly exposed to typhoons. Lagawe and Lamut, on the other hand, have moderate exposure to climate-related hazards. The municipalities located in the upper part of the province were listed under the low exposure classification.

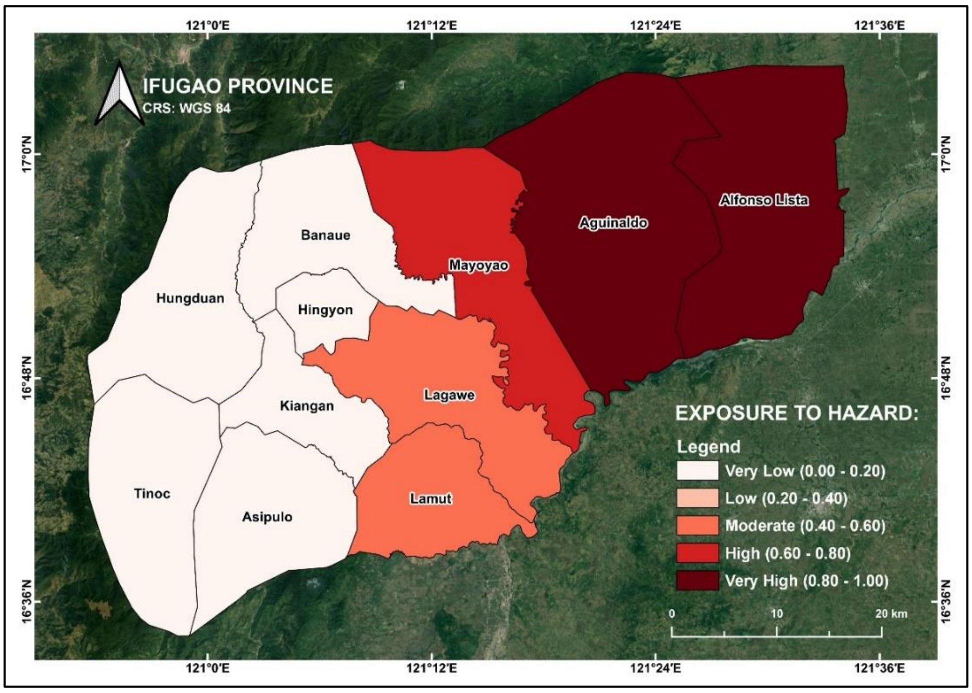

Figure 21. Overall hazard index map of Ifugao Province.

Adaptive Capacity Index

In term of economic capital, the municipalities of Alfonso Lista and Lagawe have the highest adaptive capacity among the eleven (11) municipalities, Lamut has high, Banaue has moderate, Hungduan and Aguinaldo have low, and the municipalities of Kiangan, Mayoyao, Hingyon, Tinoc, and Asipulo have a very low rating (Figure 22a). The municipality of Alfonso Lista has savings/rural banks, finance cooperatives, and microfinance institutions. In addition, it has the highest revenues and taxes collected among the 11 municipalities. All of these sub-indicators contributed to the high to very high economic capital index. In contrast, Mayoyao obtained a very low adaptive capacity rating due to the unavailability of banks in the municipality and low revenue and budget.

The municipalities of Lagawe and Lamut have very high adaptive capacity in terms of physical capital, followed by Banaue and Alfonso Lista having high while Hingyon and Hungduan have the lowest adaptive capacity (Figure 22b). The presence of a considerable number of facilities such as Public Utility Vehicles (PUVs), secondary schools, health clinics and hospitals, Automated Teller Machines (ATMs), ambulances, firetrucks, evacuation centers, drugstores, and gas stations contributed to the high index of Lagawe and Lamut.

As for the institutional capital (Figure 22c), Lamut and Alfonso Lista have a high adaptive capacity for this capital, followed by the municipalities of Lagawe, Aguinaldo, and Asipulo with high index, Banaue and Kiangan with moderate, Hungduan and Hingyon are low, and the municipalities of Tinoc and Mayoyao have very low. This capital is related to the processing of permits, and programs and project activities (PPAs) supported by the government.

On the other hand, Lamut has a very high adaptive capacity index in human capital as shown in Figure 22d, followed by Banaue as moderate, Alfonso Lista, Lagawe, and Kiangan have low, and the rest of the municipalities have the lowest adaptive capacity namely Aguinaldo, Asipulo, Mayoyao, Tinoc, Hungduan, and Hingyon. This indicates that the municipality of Lamut has high capacity in terms of health services and education.

The municipalities of Alfonso Lista, Lamut, Asipulo, Banaue, Lagawe, and Mayoyao have a very high index for anticipatory capital, followed by Kiangan and Aguinaldo having a high index, Hungduan, and Tinoc have a low, and Hingyon has a very low index as shown in Figure 22e. Among the eleven (11) municipalities, Asipulo had the most updated CLUP, although it has one with the lower budget for DRRMP.In relation to natural capital, the municipalities of Tinoc and Hungduan have the highest adaptive capacity. Aguinaldo, Asipulo, Banaue, and Mayoyao have moderate, Lagawe has low, Kiangan, Alfonso Lista, Lamut, and Hingyon have very low index as shown in Figure 22f. Parts of land located in the municipality of Tinoc constitute the Mt. Pulag Protected Landscape stated in R.A. no. 11685 while Hungduan forms part of the upper Agno River Basin Resource Reserve (UARBBR) which is also a protected area and at the same time has the largest area of closed forest.

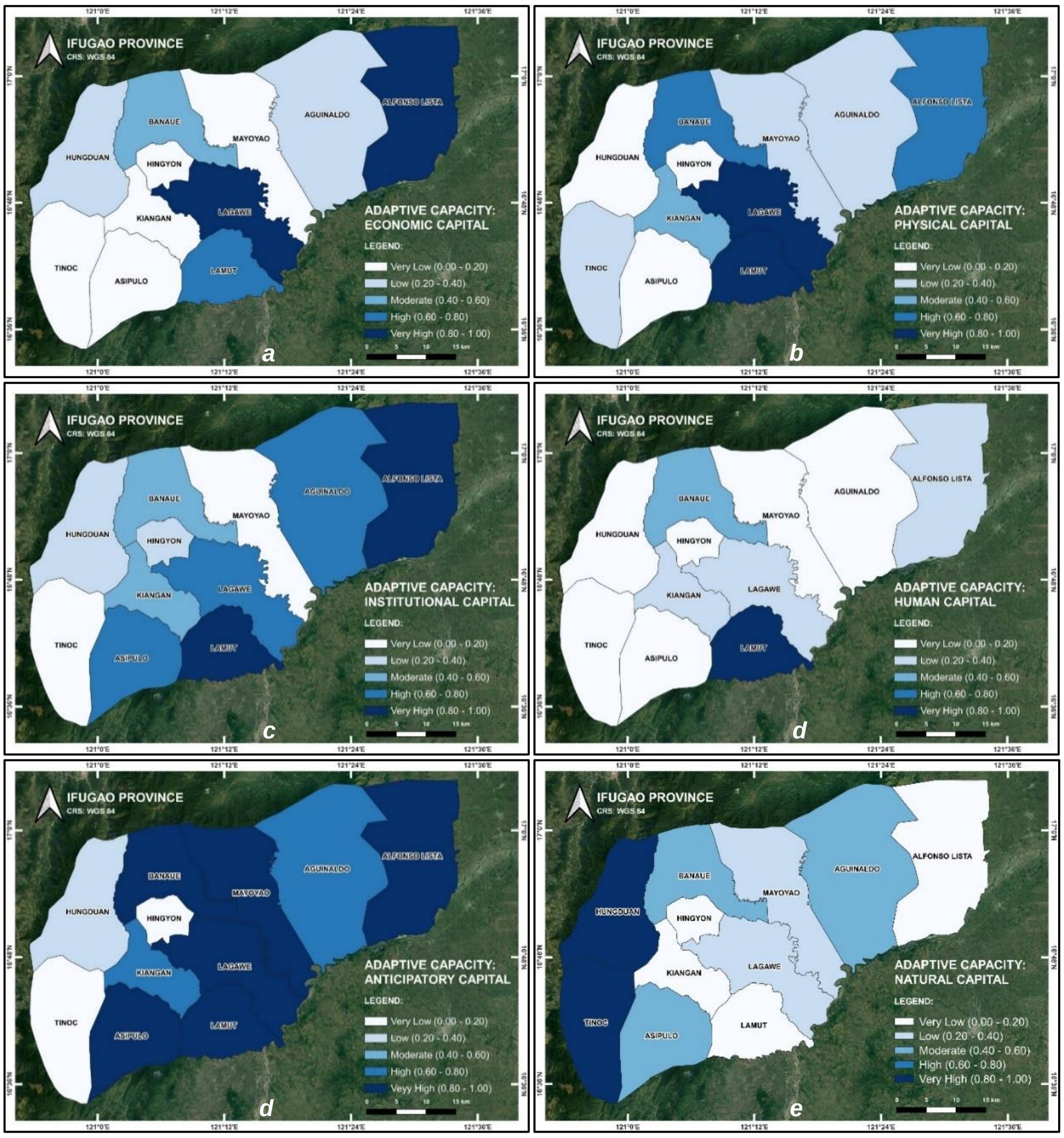

Figure 22. Economic (a), Physical (b), Institutional (c), Human (d), Anticipatory (e), and Natural (f) of Ifugao province.

Overall Adaptive Capacity Index

The Overall Adaptive Capacity Index is the integrated index of the six (6) capitals. It provides significant information on how adaptive a particular municipality to the impact of climate change. The most adaptive municipalities in Ifugao province are Lamut, Lagawe, and Alfonso Lista followed by Banaue with high AC, Aguinaldo, and Asipulo are moderately adaptive, and Kiangan, Hungduan, Tinoc, and Mayoyao have low AC (Figure 23). The municipality of Hingyon obtained the lowest adaptive capacity rating because it has a consistency rating of very low in all of the capitals except institutional capital which is low. This implies that they have inadequate tools needed to better adapt to climate change impact, especially in the agricultural sector. Since the study aims to determine the most vulnerable areas, the overall adaptive capacity index is inverted. The inverted AC index shows the municipalities with the lowest adaptive capacity in darker color (Figure 24). Hingyon has the highest adaptive capacity when inverted because the spatial analysis of the different capitals show consistency of having low to very low adaptive capacity. On the other hand, Alfonso Lista, Lagawe, and Lamut have very low since the overall result of the capital shows that it has very high adaptive capacity (Figure 24). These implies that these municipalities with moderate to very high AC have very low to low overall adaptive capacity.

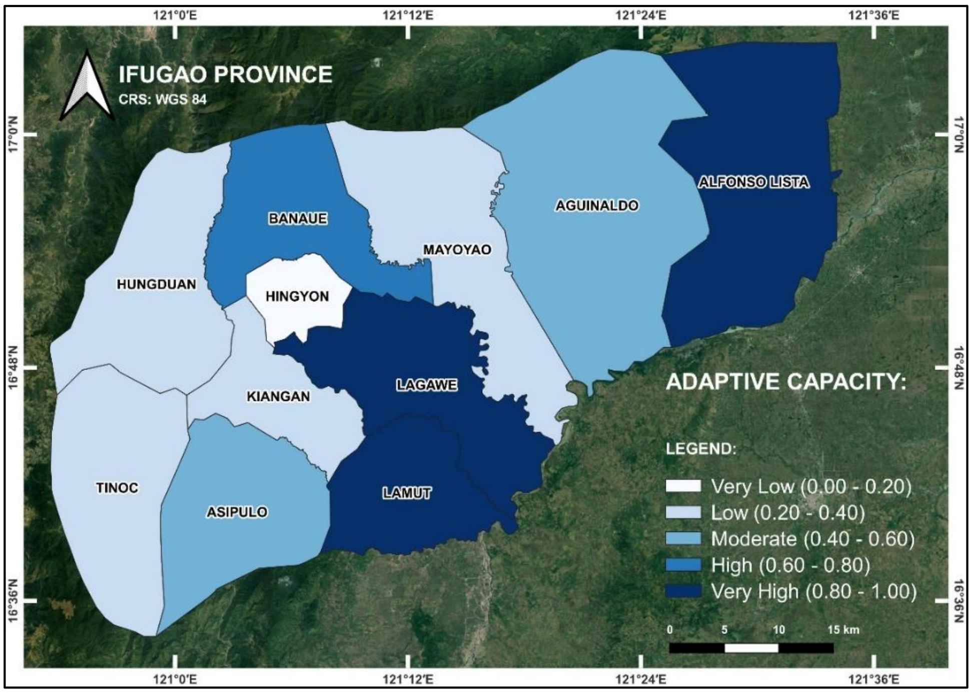

Figure 23. Overall Adaptive Capacity Index map of Ifugao Province.

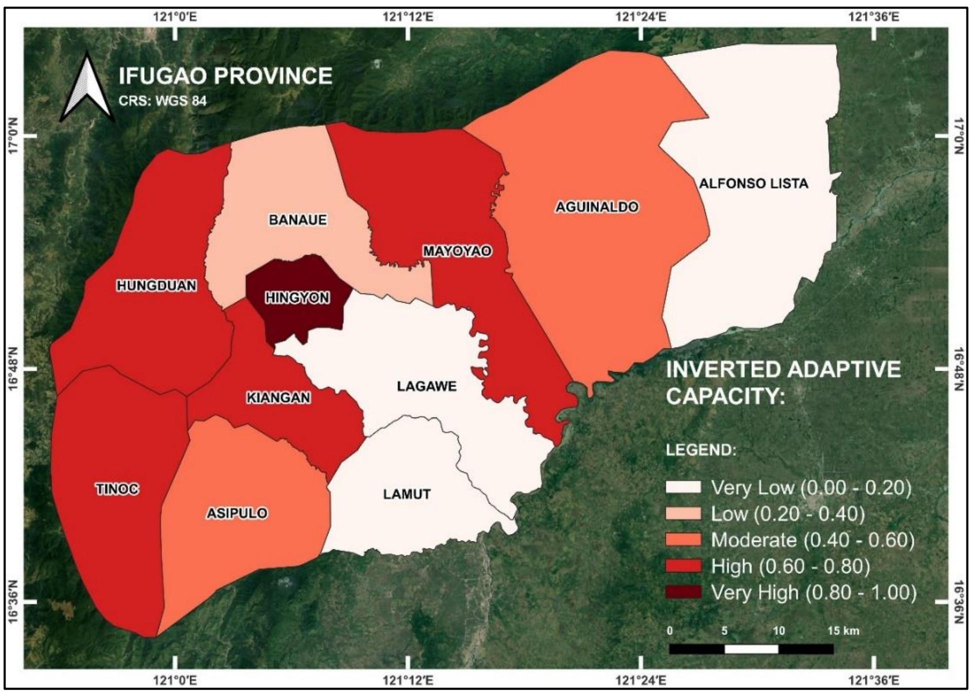

Figure 24. Inverted Adaptive Capacity Map Ifugao Province

Climate Risk Vulnerability

The final climate risk vulnerability map is a combination of municipalities' adaptive capacity components, sensitivity, and degree of exposure to hazard using the different weights provided by CIAT. The results show consistency in the detection of highly vulnerable municipalities regardless of the different weights used. However, the 70-15-15 (Version 1) proportion was used as the final reference in the prioritization, targeting, and identification of areas that threaten the resilience of agri-fisheries communities. In the identification of areas for prioritization, the municipality must be found to be highly vulnerable and at the same time must show high production of the selected crops.

Heirloom Rice

Most of the known heirloom rice in the Philippines are grown in the famous terraces in the Cordillera region (Daipan et al., 2023). But several types of Ifugao rice are on the brink of extinction and these includes Ingudpur, Imbuucan, Ulikan, Ominio, and Jeykot Sticky rice (Vista Residences, 2022).

Hingyon, Aguinaldo, and Mayoyao are the municipalities with high to very high vulnerability in terms of heirloom production as shown in Figure 25. This is because these municipalities have high to very high exposure to hazards, high loss in heirloom rice suitability, and low to very low adaptive capacity. The municipality of Mayoyao consistently has very high vulnerability despite the different weights assigned for the three components (Figures 25 and 26). Hungduan, Kiangan, Asipulo, Tinoc, and Mayoyao have moderate to very high vulnerability but with low heirloom rice production. Furthermore, as assessed in the result of participatory mapping of this crop, heirloom rice was mostly grown in Hingyon and Aguinaldo with high yield as shown in Figure 27. Therefore, Hingyon and Aguinaldo are recommended for prioritization in terms of interventions.

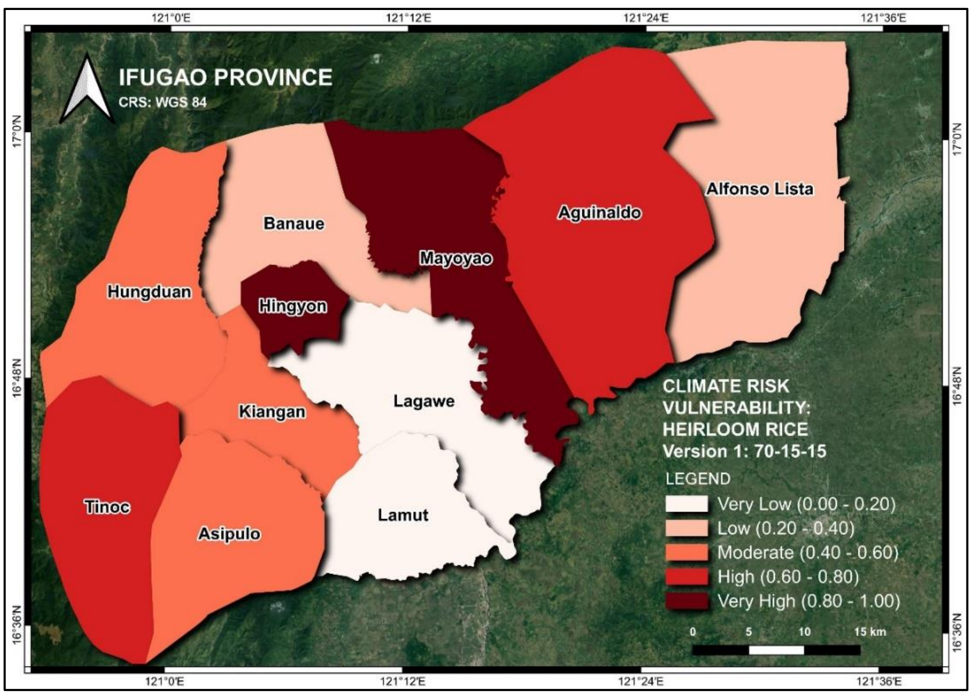

Figure 25. Vulnerability map of heirloom rice production in Ifugao (reference).

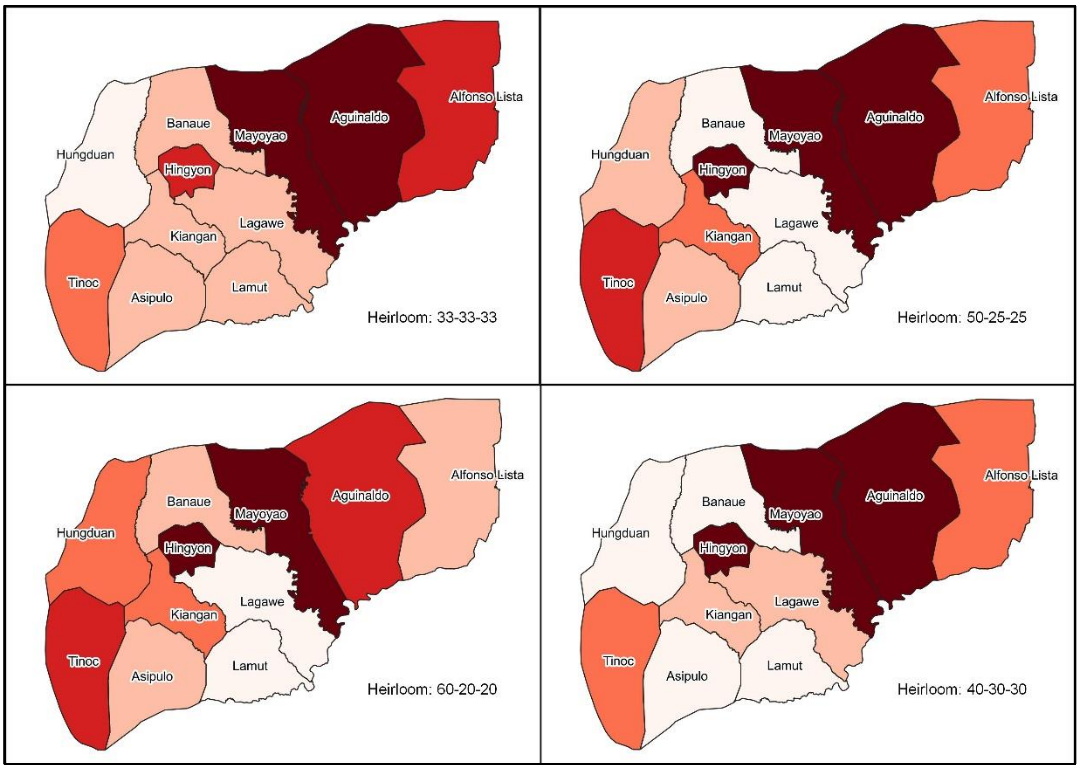

Figure 26. Vulnerability maps of heirloom rice production in Ifugao using different weight proportions.

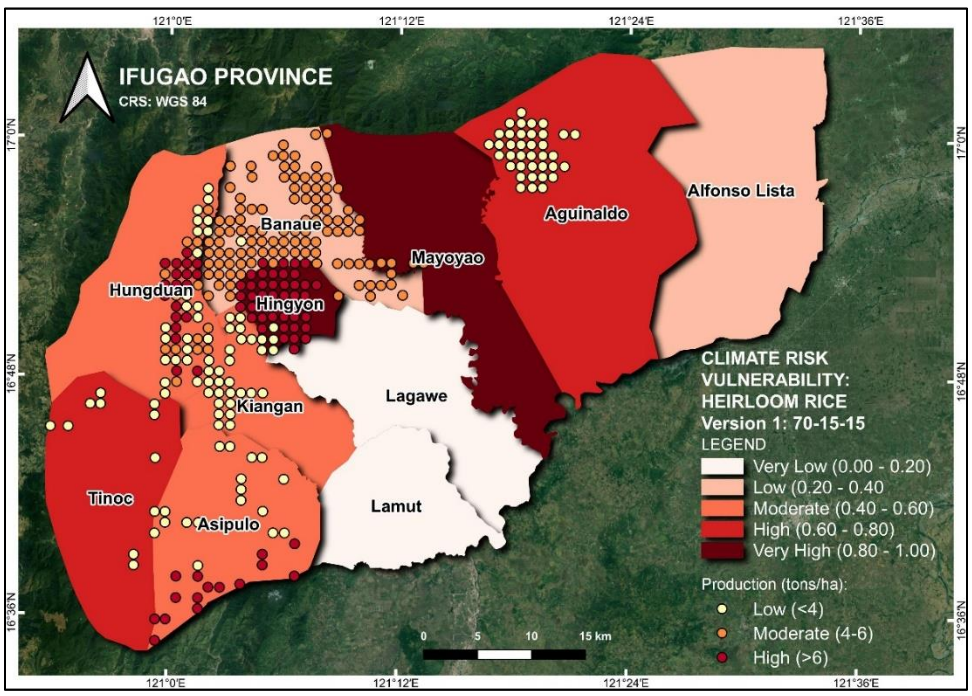

Figure 27. Crop occurrences overlaid with the corresponding CRVA reference map.

Conventional Rice

According to the Philippine Statistics Authority (PSA, 2022), the total rice production in the Cordillera went down from 377,133 MT in 2021 to 338,067 MT in 2022 which is approximately a 10.4 percent decrease. This was due to the decrease in harvest area in 2022 (97,568 ha) as compared to the harvest area in 2021 (101,556 ha) or approximately 14% decrease. Furthermore, in 2022, Ifugao province only contributed 10% or approximately 32,934 MT to the total production in the region; Kalinga province contributed the highest with 34% (114805 MT) followed by the province of Abra with 23% contribution (76,921 MT), Apayao with 22%

contribution (74, 380 MT), Benguet with 7% contribution (23,411), and Mountain province with the least contribution of only 4% (15,617 MT). In terms of average yield per hectare, Ifugao province has the lowest yield in the region with only 2.74 MT.The municipalities of Aguinaldo, Mayoyao, and Hingyon e high to very high climate-risk vulnerability for conventional rice production as shown in Figure 28 and Figure 29. Additionally, these municipalities have low to very high production. On the other hand, Alfonso Lista has low vulnerability but with moderate to high production (Figure 30). Thus, in terms of interventions, Aguinaldo, Mayoyao, Hingyon, and Alfonso Lista are recommended to be prioritized due to high climate risk vulnerability and at the same time with high production of conventional rice.

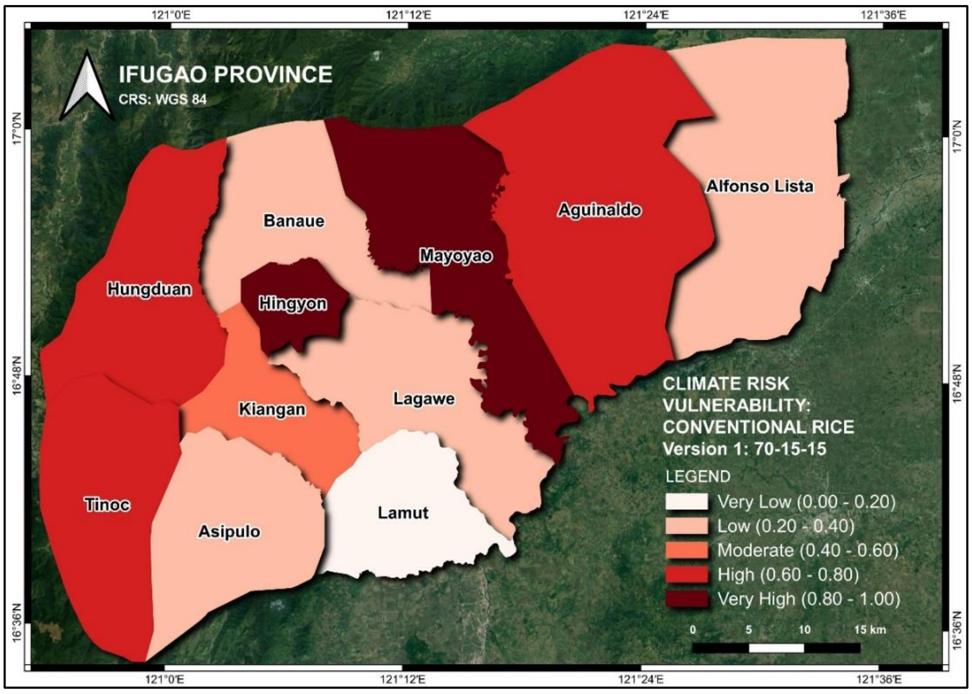

Figure 28. Vulnerability map of conventional rice production in Ifugao (reference).

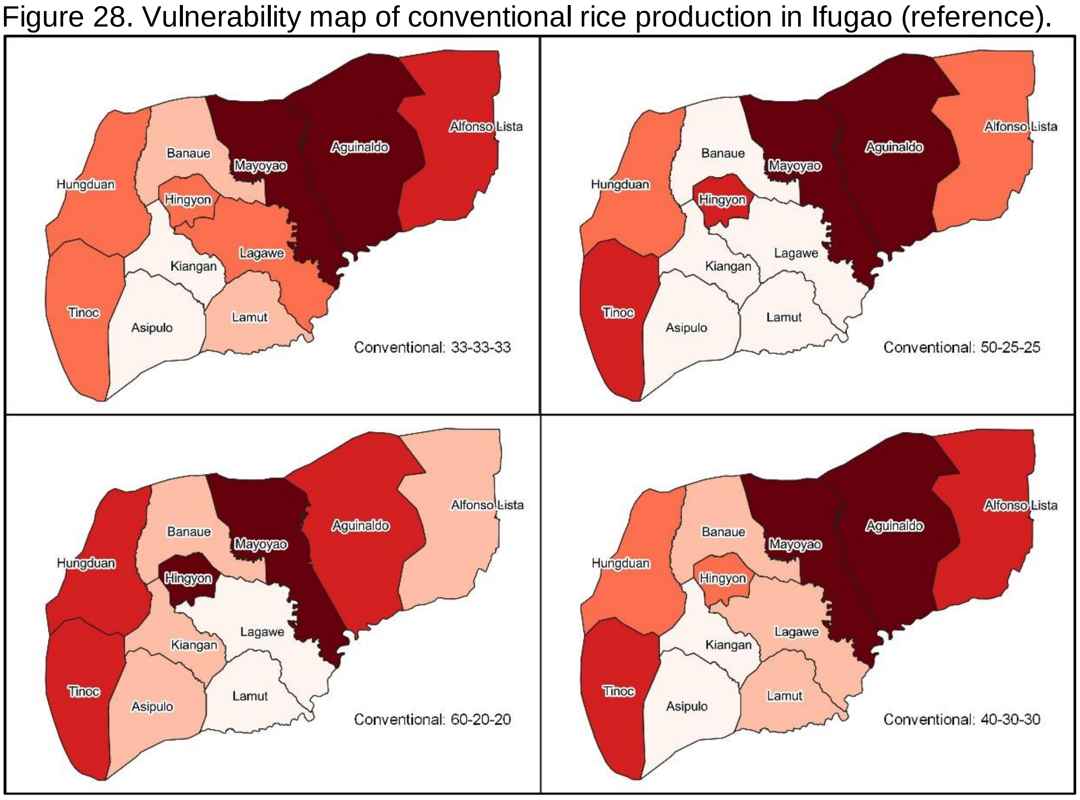

Figure 29. Vulnerability map of conventional rice production in Ifugao using different weight proportions.

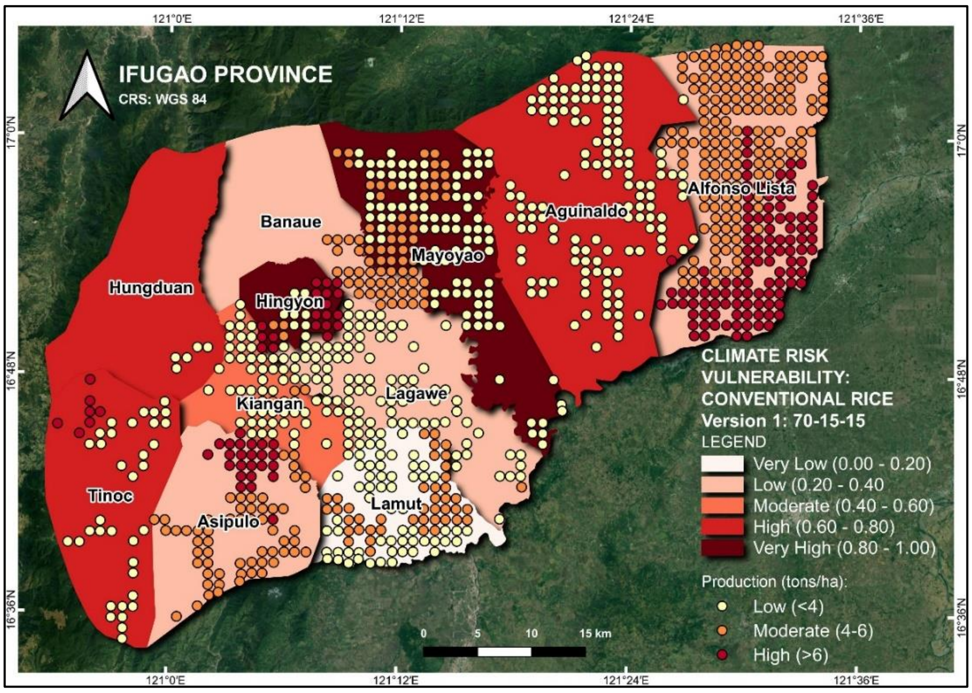

Figure 30. Crop occurrences overlaid with the corresponding CRVA reference maps.

Corn

One major economic activity in the eastern part of Ifugao is corn farming. The municipalities of Alfonso Lista and Aguinaldo are the municipalities where corn is mostly produced and harvested (Philippine Center for Postharvest Development and Mechanization, 2014). The province of Ifugao ranked first with 73,711 MT or 34% share, followed by Kalinga with 66, 720 MT or 31%, Apayao with 30,349 MT or 14%, Mountain Province with 25,133 MT (12%), Abra with 18,471 MT (9%), and Benguet with 483 MT or 0.22% share (Philippine Information Agency, 2022).

Based on the results, the municipalities of Mayoyao and Hingyon have very high vulnerability and Aguinaldo has high vulnerability (Figure 31). In comparison with other versions, Mayoyao and Aguinaldo were classified either as high or very high vulnerability (Figure 32). However, considering the production of Corn in Ifugao province, Aguinaldo was the most vulnerable municipality followed by Alfonso Lista and Lagawe (Figure 33).

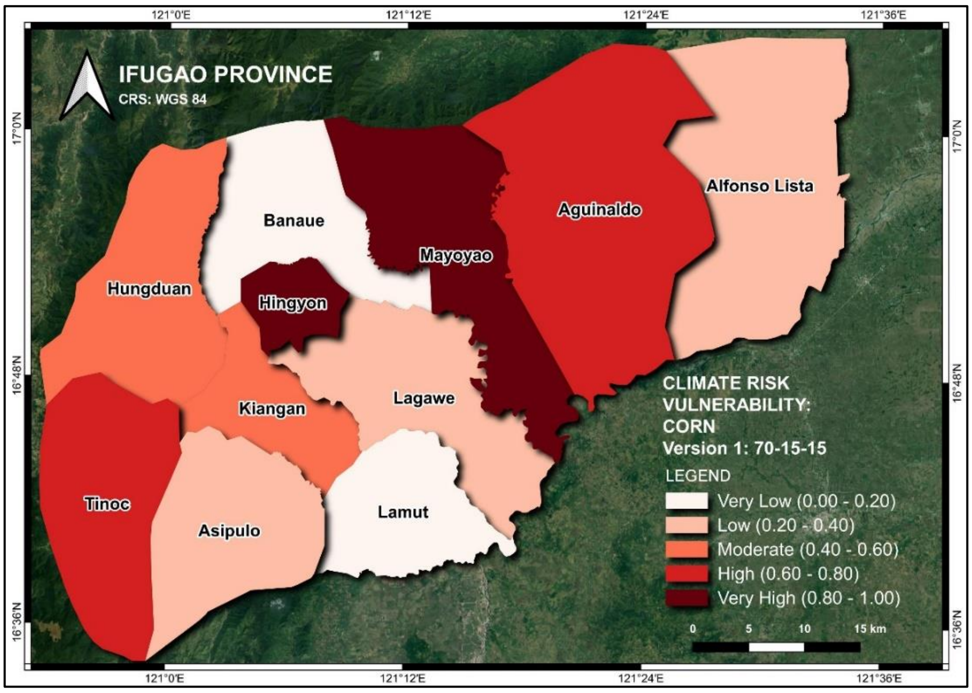

Figure 31. Vulnerability map of corn production in Ifugao (reference).

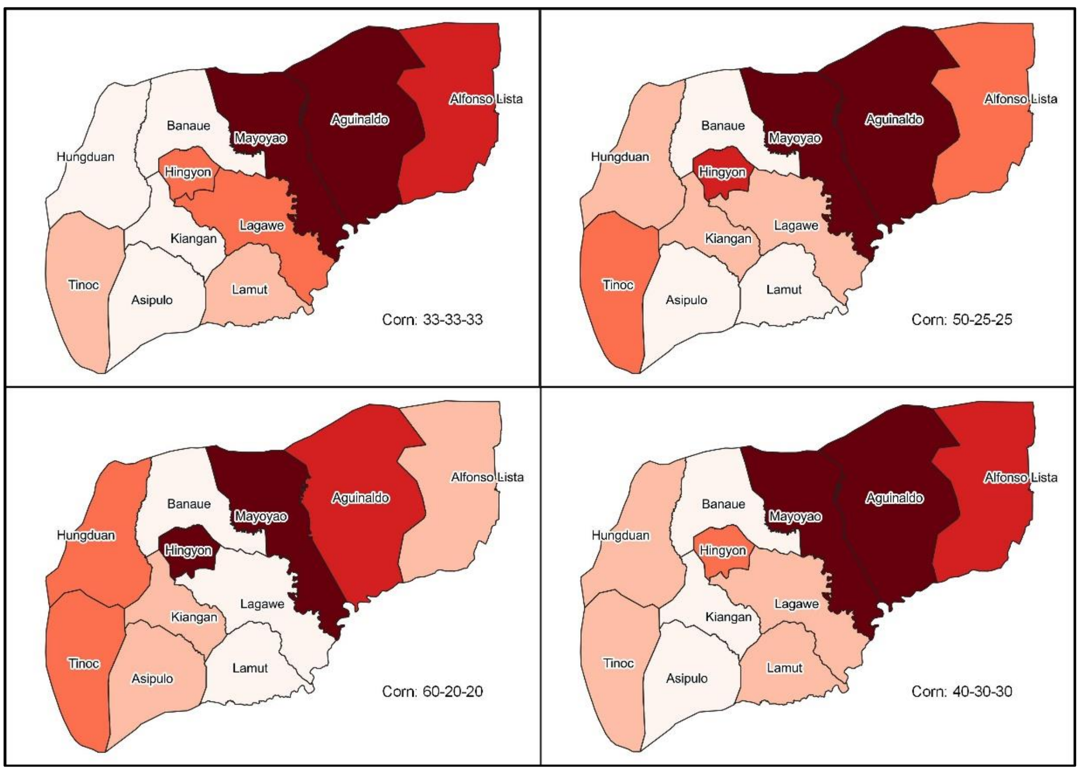

Figure 32. Vulnerability map of corn production in Ifugao using different weight proportions.

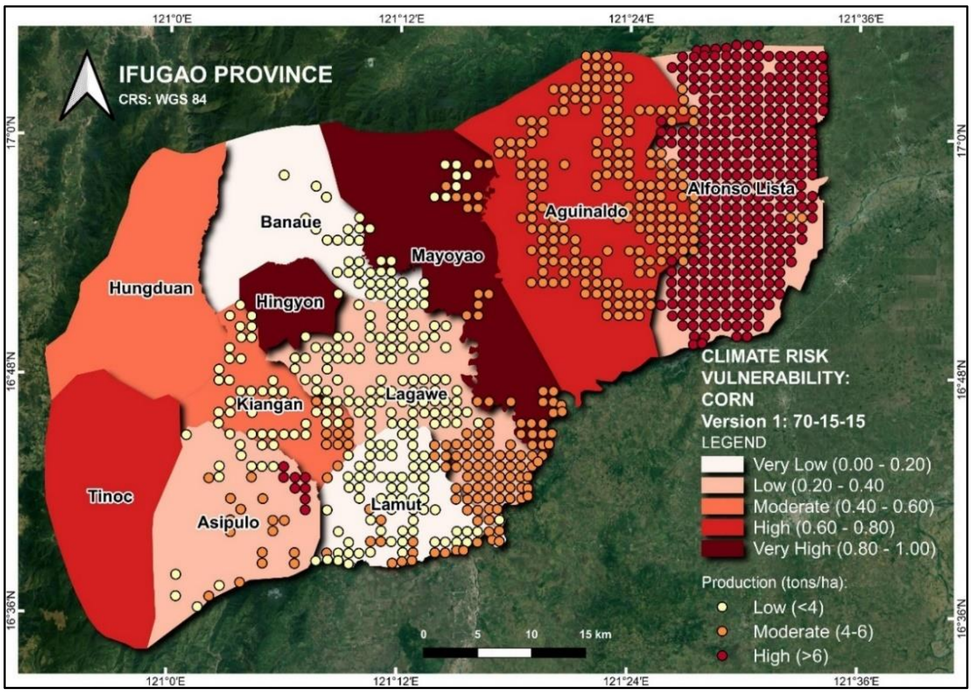

Figure 33. Crop occurrences overlaid with the corresponding CRVA reference maps.

Tomato

The major vegetables produced in the Cordillera Administrative Region include mongo, ampalaya, cabbage, eggplant, tomato, potato, onion, camote and cassava, in 2020 which amounted to 130,537.8 MT or 35.6% of the total vegetable production of the region, and Ifugao came 4th with 3.2% share (PSA, 2021).

Tinoc is the top producer of tomatoes in Ifugao province but has a high vulnerability. It was followed by the municipalities of Hingyon and Mayoyao having very high vulnerability but low production as shown in Figures 34, 35, and 36.

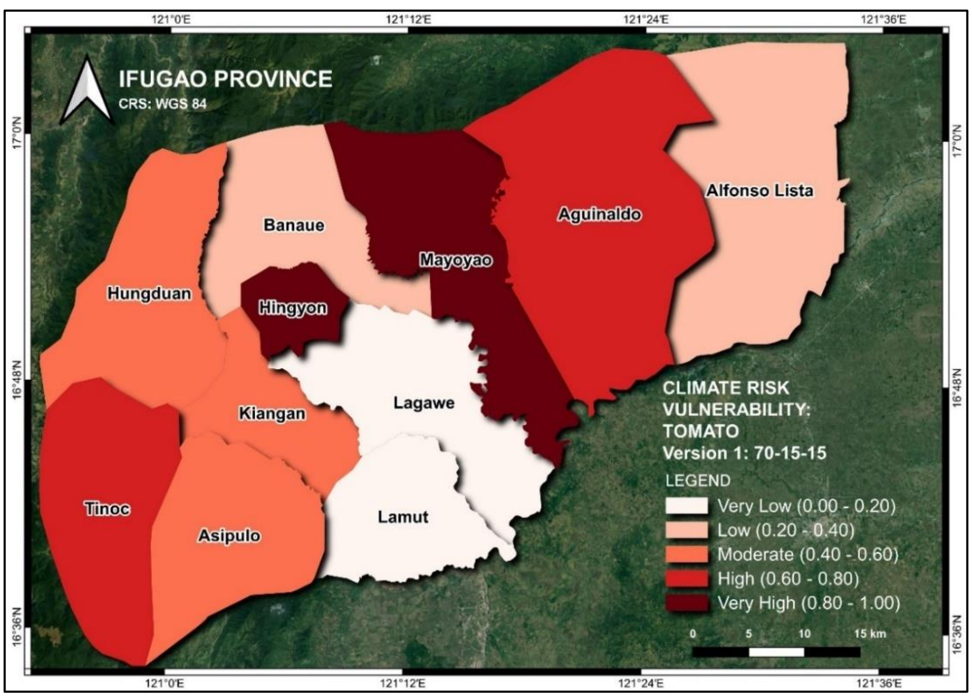

Figure 34. Vulnerability map of tomato production in Ifugao (reference).

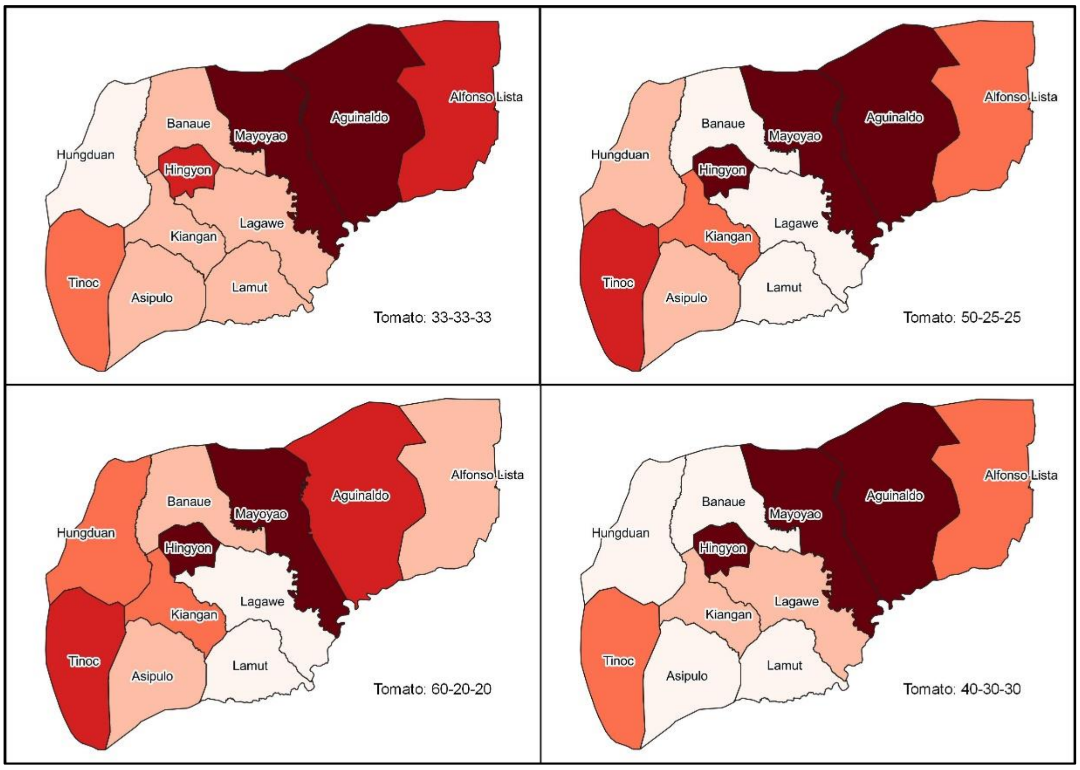

Figure 35. Vulnerability map of tomato production in Ifugao using different weight proportions.

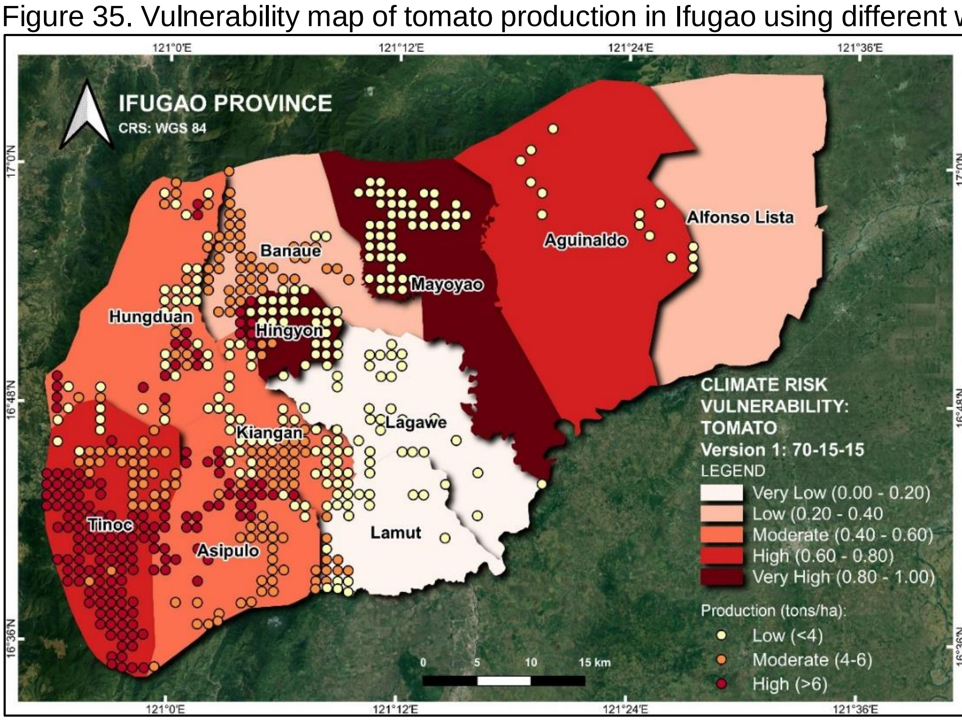

Figure 36. Crop occurrences overlaid with the corresponding CRVA reference maps.

VI. Conclusion

The potential impact of climate change on future crop yield is a major concern globally, especially in tropical countries. It has brought negative impacts to agricultural production in the Cordillera Administrative Region. This research project assessed the climate risk vulnerability of the agriculture sector, particularly rice (heirloom and conventional), corn, and tomato production in the 11 municipalities of Ifugao province through participatory mapping workshops with local experts and the use of geospatial and modeling tools. The assessment assumed that vulnerability is estimated as 70% adaptive capacity and 30% potential impact (exposure to hazards and crop sensitivity). The results of the assessment revealed the most vulnerable municipalities that need to be prioritized for climate adaptation and mitigation technological interventions.

The climatic suitability of the priority crops in Ifugao province was determined through climate and species distribution modeling. Though crop suitability in changing temperature and precipitation doesn't only mean loss in suitability, the province of Ifugao is projected to experience extreme loss in suitability for all the selected crops in almost all of its municipalities by the year 2050 under the RCP 8.5 scenario. It only means that with this projection, the reduction of rice, corn, and tomato yield is expected in the province. However, it is important to take note that a decrease in crop suitability in municipalities doesn't mean the crop will not survive.

Based on the assessment of the exposure to climate-related natural hazards, the major driving factors of the overall hazard index in Ifugao province are tropical cyclone, landslide, and soil erosion. Alfonso Lista and Aguinaldo are the most exposed to combined climate-related hazards. Similar to the result of CRVA in Apayao Province and Mountain Province (Lumbres et al., 2022 and Daipan et al., 2023), tropical cyclones, floods, and drought are predominant in lower elevations, whereas, the municipalities located in higher elevations which include Asipulo, Tinoc, Hungduan, Banaue, and Hingyon are highly exposed to landslide.

In terms of adaptive capacity, the municipality of Hingyon has the lowest adaptive capacity of almost all the capitals among the municipalities in Ifugao province which also resulted in a very low overall adaptive capacity, thus it is considered to be more vulnerable. Meanwhile, Lagawe, the provincial capital, along with Lamut and Alfonso Lista have very high adaptive capacity. This is also similar to the case of Benguet, Kalinga, and Mountain Province where the capital towns/cities have the highest overall adaptive capacity indices.

By 2050, the agriculture sector of Hingyon and Mayoyao will be the most vulnerable. However, in terms of prioritization, crop production must be considered. For instance, the CRVA of heirloom rice in Mayoyao resulted in very high but this municipality does not produce this crop. Therefore, in terms of prioritization for heirloom rice, the municipality of Hingyon was carefully chosen. For conventional rice, Hingyon, Mayoyao, and Aguinaldo have the highest vulnerability and produce conventional rice. Thus, these municipalities are considered for prioritization for this crop. Additionally, tomatoes are produced in the municipalities of Tinoc (high) and Hingyon (low to high) and are considered highly to very highly vulnerable in climate risk assessment. Furthermore, in some cases, the crop production in such municipalities was high but the CRVA was low. Similarly, corn production in Ifugao province is seen in the municipalities of Alfonso Lista (high) and Aguinaldo (moderate) but in comparison to their CRVA, Alfonso Lista resulted low while Aguinaldo is high. This result of CRVA is mainly because these municipalities were characterized by high exposure to hazards, and high sensitivity to climate change due to a decrease in crop suitability, while the adaptive capacity was low which indicates very high vulnerability. Thus, climate change adaptation and mitigation initiatives and projects of national agencies should be implemented in these municipalities to uplift their agricultural sector.

VII. Recommendation

Since it is projected that all of the selected crops will lose suitability, it is recommended to have a better cropping system adaptation by planting better-adapted varieties. Resistant crops must be developed through genomics. More research projects must be developed and funded that will focus on improving the suitability of crops to the changes in climate most especially precipitation and temperature through socially acceptable technological interventions.

The province should be encouraged to practice agroforestry farming systems, especially in the areas with steep slopes to lessen the negative impact of climate-related hazards and also promote the planting of a variety of food crops, creation of buffer zones, and the cultivation of the degraded land through reforestation and other practices. Slash and burn, as one of the agricultural practices in Ifugao, must be prevented to preserve the loss of habitat as well as global climate change effects. An improved irrigation system can also significantly help in lessening the adverse impact of drought on agricultural sectors.

In terms of adaptive capacity, the provincial LGU must prioritize municipalities with low and very low adaptive capacity the determine most especially Hingyon. Sustainable development goal and its indicators can be used as a basis for determining important projects needed in the different municipalities. National Government Agencies must fund more projects such as infrastructures, human resources development, disaster risk reduction and climate proofing and others.

Ultimately, Climate Resilient Agriculture technologies that could be identified through the Climate Resilient Agriculture component of this research program, are recommended to be implemented in the following municipalities: Hingyon and Aguinaldo for Heirloom rice, Hingyon, Mayoyao, Aguinaldo, and Alfonso Lista for conventional rice, Aguinaldo, Alfonso Lista, and Lagawe for corn, and the municipalities of Mayoyao, Hingyon, and Tinoc are recommended to be prioritized for tomato.

VIII. Impact of the Project

The results of the project are being used by Philippine Rural Development Project (PRDP), a national project under the Department of Agriculture (DA), in Provincial Commodity Investment Plan (PCIP). The PCIP is a three-year multi-sectoral development plan based on priority commodities of the province. In 2021, the DA mandated the use of CRVA results as the standard assessment and targeting tool to improve PCIPs through a memorandum. The CRVA can provide critical information to PCIP about vulnerability (hazard, adaptive capacity, and climate suitability) (DA-CRO, 2021). The results of this project, including the results of CRVA Benguet, Kalinga, Mountain Province, and Apayao can now be accessed in the PRDP Planners' Portal (https://www.daprdp-plannersportal.net/). This can serve as a basis for planning to adapt to adverse and negative impacts of climate change by various stakeholders such as local farmers, agri-based entrepreneurs, and local government units.

Additionally, Dr. Roscinto Ian C. Lumbres, the project leader, was invited by the Department of Agriculture-Climate Resilient Agriculture Office (DA-CRAO) to serve as a resource person on the Workshop on AMIA Decision Support Tools and Development Pathway. He discussed CRVA to strengthen the in-house capacity of DA in conducting/updating CRVA. This national workshop was conducted in Legazpi, Albay, Region V (Bicol) and was participated in by Adaptation and Mitigation Initiative in Agriculture (AMIA) Program Staff and Planning Officers from DA Regional Field Offices, Philippine Rural Development Program, Bureau of Soils and Water Management, and DA Disaster Risk Reduction Management Unit. The CRVA Team was also invited by DA-RFO-XII to conduct Training on Trainers (ToT) on CRVA in Region XII. It was attended by the Provincial and Municipal Local Government Units of Sultan Kudarat, Saranggani, North Cotabato, and South Cotabato, as well as the other staff from DA-RFO-XII.

Recently, Dr. Roscinto Ian C. Lumbres, the project leader, was invited by DA-PRDP Regional Project Coordination Offices (RPCO-CAR) to present the results of CRVA Mountain Province and Ifugao Province for PCIP in two separate workshops. These provincial workshops were attended by technical staff and planning officers from Local Government Units (LGUs), the Office of the Provincial Agriculturist (OPAg), and the Office of the Municipal (OMAg). Furthermore, the AMIA program of Benguet State University created four (4) Memorandum of Agreement, published one book chapter and one research article *(published in SciEnggJ, an open access journal indexed by Web of Science (ISI))*, trained numerous stakeholders on the application of Geographic Information System (GIS) in conducting CRVA.

Climate-Resilient Agriculture Practices Assessment of Major Crops in Ifugao

ABSTRACT

Climate change in the Philippines is expected to endanger food security. In the Cordillera Administrative Region (CAR), major crops such as rice, corn and tomato are widely cultivated. These crops not only contribute to the food supply but is also the main source of income for small-scale farmers. In the province of Ifugao particularly, the occurrence of typhoons and monsoon rains from May to October significantly reduce the yield resulting in low income for the farmers. Impact assessments on the vulnerability of the production system on the impact of climate change are vital in the reduction of the negative effects of climate change on the farmers. It will also facilitate the decision-making of government and non-government institutions for helping farmers through different programs and policies. Thus, further investigation is necessary on climate impacts at the farmers-level and their response, adaptation and mitigation towards climate change. The objective of the study is to assess and develop a climate-resilient agriculture platform as the basis for prioritizing climate adaptation and mitigation technological interventions for rice, corn and tomato production in Ifugao. Specifically, to characterize the value chain for major crops and identify and assess climate risks and vulnerabilities for major crops in Ifugao. The study used the methodology developed by the International Center for Tropical Agriculture (CIAT) for climate risk assessments. Secondary data and information were gathered through desk review and primary data were gathered through focus group discussions (FGDs), key informant interviews (KIIs), field observation and photo documentation. Structured workshop templates and questionnaires were also used. The chosen crops and study sites were identified by the Department of Agriculture – Regional Field Office – Cordillera Administrative Region (DA-RFO-CAR).

Results revealed that corn and tomato production volume in Ifugao increased from 2012 to 2021 due to an increase in the area of production. On the other hand, rice production decreased by 32.92 percent from 2012 to 2021. This decrease was due to the El Niño phenomenon and the occurrence of typhoons. In terms of farming systems practiced, monocropping was predominantly practiced for rice, corn and tomato at different cropping calendars. Farmers, laborers, farm suppliers and traders/buyers are the main value chain actors involved from the provision of farm inputs to product marketing. Activities such as land preparation, planting, crop maintenance, harvest and post-harvest activities were commonly done in the value chain of rice, corn and tomato. The common climatic hazards observed for rice, corn and tomato were typhoons, monsoon rains and drought. These climatic hazards were observed by the farmers to be more unpredictable and noticeably prolonged. As a result, severe to major consequences were observed during the acquisition of farm inputs and on-farm production. The underlying factors that exacerbated these climatic impacts were limited government support, poor road conditions and insufficient or poor irrigation systems. On the involvement of men and women in the production process, men generally had high to very high involvement, women had a medium to very high involvement, youth had medium to high involvement, while children had low to no involvement. As to farmers' priority adaptations on

rice production, the use of drought and cold-tolerant varieties and planting of alternative crops were identified with a 60-100% adoption rate. Furthermore, during typhoons, construction, maintenance and clearing of canals and drainages, control of irrigation water and application of pesticides are the priority adaptations with 60-100% adoption rate. For corn and tomato, use of crop insurance, delayed planting and use of appropriate seeds were the adaptation options identified for drought and typhoons (60-100% adoption rate). However, not all adaptation options are practiced by rice, corn, and tomato farmers due to financial (high cost of adoption, high interest rate on credit, long payback period), technical (lack of human and technical capacity), behavioral (conflict of beliefs), informational (low awareness), and institutional factors (lack of institutional support, regulatory framework and weak linkage within government).

I. Rationale

The Philippines is highly vulnerable to climate change. The impacts are expected to be more severe with the continuing rise in global temperature and sea level. The changing pattern of climate has resulted in stronger typhoons, brought more heavy rains, increased flooding, and prolonged drought in many agricultural production areas in the Philippines. As a result, the country is exposed to several climate risks such as reduced crop yield due to heat stress, increased incidence of pests, need for irrigation, reduced soil fertility, increased demand for imports and others.

Climate change highly endangers food security. It has a greater impact on agriculture since it is the source of income of a large part of the population. Rice farmers compose the majority of farm producers thus, they are the most economically strained due to climate change. In the Cordillera Administrative Region (CAR), there are approximately 131,305 rice farms distributed over a total of 192,278 hectares of arable land (PSA, 2002). Corn is considered the second most important cereal crop with a production of 8.30 million metric tons in 2021. Seventy-three percent of which is contributed by yellow corn while the remaining 27.00 percent is from white corn. Likewise, tomato is ranked as the 4th most important vegetable in the country together with sweetpotato, eggplant and onions. Tomato production contributes about 7.50 percent (or 222,002.24 MT) of the total volume of production of vegetables in the country, 1.39 percent of which is produced by CAR. The average tomato yield per hectare in CAR is 10.17 metric tons per hectare, which is 24.67 percent lower than the national average yield of 13.50 metric tons per hectare. Tomato production was observed to decrease in CAR by 2.41 percent in 2020 (DA-BAR, 2022), which may be due to weather extremes such as high temperature, prolonged drought and typhoons. Tomato is usually adapted to a wide range of climatic conditions but very sensitive to water logging, commonly observed during the wet season. Therefore, it requires well-drained soil or elevated farm areas with good drainage (DA-RFO2, 2017).

Typhoon and monsoon rains in Ifugao usually occur from May to October with 3 to 5 typhoons occurring annually. The occurrence of strong rains coincides with the planting or harvesting of these priority crops resulting in the reduction of yield and consequently farmer income. Moreover, the frequency and volume of rainfall generally increased and attributed to climate change. With the projected changes in precipitation, temperature and drought, it is critical to assess the vulnerability of various production systems (PAGASA, 2011) to introduce new or strengthen existing climate-smart or adaptation techniques. Such adaptation techniques may cushion the impacts of climate change or hazards.

The vulnerability of a production system may be determined through impact assessments using various tools involving focus group discussions, key informant interviews and others. Impact assessments help to determine adaptation and mitigation measures to reduce the vulnerability of a production system to climate hazards. Reducing vulnerability also means reducing the risk of financial loss for farmers. Furthermore, information from impact assessments may increase awareness of government and non-government institutions and direct their resources to help farmers develop climate-smart technologies or infrastructures. Policies toward supporting climate-smart technologies will go a long way in preventing the loss of farm income.

Hence, it is time to study further the micro-level or farmers-level evidence of climate change impacts and how the agriculture sector responds and initiates adaptation and mitigation mechanisms and/or activities.

II. Review of Literature

Crop Production in CAR

In 2021, CAR ranked 15th with 377,133.35 metric tons, harvested from a total area of 101,555.75 hectares, or equivalent to 1.89 percent share of the national rice production. Rice production increased by 0.18 percent as compared to 2020 production of 376,473.48 metric tons. Meanwhile, the production area for rice decreased by 0.98 percent from 102,532.19 hectares in 2020. Of the CAR's total rice production in 2021, 79.31 percent came from irrigated areas and the remaining 20.69 percent came from rainfed areas. Among the provinces of CAR, Kalinga remained the top producer with 122,959.34 metric tons or 32.60 percent of CAR's total rice production in 2021. This was followed by Abra with 23.98 percent share (90,434.39 MT), Apayao with 21.87 percent share (82,468.92 MT), Ifugao with 11.11 percent share (41,902.46 MT), and Benguet with 6.28 percent share (23667.00 MT). Meanwhile, Mt. Province contributed the least at 4.16 percent (15,701.24 MT).

CAR produced 216,066.47 metric tons, harvested from a total area of 60,342.26 hectares, or 2.35 percent share of the national corn production in 2021. Corn production decreased by 11.65 percent as compared to 2020 production of 244,550.47 metric tons. Likewise, the production area for corn decreased by 4.55 percent from 63,221.00 hectares in 2020. Of the CAR's total corn production in 2021, yellow corn accounted for 91.50 percent and the remaining 8.50 percent is the production of white corn. The highest-producing province of corn is Ifugao which contributed 73,711.39 metric tons or 34.12 percent of CAR's total corn production in 2021. It was followed by Kalinga with 30.91 percent share (66,786.67 MT); Apayao with 14.60 percent share (31,555.12 MT); Mt. Province with 11.60 percent share (25,055.75 MT); Abra with 8.55 percent share (18,471.00 MT), and lastly by Benguet with 0.23 percent share (486.54 MT).

In CAR, there are approximately 2,871.30 tomato farms distributed over a total of 287.54 hectares of arable land in 2021, Benguet recorded the highest production among the provinces. It contributed 57.14 percent (1,640.62 MT) of CAR's total tomato production. This was followed by Mt. Province with 18.62 percent share (534.73 MT), Abra with 15.66 percent share (449.76 MT), Ifugao with 6.39 percent share (133.44 MT), Kalinga with 1.78 percent share (51.01 MT), and Apayao with 0.41 percent share (11.67 MT).

Effects of Climate Variabilities and Hazards on Crops Production

Climate variability and hazards have a wide range of impacts on crop production. Occurrences and fluctuations of climate variability and hazards especially at critical crop growth stages could significantly hamper crop growth and development which result in crop yield reduction (Lansigan et. al, 1997). Thus, climate hazards are a threat to food production.

Tropical cyclones (typhoons) and droughts are among the key climate-related hazards (Giles et al., 2019). Tropical cyclones, usually characterized by strong winds and heavy rainfall disrupt the activities of farmers and are destructive to crops. The damage to crops may range from negligible to total wipeout depending on the intensity and duration of the typhoon as well as the prevailing crop growth stage during its occurrence (Lansigan et. al, 1997). Heavy rains brought by typhoons also result in soil erosion and landslides, destroying planting areas and blocking farm-to-market roads (Supangco et. al, 2022).

Drought and changes in the usual pattern of dry and wet season remains by far the most important constraints to crop production especially in upland areas and for rainfed production. Scarcity of water during early crop development may result in seedling mortality, retarded development and reduced yield. High temperatures during the flowering stage can reduce pollen viability and grain set in cereals and grain crops like rice and corn.

III. Objectives

The general objective is to assess and develop a climate-resilient agriculture platform as the basis for prioritizing climate adaptation and mitigation technological interventions for rice, corn and tomato production in Ifugao.

Specifically, the study aims to accomplish the following objectives:

1. Characterize the value chain for major crops in Ifugao in terms of:
    a. Production profile
    b. Farming system
    c. Value chain key actors and activities

2. Identify and assess climate risks and vulnerabilities for major crops in Ifugao in terms of:
    a. Consequences
    b. Underlying factors
    c. Adaptation options
    d. Farmers' priority adaptations
    e. Barriers for adoption

IV. Procedure/Methodology

Time and Location of the Study

The study started March 7, 2022 and ended on March 6, 2023 and was conducted in the municipalities of Aguinaldo, Alfonso Lista, Asipulo, Hungduan, Lagawe, Lamut, and Tinoc, Ifugao.

Methodology

The study used both primary and secondary data. Desk reviews were done to gather secondary data and information regarding the identification of target crops and study sites. Primary data were gathered through focus group discussions (FGDs), key informant interviews (KIIs), field observation and photo documentation.

The crops chosen for the study were those identified as priority crops by the Department of Agriculture - Regional Field Office - Cordillera Administrative Region (DA-RFO-CAR), and of which is based on the volume and area of production. The study sites were selected based on their crop production, gathered from the Philippine Statistics Authority (PSA), DA-RFO-CAR, and the provincial and municipal agricultural offices. During the field activities, the priority crops identified were verified in the study sites based on their crop production.

Courtesy calls and reconnaissance meetings were first conducted with the Office of the Provincial Agriculturist (OPAG), the Offices of the Municipal Agriculturist (OMAG) and some barangay officials then followed by the focus group discussions and key informant interviews with farmers and local officials. Structured workshop templates and questionnaires were used.

The respondents came from the 7 municipalities of Ifugao. The respondents were selected through convenience sampling from each municipality.

The tool used for the climate risk assessment for agriculture was adapted from the methodology developed by the International Center for Tropical Agriculture (CIAT) (Figure 37). Structured workshop template and questionnaires were used that includes the following indicators and parameters collected through desk reviews, FGD and KII:

1. Agriculture context
    a. People and livelihoods (gender-specific variables): demographics (current and trend; specific emphasis on rural populations); economic and social prosperity

(poverty, access to basic needs - water and electricity, education, etc.); food security and nutrition

b. Agriculture activities: land use, farm size and title deeds; agriculture jobs and incomes; agricultural input use (water/irrigation, fertilizer, pesticides)
c. Key value chain commodities: identification and description of key value chain commodities relevant for food security and national and country economy
d. Challenges for the agriculture sector: outlining the key challenges for the agricultural sector in the county

2. Climate vulnerabilities
   a. Past Climate Change and variability of the agricultural sector
   b. Farmers´ perceptions of Climate Change and related risks
   c. Future projected changes (with some discussion on uncertainty)
   d. Climate vulnerabilities per commodity (across major value chains)
3. Adaptation options/interventions
   a. Current interventions, programs and policies
   b. Gaps in current adaptation options and needed interventions, programs and policies (conceptually mapped to specific vulnerabilities in the major commodities)
4. Institutional resources and capacity to implement adaptation strategies
   a. Types of institutions engaged in facilitating the implementation of adaptation strategies
   b. Resources and capacity to tackle climate change aspects, to deliver services (extension, insurance, financial services, etc.) and to execute (staffing, planning, implementation, financial management)
   c. Intra- and inter-institutional coordination for effective management
   d. Gaps in institutional management and governance to support the implementation of adaptation strategies

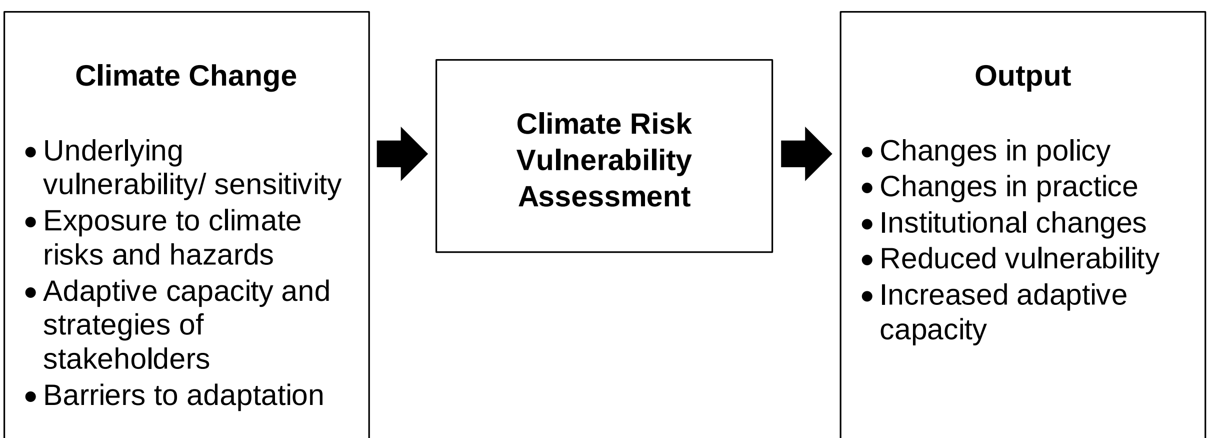

Figure 37. Conceptual framework of the study.

V. Results and Discussion

Characterization of the Value Chain for Major Crops

Production Profile

Rice

Ifugao's rice production decreased by 32.92 percent from 62,465.00 metric tons in 2012 to 41,902.46 metric tons in 2021 (Figure 38). The decrease in the volume of production in 2016 is attributed to the effects of drought or the El Niño phenomenon in the first quarter and typhoons "Karen" and "Lawin" in the fourth quarter. In recent years, heavy and prolonged monsoon rains worsen the decrease in crop yields. The southwest monsoon (Habagat) in the third quarter of 2018 enhanced by typhoons "Henry", "Inday" and "Jose" cost rice production damages and losses (NDRRMC, 2018). Followed by typhoons "Ompong" and "Rosita" in the fourth quarter thus incurring further damages on production.

The production in 2019 is adversely affected by El Niño in the first to third quarter of the year. Late onset of the rainy season, early termination of the rainy season, weak monsoon events characterized by isolated heavy rainfall events of short duration, and weak tropical cyclone activity characterized by less intense cyclones and less number of tropical cyclones occurring within the Philippine Area of Responsibility are usually the results of El Niño (Lansigan et. al, 1997). Typhoons "Ambo", "Pepito" and "Ulysses" affected the production in 2020 while heavy rains and flashfloods in 2021 (PAGASA, 2023).

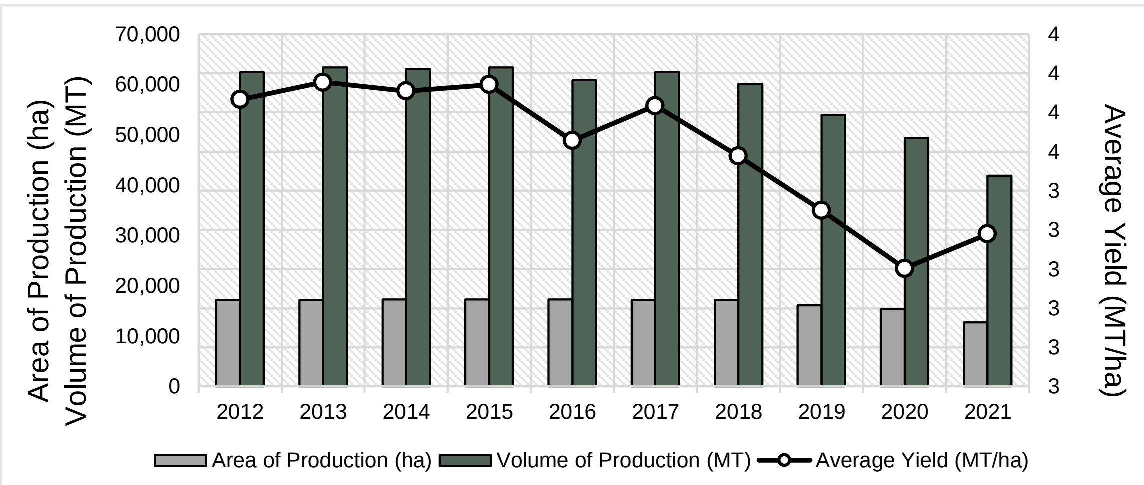

Figure 38. Annual production and harvested area of rice in Ifugao (Source: PSA, 2018 & 2023).

Corn

Corn is a crop that ideally grows in an area with distinct wet and dry seasons. Climate impacts on corn production are due to the changing temperature and precipitation regimes. The largest impact of these changes becomes more noticeable at the local scale where within-season weather is induced by the change in climate. On the other hand, changes in weather patterns due to climate change also posed a threat to corn production especially those that are open-pollinated.

Generally, the corn production trend in the province of Ifugao is relative to the minor increase in harvested area or area devoted to corn production that may directly affect the increase in the yield produced for the last ten years (Figure 39). The higher production was in 2014 of 119,409.00 metric tons in an area of 30,114.00 hectares while the lowest production in 2021 is 73,711.39 metric tons when the area of production was reduced by 20.97 percent (23,798.01 ha).

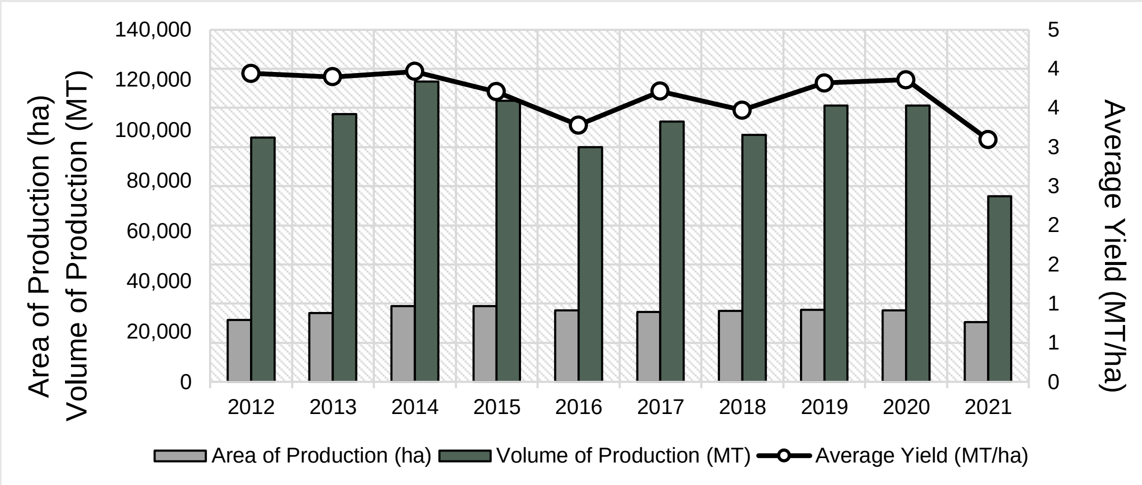

Figure 40. Annual production and harvested area of corn in Ifugao (Source: PSA, 2018 & 2023).

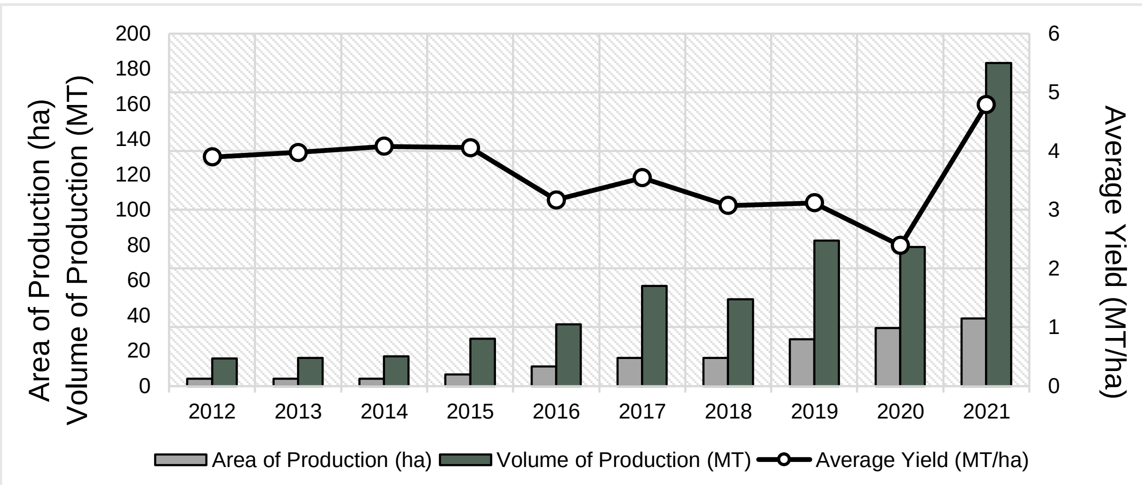

Figure 39. Annual production and harvested area of tomato in Ifugao (Source: PSA, 2018 & 2023).

Tomato

The tomato production in Ifugao increased to approximately 167.84 metric tons from 2012 to 2021 (Figure 40). The increase in the volume of production is due to the increase in the area of production from approximately 4.00 to 38.31 hectares within the last 10 years. Sloping areas that were not cultivated in the past have been increasingly used for tomato production. Tomato is preferred by farmers as an additional source of income due to its increasing demand in the market.

Farming System and Planting Calendar

Rice

The rice farming system adopted in Ifugao is predominantly monocropping (Figure 41) where farmers plant twice a year. For some farmers who practice crop rotation, rice is planted once a year. Some farmers plant rice as the main crop (wet season) and interchange it with corn during the dry season. Some farmers of Alfonso Lista, Lagawe and Lamut also practice monocropping with border crops such as string beans, winged beans, onions, etc. Farmers with wider fields plant rice and corn at the same time (multiple cropping systems). A portion of their field is allotted for rice and another portion for corn. Their rice produce is mainly used for household consumption.

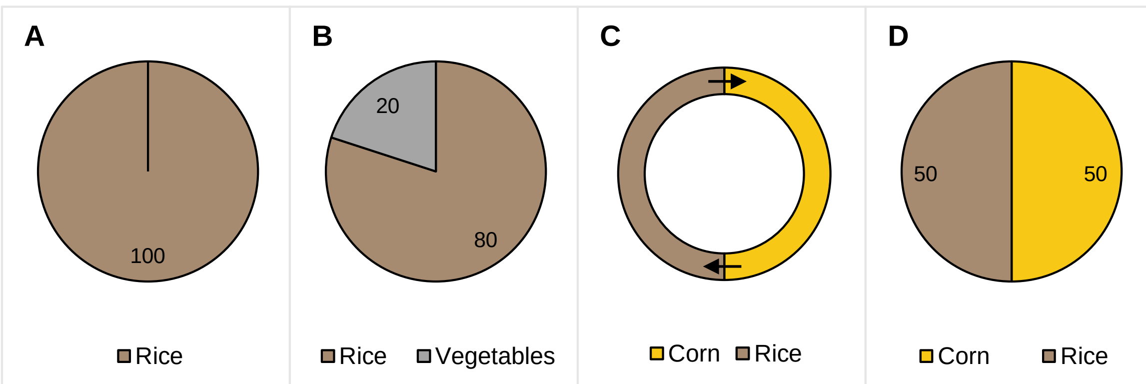

Figure 41. Proportion of rice in a (A) monocropping system; (B) monocropping system+ border crops; (C) crop rotation scheme; and (D) multiple cropping system.

The rice first cropping is usually planted in June and then harvested from September to October, while the second cropping is planted in January and harvested from April to May for irrigated rice areas. For the rainfed producing areas, their first cropping is planted in May and harvested from August to September while their second cropping is planted as early as November and harvested from February to March.

Corn

The top three municipalities growing corn in Ifugao are Alfonso Lista, Aguinaldo and Lamut. The corn farmers practice four cropping systems (Figure 42) as mentioned in the conducted FGDs. The farming adopted for corn growing is either as a sole or monocrop. Aside from monocropping, the municipality of Aguinaldo incorporates border crops while crop rotation is practiced in Lamut.

As a monocrop in Alfonso Lista, the first cropping starts in May and is harvested in October. Immediately after harvest, the second crop is planted in November for harvest in April. Generally, for monocropped corn, farm operation is manual and partly mechanized and dependent on the use of synthetic chemicals and fertilizers.

An estimated five percent of the area is planted with vegetable crops serving as border crops surrounding the corn plants. The vegetables usually planted include herbs such as squash, eggplant, okra and yardlong bean. Others are planting shrubs and the most common is "katuray" or *Sesbania grandiflora* whose flowers can be harvested for vegetable and for shade.

In the municipality of Lamut where crop rotation is practiced, rice is rotated to corn which is planted in June and harvested in October followed by corn planted in November and harvested in April.

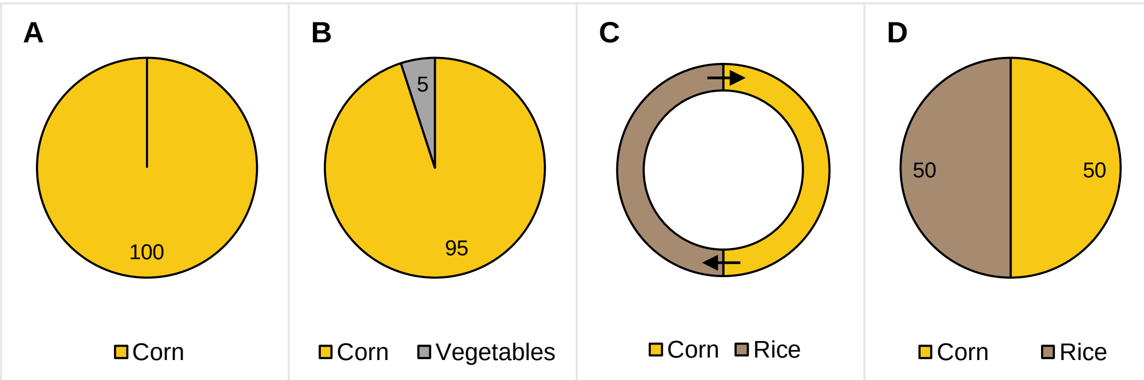

Figure 42. Proportion of corn in a (A) monocropping system; (B) monocropping system+ border crops; (C) crop rotation scheme; and (D) multiple cropping system.

Tomato

Monocropping and crop rotation systems are primarily practiced by tomato farmers in Ifugao (Figure 43). In a monocropping system, tomatoes may be planted at various times of the year from January to May, April to August, September to January, or October to February. Vegetables such as beans, onions, pepper, okra, and eggplant may also be planted on the borders of the farm or rotated with tomato. There are three crop rotation schemes used where tomato is planted either once or twice a year. Farmers observed that there is lesser pest infestation when tomato is planted or rotated with other types of vegetables.

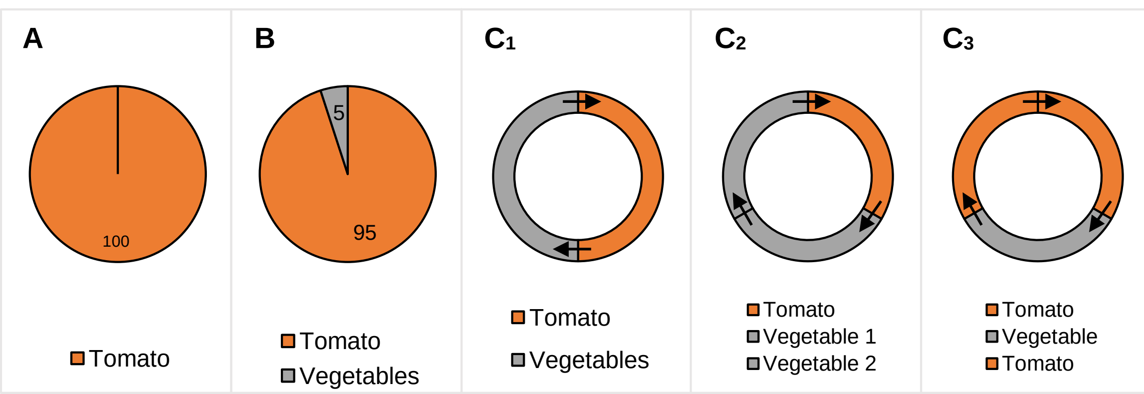

Figure 43. Proportion of tomato in a (A) monocropping system; (B) monocropping system+ border crops; and (C1-C3) crop rotation scheme.

Value Chain Key Actors and Activities

Rice

The different activities involved in the production and marketing of rice in Ifugao are as follows (Figure 44):

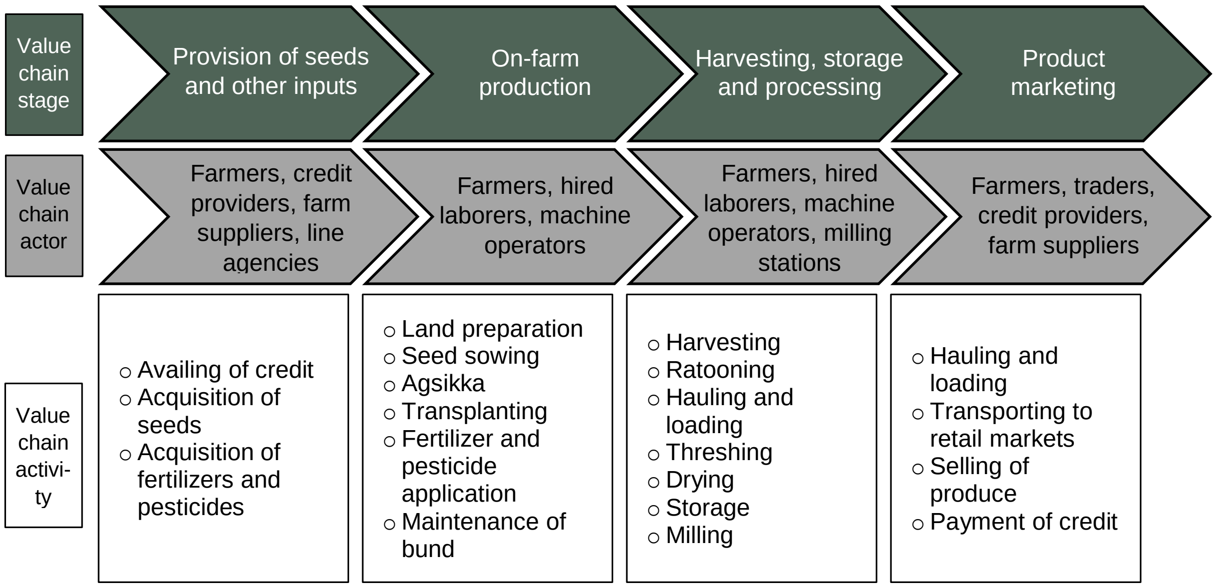

Figure 44. Value chain stages, actors and activities of rice production in Ifugao.

Stage A (Provision of seeds and other inputs). All rice farmers from the focus group discussion and key informant interview acquire seeds from agricultural farm supply/stores in addition to the seeds given by the Department of Agriculture. Some farmers with less income apply for a loan from cooperatives, private individuals, etc. to purchase seeds and other farm inputs such as fertilizers and pesticides.

Stage B (On-farm production). Seedbed preparation and land preparation starts with land clearing, which is done manually or through the application of herbicides. Land preparation is done in the field once irrigation water is introduced on the farm. Primary and secondary tillage operations are done manually or through the use of hired rotavator, tractors, animal-droned farm implements, etc.

The majority of the farmers employ seed sowing than direct seeding and they mostly hire laborers, mostly women, to uproot the rice seedlings (agsikka) and in transplanting rice seedlings (agraep) after 18-21 days upon sowing. Fertilizers are applied twice, first during the seedling stage (7 days after sowing: basal application) and second during the early vegetative stage (30 days after transplanting: top dress application). Maintaining and clearing of bunds through manual weeding or with the use of a grass cutter is done every time field irrigation is done for better flow of water and sanitation. For pest management, farmers apply insecticides (50 days after transplanting and 70 days after transplanting), fungicides (15 days after transplanting and 35 days after transplanting) and molluscicides (3 days after transplanting) or as necessary. Irrigating is done weekly as possible or as necessary, especially during the booting stage.

Stage C (Harvesting, storage and processing). Harvesting is done when rice is fully matured with the use of a combine harvester or in other areas, they still employ hired laborers for manual harvesting. Some farmers practice ratooning, cutting the rice plant leaving only about 1.00-1.50 feet from the soil. This would provide farmers with another harvest. Farmers thresh and then dry their rice grains on a flat surface under the sun locally called "solar drying" intended for household consumption. Storing and milling of produce after sun drying is done for food consumption.

Stage D (Product marketing). Rice is being sold in fresh and/or dried weight. Straight buying (by traders) is common in the province where buyers directly buy rice right at the farmer's field. All these activities are done by the farmer, hired laborers or contract workers.

Corn

Four major value chains were identified for corn production: (a) acquisition of inputs, (b) on-farm production management practices, (c) harvesting, storage and processing and (d) product marketing (Figure 45).

Stage A (Provision of seeds and other inputs). From the focus group discussions and key informant interviews, most of the 31 farmer participants acquire corn seeds from agricultural farm supply outlets. The most preferred variety is NK 6410, Dekalb, and Pioneer. Other farmers use "labus" which is the local term for farmers' seeds. Despite the additional corn seeds provided by the Department of Agriculture, some farmers seek credit to purchase seeds and other farm inputs such as fertilizers, herbicides and pesticides. The farmers who resorted to acquiring credit are those who had low production from the previous cropping and those financially challenged - with less or no capital. Farmers who don't own land and those with less land for cultivation lease land from other individuals.

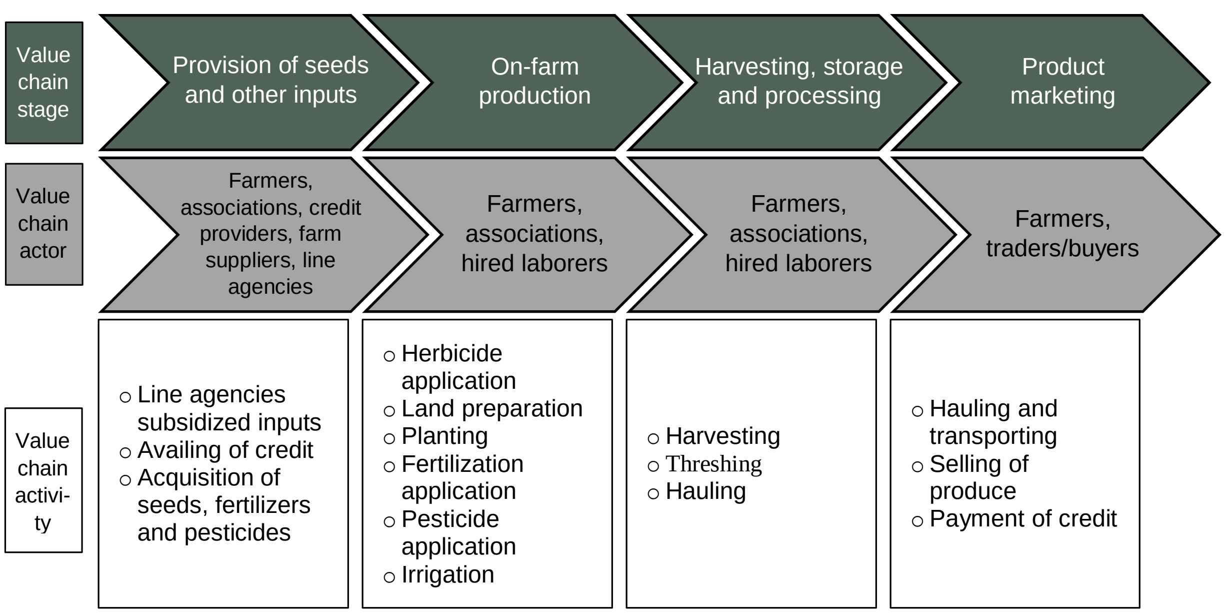

Figure 45. Value chain stages, actors and activities of corn production in Ifugao.

Stage B (On-farm production). Cleaning, harrowing and furrowing are done before planting. Some farmers with wider production areas hire additional laborers to augment family labor. Rental tractors and harrowing machines are common during land preparation.

Farmers in sloping areas employ manual sowing until harvesting while some farmers in flat areas can mechanize sowing with the use of seeders to accelerate their planting activities. During seed planting, men, women, hired laborers and the youth are engaged.

For fertilizer management, sidedressing at 15 days after planting and topdressing at 35 to 40 days after planting is done. 2 bags of complete fertilizers each bag (50kls) cost 2,200 php and 2 bags of urea fertilizers 2,500 php (50kls) each bag was applied every cropping in their crops. Fertilizer application is done by men and women either family or employed laborers.

Corn farming is dependent on rainfed irrigation and is done by men and women in the family while others may hire men laborers. Farmers adopt delayed planting until the onset of rain and prepare quality seeds during that season.

The first crop is planted from May to June where the seeds are planted along the canals of the 'eras' where water is more available for better chances of survival. Harvest time for the first cropping is in September and October. The second crop is planted from November to December and this time the seeds are planted in between the hills to avoid rotting. Harvest for the second crop is in March to April.

Stage C (Harvesting, storage and processing). This value chain includes activities on harvesting, threshing, hauling, transporting and sundrying.

During harvest, farmer prefers to dry their corn before harvesting so that they can immediately sell their produce to the traders and avoid drying along pavements or highways. When corn is mature in the field it has approximately 30% moisture (water). Farmers let corn dry in the field for as long as possible and will ideally harvest when the moisture level is 23 to 25% or lower. At this moisture level, kernels shell easily and stalks generally stand better making harvest more efficient.

Corn farmers are aware that the crops have to attain maturity before harvesting and are even mindful of the state of the drying to shorten the drying time before selling, especially during the rainy season. Farmers harvest their corn at 120 days after planting where most of them employ combine harvesters while some do manual harvesting. Some farmers hire combine harvester operators who are responsible for harvesting and bagging the produce. In manual harvesting, women, youth and children are involved in picking, bagging and collecting the corn ears until threshing. The corn ears are collected in sacks. Mechanical threshing is done to separate the kernels from the cobs and husks. The kernels are packed in sacks. Harvesting and threshing are done by men, women and youth of the family. Hired laborers may be men or women. Manual harvesting and threshing are done by the farmers especially in sloping areas while combine harvester is used by the farmers in flat or accessible areas.

The corn grains are hauled near the roadway and covered with tarps for protection. The harvest is also easier to transport to the market this way. Others dispose of their produce to direct buyers. Hauling is done by the farmer, hired laborers and traders which is male-dominated.

During drying, corn grains are generally spread on cemented pavements or roadways and covered with tarpaulin or canvas to cover the seeds during downpours or for aeration. Other farmers keep three to five bags as feeds for their animals.

Stage D (Product marketing). Dried corn grains are sold within Ifugao and in the neighboring province of Isabela. All these activities are done by the farmer, hired laborers or contract workers. Marketing is mostly done by women.

The farmers usually pay their credit to banks, cooperatives or individual creditors when their produce is sold. These credit providers are located within Ifugao and from Isabela.

Tomato

Stage A (*Provision of seeds and other inputs*). Seeds and other inputs are primarily purchased by farmers from farm supply stores in La Trinidad and Nueva Vizcaya using their income from the previous cropping (Figure 46). The Department of Agriculture occasionally helps farmers through donation of tomato seeds for the current or next cropping season. Farmers with lesser income or capital opted to apply for a loan from crediting agencies despite of high-interest rates. Some disposers also supply the needed inputs on loan and paid after harvesting and marketing of tomatoes.

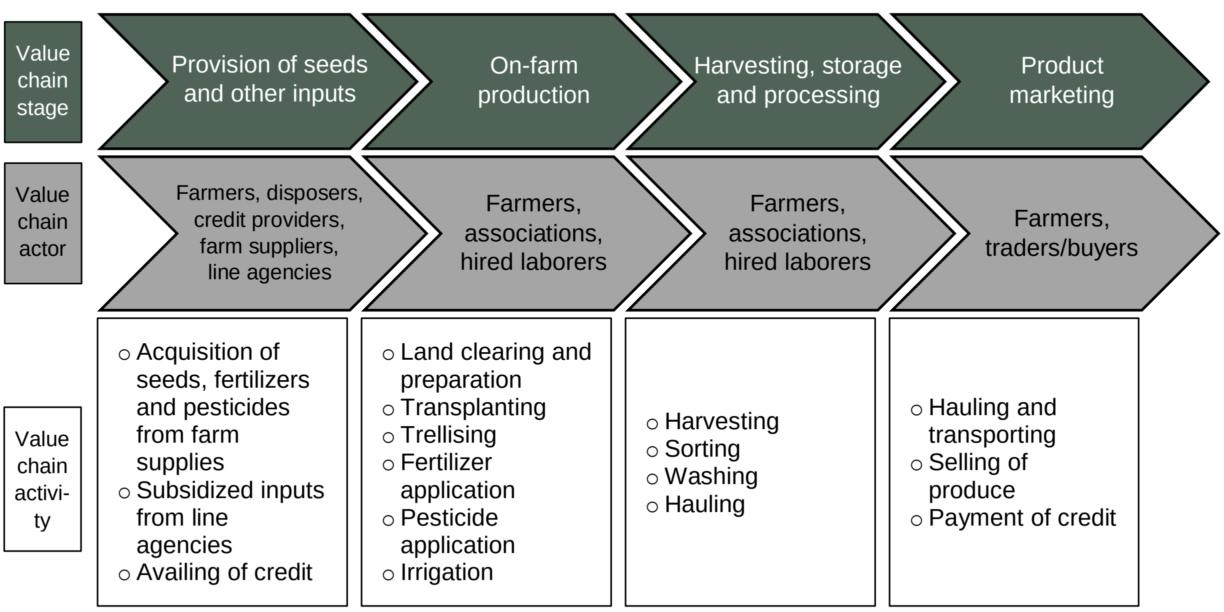

Figure 46. Value chain stages, actors and activities for tomato production in Ifugao.

Stage B (*On-farm production*). Land clearing is conveniently done through the application of herbicides. Tillage operations and basal application of chicken dung are done subsequently one week before transplanting of 20-day-old tomato seedlings. Farmers then prepare bamboo sticks for trellising two weeks after transplanting. Bamboo sticks are either collected from neighboring areas or bought from other municipalities (Kiangan or Lamut) within Ifugao. Land preparation to transplanting seedlings is done through an 'ug-ugbo or bayanihan' system where neighboring farmers help each other in exchange for free labor. Some farmers, however, offer their services for hire to other farmers during land preparation, harvesting and postharvest stages.

Organic or inorganic fertilizers are sidedressed 30-35 days from transplanting. Manual weeding is done as needed whereas herbicide application is done twice during the cropping season in wider farm areas. The common irrigation systems used are "rainburst" application from an identified water source during the dry season and rainwater collection and distribution during the wet season.

Stage C (*Harvesting, storage and processing)*. Mature tomatoes can be harvested up to 20 times in one cropping season notwithstanding the occurrence of typhoons and/or pest infestation. However, tomatoes can be harvested between 7-9 times only when rainfall is continuous or pest infestation has occurred. The "bayanihan" system is again practiced during manual harvesting, hauling and sorting of tomatoes.

Stage D (*Product marketing).* Packed tomatoes are transported and marketed either in the La Trinidad trading post or Nueva Vizcaya markets with the aid of disposers.

Assessment of Hazard and Climate Change Sensitivity

Identification of Climate Hazards

Rice

Rice farmers perceive that the weather nowadays has become more unpredictable, both wet and dry seasons are noticeably prolonged. Three to five typhoons and longer monsoon season which brings strong wind, heavy rains, flooding, soil erosion and landslides occur in their area during unexpected times mostly from June to October (Figure 47). As they were unprepared and had no way to combat such hazards, their rice production is negatively impacted (Table 5). It reduces farm productivity by damaging farm inputs, and affects the growth and development of rice plants and grain yield. It delays farm activities which also affects the source of income of farm laborers. Soil erosion and landslides also occur on the roads and mountainsides.

Some farmers also witnessed and experienced an increase in temperature, prolonged summer and occurrence of droughts, which have negative effects on rice growth stages and development such as reduction of spike-let fertility and panicle exertion ultimately yield loss, attack of pests and diseases become more severe, crop wilting and drying and/or to an increase in on-farm water consumption given faster evaporation rates which forces farmers to incur additional expenses for fuel in irrigating their field using water pumps.

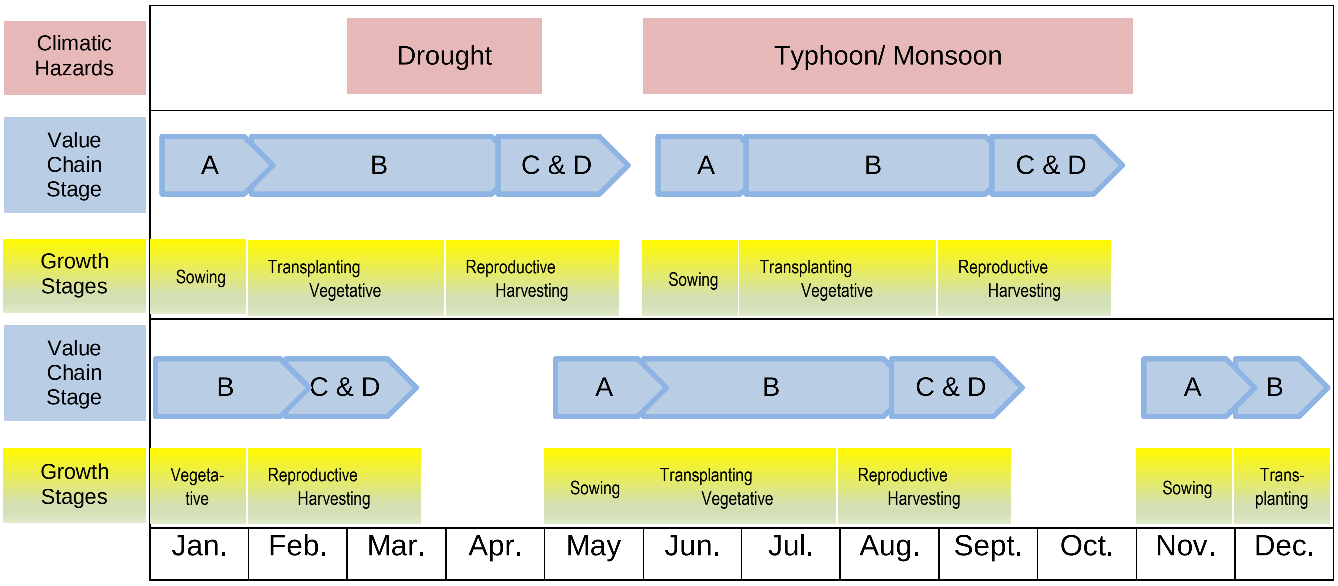

Figure 47. Climatic hazards and adaptation options based on time, growth and value chain stages in rice production.

Table 5. Perception of farmers on climate hazards and impact on rice production.

Climate Hazard	Perception of Farmer on Climate Hazards and its Impacts
Typhoon and continuous rain	Present typhoons are stronger in intensity, frequency and volume compared to past typhoons thereby affecting the livelihood and income of farmers. Floods, erosion or landslides are expected during a strong typhoon resulting in a loss in income. Rice grains become underdeveloped or become easily vulnerable to shriveling, blackening and discoloration; marketing and distribution also became a problem.
Prolong dry season and drought	The heat index seems to be higher during periods of drought compared to the occurrence of drought in the past. The usual time for the occurrence of drought changed from March to April. Prolonged drought has negative effects on rice growth and development.

Corn

Corn farmers perceive that the weather nowadays has become more unpredictable (Figure 48 and Table 6), citing that typhoons bearing strong winds occur in their area during unexpected times. Farmers were also concerned that heavy rains and strong winds/typhoons prevented them from using their usual farm facilities. On the other hand, Ifugao has experienced landslides, irregular rainfall, long dry spells, and intense typhoons which have made corn production more difficult for the farmers. As they were unprepared for such, their corn production is negatively impacted. The changing wet and dry seasons have made estimating the right planting time or selecting the right crop type increasingly difficult. Some farmers also perceive that summer temperatures are more elevated and prolonged dry seasons and drought are more common, which have led to crop wilting and drying. This necessitates mitigation measures to increase or augment on-farm water consumption given faster evaporation rates.

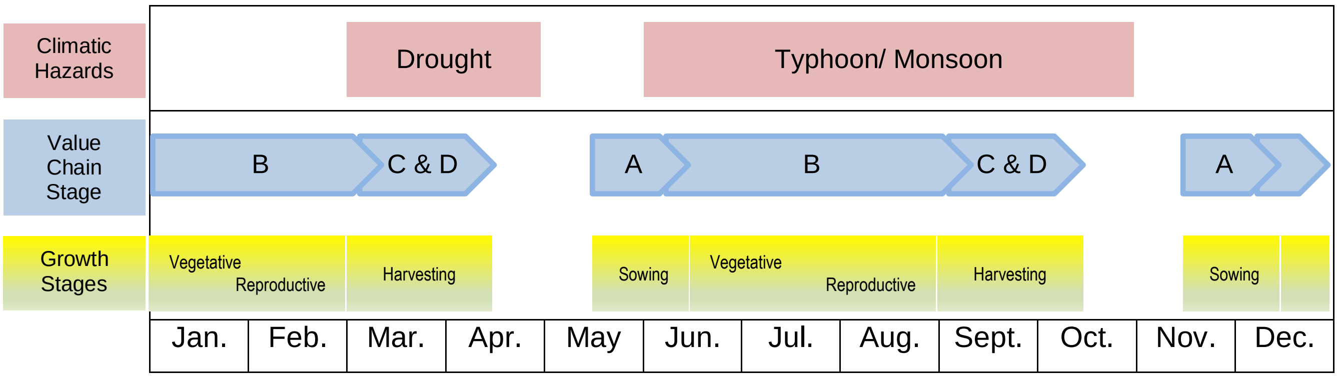

Figure 48. Climatic hazards and adaptation options based on time, growth and value chain stages in corn production.

Table 6. Perception of farmers on climate hazards and impact on corn production.

Climate Hazard	Perception of Farmer on Climate Hazards and its Impacts
Typhoon and continuous rain	Typhoons reduce farm productivity by damaging farm inputs, pests attacking corn crops grown in flooded fields, corn grain becoming underdeveloped "abortion of flowers" or becoming easily vulnerable to shriveling, blackening and discoloration; marketing and distribution also became a problem. Continuous rain and prolonged submerging of corn crops significantly affected growth development and grain yield. Soil erosion is one problem of the farmers in sloping areas during typhoons especially when the rain is continuous, particularly during crops critical stage.
Prolong dry season and drought	Prolonged dry season and drought have negative effects on corn growth and development and ultimately yield loss; and attack of pests and diseases "tarakitik"- blackening or yellowing of some parts of corn plants become more severe. Weather is unpredictable and both rainy and dry seasons are noticeably prolonged, alternately.

Tomato

The common climatic hazards experienced by tomato farmers are typhoons, monsoon rains and drought. Typhoons and monsoon rains primarily occur from May to October whereas drought occurs from March to April (Figure 49). Depending on when the tomato plants were sown, the seedling, vegetative, and reproductive stages are negatively impacted by these climatic hazards. The farmers observed that there is a typical increase in pest infestation and ultimately yield loss during the occurrence of typhoons and drought (Table 7). An infrequent hailstorm was also experienced during the onset of the rainy season in May, which severely damaged the tomato plants.

Some farmers have observed increases in summer temperatures and prolonged dry seasons and drought, which have led to crop wilting and an increase in water consumption. The unpredictability of wet and dry seasons made estimating the right planting time or selecting the right crop type more difficult for tomato farmers in the province.

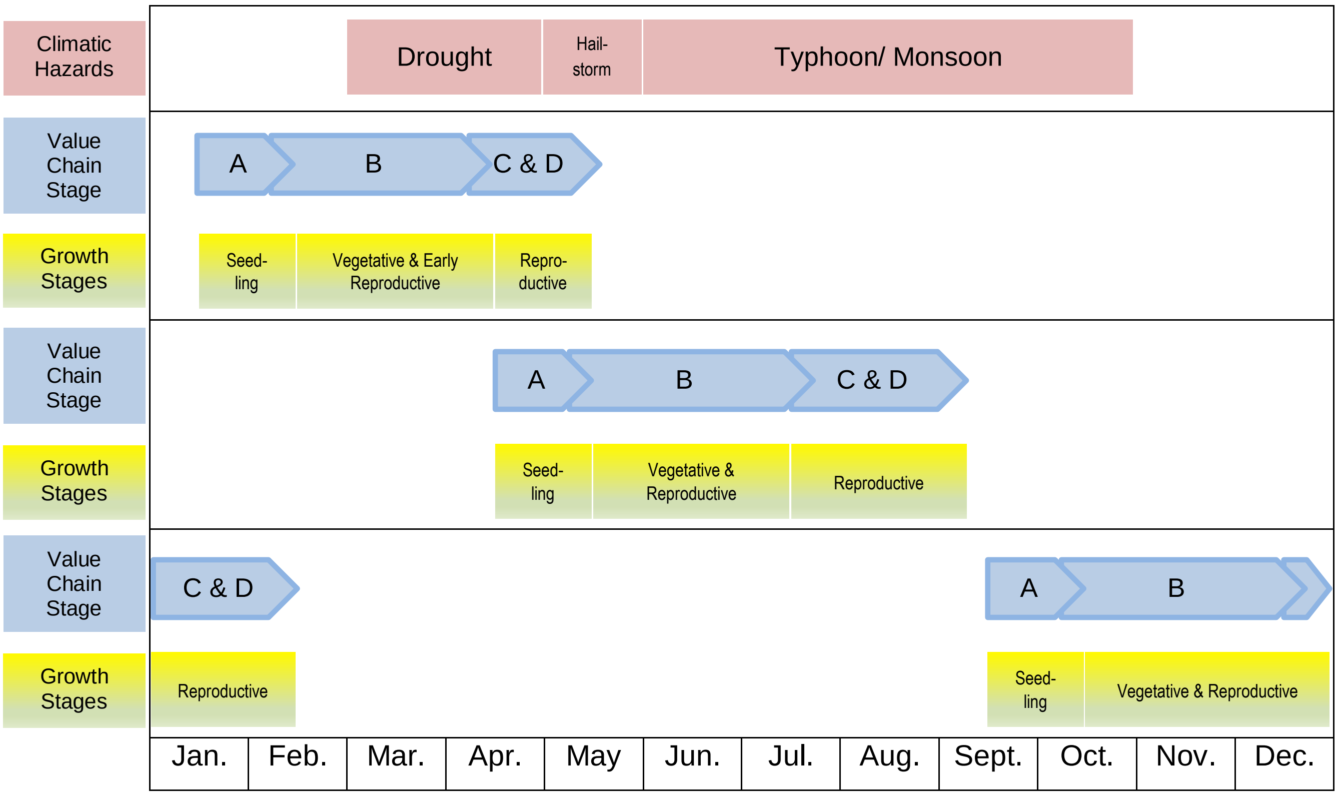

Figure 49. Climatic hazards based on time, growth and value chain stages in tomato production.

Table 7. Perception of farmers on climate hazards and impact on tomato production.

Climate Hazard	Perception of Farmer on Climate Hazards and its Impacts
Typhoon and continuous rain	Tomato, being a sensitive plant, can be easily damaged
Prolong dry season and drought	Negative effects on tomato growth and development and ultimately yield loss; attack of pests and diseases become more severe. Weather is unpredictable and both rainy and dry seasons are noticeably prolonged.
Hailstorm	Hail can severely damage all plants in the field. Leaves are torn or shredded, lodging of stems and eventual death are observed if a hailstorm occurs for a longer time.

Assessment of Climate Hazard Consequences

Rice

The major climatic events that the agricultural community experiences are typhoons and monsoon rains that occur from June to October while drought or prolonged dry season was experienced from March to April. The significant climatic events recalled by the respondents are the typhoons Harurut, Pedring, Yolanda and Paeng where they experienced more than 50 percent or the total loss of their produce as the typhoon occurrences coincides with the vegetative stage up to the harvesting time (Table 8). Flooding and lodging are the direct effects of the storms that lead to delayed harvesting causing vivipary or germination of the rice grains while still attached to the panicle and eventually delayed drying activity. Minor to major landslides on farms, roads and bridges, houses, watershed and irrigation system hinders agricultural activities especially the transport of produce. Recently, the occurrence of flash floods was experienced in a residential and tourism site in Banaue causing damage to infrastructures and properties. The cause of the flash flood is still being researched on and some assumptions were being looked into.

The longer period of the summer season, where in some municipalities they experience almost 10 months of no rain resulted in not planting any crop for the season due to the limited and absence of irrigation. The prolonged drought is claimed to significantly and negatively affect crop and animal production and inland aquaculture like fish kill of about 60 percent.

Table 8. Type of hazard, consequences and severity of impact on rice production.

Type of Hazard	Affected Value Chain Stage*	Consequence	Severity**
Typhoon/ Monsoon rain	A	Delay in buying of inputs	Minor
	B	Delay in seed bed preparation	Minor
		Delay in seeds sowing	Moderate
		Destruction of rice seedlings	Moderate
		Delay in land preparation	Minor
		Delay in transplanting	Moderate
		Delay in application of fertilizers and pesticides	Moderate
		Damage to irrigation system	Major
		Flooding of rice fields	Major
		Lodging of rice plants	Moderate
		Shattering of rice grains	Moderate-Major
		High incidence of unfilled grains "kulyapis"	Moderate-Major

Type of Hazard	Affected Value Chain Stage*	Consequence	Severity**
	C	Difficulty in using combine harvester during harvesting	Moderate
		Difficulty in drying the rice grains	Major
		Low quantity and quality of produce	Major
		Less supply for home consumption	Moderate
	D	Delays in transporting of products	Moderate
		Low prices of products	Major
		Low to negative income	Major
		Less palatability of rice	Moderate
Drought/ Prolonged dry season	B	Scarcity of water for irrigation	Major
		Difficulty in seed bed preparation	Moderate
		Delay in sowing seeds	Moderate
		Reduction in seed germination and seedling growth	Major
		Weak and stunted plants	Major
		Production of fewer tillers	Major-Severe
		Delayed flowering	Major
		High incidence of unfilled grains "kulyapis"	Major
		Incur additional expenses for irrigation	Moderate-Major
	C	Less quantity of produce	Major
	D	Low to negative income	Major

Note: *A- Provision of seeds and other inputs; B- On-farm production; C- Harvesting, storage and processing; and D- Product marketing
**Minor- reversible effect; Moderate- slight effect; Major- irreversible effect but remedial available; and Severe- extensive irreversible effect

Corn

Typhoons and monsoon rains as climate hazards have severe to major consequences such as loss of life or property, damage or loss of assets and infrastructure (Table 9). The occurrence of typhoons with strong winds and continuous rain can result in impassable roads due to blockages or soil erosion which are common, especially in mountainous areas. Primary hazards can also create secondary hazards events such as landslides, erosion and flood. Typhoons with continuous rain can lead to the following: (a) limited supply of important farm inputs such as seeds, fertilizers and pesticides, (b) delayed farm activities, (c) damage of crops especially during their vegetative and flowering stage, (d) high incidence of pest and diseases like 'tarakitik' which causes the blackening or yellowing of the whole plant. Landslides caused by typhoons reduce market accessibility and heavy rains brought on by typhoons also increase the incidence of pests and diseases, lack of drying facilities and advance soil erosion, causing significant nutrient losses. Meanwhile, dry conditions, dry spells and drought have a minor to severe impact on corn production in Ifugao. Prolonged droughts reduce yield and crop quality. In extreme cases, the crop may totally fail.

Table 9. Type of hazard, consequences and severity of impact on corn production.

Type of Hazard	Affected Value Chain Stage*	Consequence	Severity**
Typhoon/ Monsoon rain	A	Limited credit sources	Moderate
		Inputs Increase prices of seeds and inputs	Severe
		Inaccessibility to acquire seeds and	Severe
	B	Delays in land preparation	Moderate
		High incidence of pests and diseases	Major
		Decrease in pollination	Major
		Flooding	Severe
	C	Low productivity due to production loss	Major
		Poor quality of product	Moderate
	D	Inaccessible market	Moderate
Drought/ Prolonged dry season	B	Delays in land preparation	Moderate
		High incidence of pests and diseases	Major
		Stunted and weak plants	Major
	C	Low productivity due to production loss	Major
		Poor quality of product	Moderate

Note: *A- Provision of seeds and other inputs; B- On-farm production; C- Harvesting, storage and processing; and D- Product marketing
**Minor- reversible effect; Moderate- slight effect; Major- irreversible effect but remedial available; and Severe- extensive irreversible effect

Tomato

The purchase of seeds or other inputs and marketing of produce by farmers are negatively impacted by the occurrence of typhoons or monsoon rains (Table 10). Trips to farm supply stores and market outlets become more difficult or even inaccessible due to landslides and other damages to farm-to-market roads during and after a strong rainfall. Consequently, an increase in the prices of farm inputs may occur especially in small farm supply stores located within the vicinity of the tomato farm/s. Occasionally, delays in transportation and marketing of produce due to road closure may result in a sudden increase in tomato supply in the market, which may in turn decrease its price.

There may also be a delay in the processing of loans due to work suspension in crediting agencies during a strong typhoon. Albeit not a consequence of typhoons or monsoon rains, tomato farmers mostly complain of high-interest rates and service fees from credit agencies. Farmers are also severely impacted by decreased yield and income as a result of flooding and the incidence of pests. There may also be a delay in land preparation due to a lack of laborers for hire. These laborers may have difficulty traveling to the farms or are needed on their farms due to damage caused by typhoons.

The infrequent occurrence of hail storms may damage tomato seedlings or fruits depending on the cropping season. The occurrence of drought, on the other hand, may reduce yield and fruit quality. The reduction in yield may be due to the observed dropping or abortion of flowers.

Table 10. Type of hazard, consequences and severity of impact on tomato production.

Type of Hazard	Affected Value Chain Stage*	Consequence	Severity**
Typhoon/ Monsoon rain	A	Inaccessibility to acquire seeds and inputs	Severe
		Increase prices of seeds and inputs	Severe
		Limited credit sources	Moderate
	B	Damage to crops resulting to lower yield	Severe
		Flooding	Severe
		High incidence of pest	Major
		Delays in land preparation	Moderate
		Limited laborers	Moderate
	C	Low productivity	Major
		Poor quality of fruits	Moderate
	D	Low market prices	Major
		Inaccessible market	Moderate
Hailstorm	B	Damage to seedlings and/or newly transplanted seedlings	Severe
		Rotting of tomato fruits	Moderate
Drought/ Prolonged dry season	B	Damage to plants during its reproductive stage (flower abortion)	Major
		Stunted and weak plants	Major
	C	Poor quality of product	Moderate

Note: *A- Provision of seeds and other inputs; B- On-farm production; C- Harvesting, storage and processing; and D- Product marketing
**Minor- reversible effect; Moderate- slight effect; Major- irreversible effect but remedial available; and Severe- extensive irreversible effect

Underlying Factors

Rice

The respondents identified some of the factors that make them more vulnerable or affected by the consequences of the climatic hazards and how they are impacted based on institutional/cultural, socioeconomic, and infrastructure support (Table 11). Accordingly, most of the agricultural programs of the government are not reaching the intended beneficiaries who are really in need of the service and some farmers claim that beneficiaries are chosen. The most vulnerable are the poor farmers who are not members of any farmer organization as they have no resources for the membership and other financial requirements of membership while the least vulnerable are the farmers who are members of the organization and know how to make a proposal or request for government support and assistance.

The high interest by the lending agencies also post limitations for access by the farmers, thus even with the presence of credit companies, some farmers do not take chances due to the high-interest rate. The affected are the farmers with no starting capital. Another difficulty for farmers that are highly dependent on farm inputs is the increasing prices of inputs. Added to that is the micro-control imposed by some suppliers to limit the availability of supplies to insist increase in input prices.

Poor road conditions cause difficulties in the procurement of farm inputs, especially during typhoons which affect the transportation of farmers produce to the market. The most vulnerable are the farmers located in the far-flung and remote areas and far from the markets or center towns and where the access roads are rough and prone to landslides.

The present irrigation system has no regular maintenance and improvements also that affects the availability of irrigation water for the rice plants during the dry season.

Table 11. Underlying factors and stage of value chain affected in rice production.

Underlying Factor	Type of Factor	Affected Value Chain Stage*
Limited government support Poor road conditions Insufficient/poor irrigation system	Infrastructure/ Institutional/ Socio-cultural	A, B, C, D
High interest on lending agencies Increase of price on inputs	Socioeconomic	A

Note: *A- Provision of seeds and other inputs; B- On-farm production; C- Harvesting, storage and processing; D- Product marketing

Corn

There could be several underlying factors why corn farmers are vulnerable to drought, typhoons and continuous rain. These include poor road conditions, lack of drying facilities, insufficient/poor irrigation system, lack of farm facilities, lack of farm equipment/machinery, and the precarious location of farms - either they are flood prone or prone to erosion or landslide. Furthermore, there is no established price regulation which ties the farmers to the pricing scheme of traders. Labor or manpower is limited, and the farmers have insufficient technical knowledge on insect pest and disease management and have apprehensions or difficulty in availing credit or loans. The high-interest rates imposed by lending agencies and the continuous increase of the price of inputs (Table 12) are detrimental to the farmers. The majority of the corn farms are located in low-lying areas where they are prone to landslides and flooding.

Table 12. Underlying factors and stage of value chain affected in corn production.

Underlying Factor	Type of Factor	Affected Value Chain Stage*
Poor road conditions Insufficient/poor irrigation system Lack of farm and processing facilities Lack of farm equipment/machinery	Infrastructure/ Institutional	A, B, C, D
High incidence of pests and diseases	Biological	B, C, D
Areas prone to flooding and drought Flood-prone farm areas Erosion or landslide-prone areas	Biophysical	B, C,
No established price regulation Limited manpower or labor available Insufficient knowledge on insect pest and disease management Difficulty in getting credit or loans	Infrastructure/ Institutional/ Socio-cultural	A, C,
High interest on lending agencies Increase of price on inputs	Socio-economic	A

Note: *A- Provision of seeds and other inputs; B- On-farm production; C- Harvesting, storage and processing; D- Product marketing

Tomato

The severity of the impact of typhoons and drought on a tomato farm depends on underlying factors such as elevation of the farm, lack of farm-to-market roads, susceptibility of plants to pests, etc. (Table 13). In farms where non-existent or unimproved farm-to-market roads exist, the purchase of farm inputs and marketing of produce are especially difficult for tomato farmers. Lack of farming or processing facilities or equipment such as cultivators, irrigation systems, mechanical dryers or drying pavement, mechanical harvesters, etc. that could enhance or speed up farm work especially during the wet season can result in loss of yield and income. Provision of processing facilities that may convert low-quality fruits into marketable products may compensate for losses in the marketing of fresh produce.

The lack of consistency in price regulation of produce in the market may also aggravate the loss of income of farmers. Furthermore, farmers who have lost their income find it difficult to apply for loans due to the bulk of requirements and high-interest rates set by crediting agencies.

The high incidence of pests during a drought or typhoon coupled with a lack of knowledge of farmers regarding other pest management options may increase yield loss. Farms located in high-elevation or sloping areas are prone to landslides while those located in lower-elevation areas are prone to flooding during a typhoon.

Table 13. Underlying factors and stage of value chain affected in tomato production.

Underlying Factor	Type of Factor	Affected Value Chain Stage*
Poor road conditions Insufficient/poor irrigation system Lack of farm and processing facilities Lack of farm equipment/machinery	Infrastructure/ Institutional	A, B, C, D
High incidence of pests and diseases	Biological	B, C, D
Areas prone to flooding and drought Erosion or landslide-prone areas	Biophysical	B, C,
No established price regulation Limited manpower or labor available Insufficient knowledge on pest management Difficulty in getting credit or loans	Infrastructure/ Institutional/ Socio-cultural	A, C,
High-interest rates of lending agencies Increase in the price of inputs	Socio-economic	A

Note: *A- Provision of seeds and other inputs; B- On-farm production; C- Harvesting, storage and processing; D-Product marketing

Climate Impacts on Gender

Rice

Men, women, youth and children, as an integral part of the farm operation, experience climate hazards differently because they have different vulnerabilities. Generally, in rice production, the degree of involvement of men is very high (Table 14). Men are engaged almost exclusively in productive activities, especially on farm production management activities that are physically demanding thereby exposing themselves to harsh weather conditions like strong winds and heavy rains. Women's involvement has a medium to high involvement in the different value chains. They actively participate in less strenuous agricultural activities while being responsible for household activities like caring for their children, preparing food and other basic needs, and in non-farm income-generating activities. The youth and children have normally no to low involvement in farming activities except for the medium involvement of the youth during harvesting, sorting and hauling of produce.

Table 14. Degree of involvement of each gender in the value chain stages for rice production.

Value Chain Stage	Gender	Degree of Involvement	
		Rating	Description
Provision of seeds and other inputs	Men	5	Very High
	Women	4	High
	Youth (15-30 y/o)	2	Low
	Children (<15 y/o)	0	No Involvement
On-farm production	Men	4	High
	Women	5	Very High
	Youth (15-30 y/o)	3	Medium
	Children (<15 y/o)	1	Very Low
Harvesting, storage and processing	Men	5	Very High
	Women	3	Medium
	Youth (15-30 y/o)	3	Medium
	Children (<15 y/o)	1	Very Low
Product marketing	Men	5	Very High
	Women	4	High
	Youth (15-30 y/o)	1	Medium
	Children (<15 y/o)	0	No Involvement

Corn

Gender roles in agricultural production are important to understand because it shows the division of labor which is believed to sculpt relationships and roles in the family and society (Table 15). Ifugao women spend a considerable part of their day working in the fields and doing other chores and food production-related activities. The farmers recognize that both are affected because men and women are equally working in the field. Women are primarily responsible for household activities like attending to child care, basic needs, and food preparation. They also actively participate in less strenuous agricultural activities such as watering and other productive tasks like sewing or non-farm income-generating activities. Men are engaged almost exclusively in on-farm production management activities that are physically demanding like the application of pesticides or fertilizers. Some women are marginalized when it comes to decision-making power and influence, as well as access to land and other resources, capacity building, training, and income-generating opportunities. However, many respondents in these agricultural households noted that women often controlled the family finances, making decisions on the purchase of seeds and other inputs and marketing farm produce.

Table 15. Degree of involvement of each gender in the value chain stages for corn production.

Value Chain Stage	Gender	Degree of Involvement	
		Rating	Description
Provision of seeds and other inputs	Men	4	High
	Women	3	Medium
	Youth (15-30 y/o)	4	Medium
	Children (<15 y/o)	0	No Involvement
On-farm production	Men	5	Very High
	Women	4	High
	Youth (15-30 y/o)	4	High
	Children (<15 y/o)	3	Medium
Harvesting, storage and processing	Men	5	Very High
	Women	4	High
	Youth (15-30 y/o)	4	High
	Children (<15 y/o)	4	High
Product marketing	Men	5	Very High
	Women	5	Very High
	Youth (15-30 y/o)	3	Very Low
	Children (<15 y/o)	0	No Involvement

Tomato

Men and women equally help each other from land preparation to the marketing of tomatoes (Table 16). Specifically, men are involved in the purchase of inputs, operation of heavy farm equipment, land preparation, pesticide application, hauling and transportation of produce to the market. Women are mostly involved in transplanting, trellising, fertilizer application, weeding, and harvesting. Youths help in the purchase of inputs, sorting, cleaning, hauling and transportation of produce to the market. Depending on when the climate hazard occurred, men and women are equally vulnerable due to their high to very high involvement in all the value chain activities for tomato production. However, when a typhoon occurs, men are usually involved in checking for and repairing damages, e.g. landslides, to the farm. Men in the community may also gather to clear roadblocks due to toppled trees and other structures. The women usually do the household chores including caring for their children.

Table 16. Degree of involvement of each gender in the value chain stages for tomato production.

Value Chain Stage	Gender	Degree of Involvement	
		Rating	Description
Provision of seeds and other inputs	Men	5	Very High
	Women	4	High
	Youth (15-30 y/o)	3	Medium
	Children (<15 y/o)	1	Very Low
On-farm production	Men	5	Very High
	Women	4	High
	Youth (15-30 y/o)	3	Medium
	Children (<15 y/o)	1	Very Low
Harvesting, storage and processing	Men	4	High
	Women	5	Very High
	Youth (15-30 y/o)	4	High
	Children (<15 y/o)	0	No Involvement
Product marketing	Men	5	Very High
	Women	4	High
	Youth (15-30 y/o)	2	Low
	Children (<15 y/o)	0	No Involvement

Identification and Prioritization of Adaptation Options

Rice

The different stakeholders as respondents identified the use of climate-proof varieties adapted for drought and colder temperatures, planting alternative crops and availability of water pumps for irrigation (Figure 50). During typhoons and heavy rains, construction, maintenance and clearing of canals and drainages, control of irrigation water, application of pesticides and planting of bamboo along or near the river banks were identified. The adaptation options were identified and practiced by the farmers to help them cope with climatic hazards.

Farmers and the community including the line agencies such as the Department of Agriculture, the Local Government Units and farmer's associations are collaborating on activities to clean, maintain or make drainage canals to avoid clogging, flooding, and erosion during the occurrence of typhoons. The planting of bamboo along the river banks had been observed to serve as a windbreak or barrier during flooding and can be adopted by farmers with limited capital as the planting of bamboo entails no adaptation cost. During heavy rains, the farmers block the sources of irrigation going to the farms as a preventive measure to avoid flooding.

Proper selection of appropriate seed varieties is adopted by farmers best suited in the areas and season of planting, especially during the prolonged dry season. Support from the government agencies on seed was acknowledged by the farmers. Although, there are still farmers who are not knowledgeable about the importance of good seed varieties and still practice some traditional beliefs that are assumed to help them. Most of the farmer respondents also plant other crops such as corn, root crops and vegetables as an alternative crop during the dry season.

The introduction of solar water pumps by the Department of Agriculture was mentioned to help them in the irrigation system. However, there are limitations to adopting the technology due to limited capital and no alternative source of water to pump that needs to be taken into consideration in the provision of support.

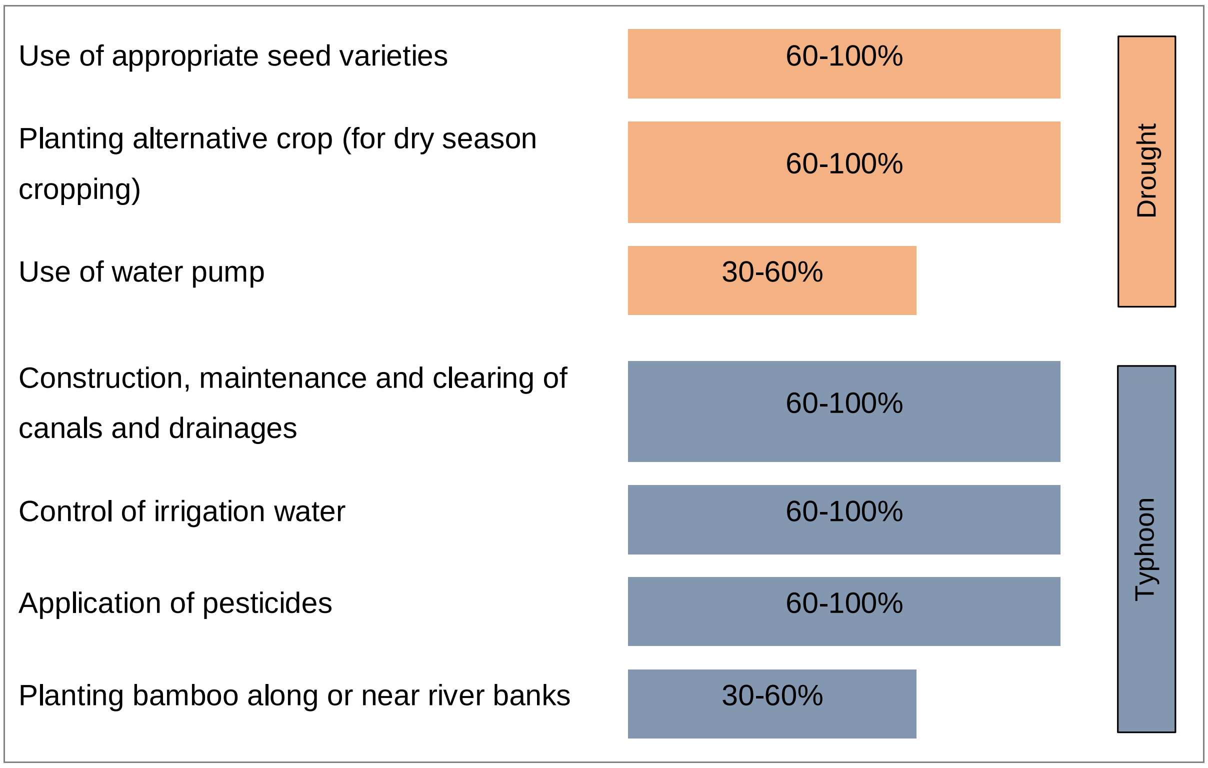

Figure 50. Adaptation options and degree of adoption by rice farmers.

Corn

The adaptation options identified and practiced by the farmers to help them cope with climatic hazards are the following (availing crop Insurance, delayed planting and use of appropriate seeds) (Figure 51).

With the help of the Local Government Units and the Philippine Crop Insurance Corporation, farmers may ensure their crops 15 days after planting for them to have at least 35-70% assistance if their crops are affected by climate hazards.

Farmers practice delayed planting especially during the summer season to wait for the rainwater to pour down and during the rainy season to avoid the rotting of seeds.

Proper selection of appropriate seed varieties is adopted by farmers best suited in the areas and season of planting, especially during the prolonged dry season and typhoons even monsoon rain.

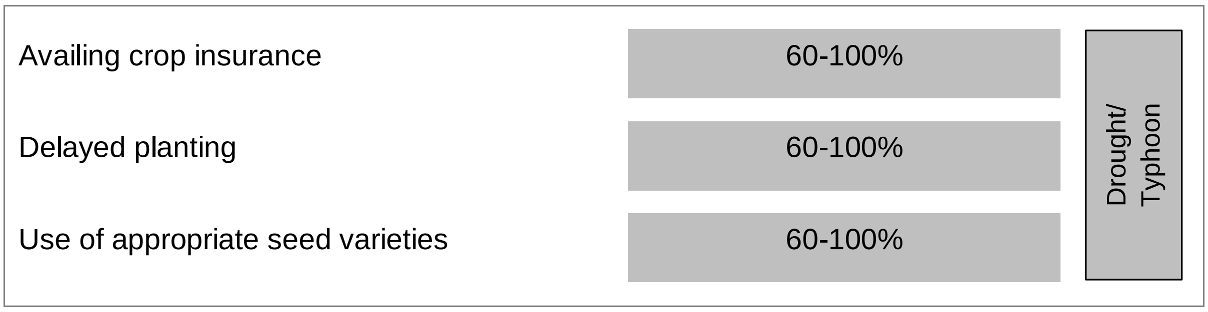

Figure 51. Adaptation options and degree of adoption by corn farmers.

Tomato

Most tomato farmers apply for crop insurance 15 days after planting to subsidize any financial losses incurred due to negative impacts from strong typhoons or drought (Figure 52). The Department of Agriculture (DA) also occasionally assists farmers to reduce their expenses by giving them seeds and fertilizers for free. However, assistance from DA is only available for farmers who are members of the Registry System for Basic Sectors in Agriculture (RSBSA). Another adaptation option that most farmers commonly practice is a delay in the planting schedule either to escape strong rains during the wet season or wait for early rains during a prolonged dry season. The selection of tomato varieties that are tolerant to drought is also commonly practiced by farmers.

Some farmers prepare for the possibility of drought by storing rain water in large drums or canals during the rainy season. Others use a water pump and/or 'rainburst' to irrigate all plants in the field and be more cost-effective by reducing the number of man-days.

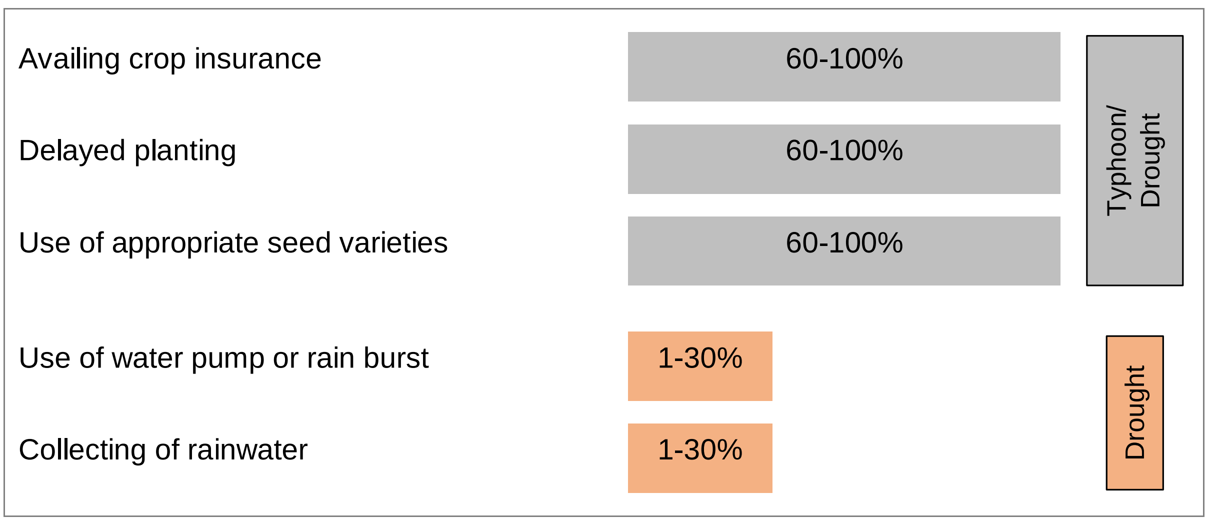

Figure 52. Adaptation options and degree of adoption by tomato farmers.

Barriers to Adoption

Rice

The adaptation options that are identified and available to farmers poses some barrier to adopting by the farmers (Table 17).

On the provision of seeds and other inputs, the cost of adoption, high-interest rate and high prices of inputs were among the hurdles for adoption. Among the technical barriers to adoption are lack of human capacity, lack of technical capacity and lack of access to facilities and equipment. The behavioral barriers are differences in climate change beliefs, short-term thinking, conflict with traditional methods and the "sapalaran" behavior.

Low awareness of climate-smart techniques and lack of information services are claimed by the respondents and is seeking assistance from appropriate agencies to provide technical know-how and awareness campaign. Under institutional barriers, low institutional support, lack of regulatory framework and weak linkages and collaboration within government agencies were identified.

Table 17. Barriers in technology adoption for climate hazards affecting rice production.

Barrier Type	Description
Financial	High cost of adoption, high interest on credit
Technical	Lack of human capacity, lack of technical capacity, lack of access to facilities and equipment
Behavioral	Differences in climate-change beliefs, short term thinking, conflicts with traditional methods
Informational	Low awareness of climate-smart techniques, lack of climate information services
Institutional	Low institutional support, lack of regulatory framework, weak linkages within the government

Corn

According to the farmers, the barriers to the adoption of the various adaptation practices include high-interest rates of lending companies, high cost of inputs, limited credit sources and lack of capital (Table 18). The farmers believed that the high price of seeds, pesticides and fertilizers has increased their total cost of production, thus decreasing their profit. Land preparation requires machinery i.e., tractors and other equipment installed with the tractors. Most of the farmers in the study rent equipment and machinery along with the operator (driver of the tractor who also has expertise in preparing and leveling the land). The increased price of fuel has also increased the rent charges for such services. The same situation is faced by the farmers at the harvesting stage of corn crops.

The low price of corn is also identified by farmers as a big challenge, mainly because of the unavailability of postharvest and drying facilities. They cannot store their produce; thus, they sell their product fresh, at a much lower price. Challenges due to climate change include the occurrence of strong typhoons which often lead to yield loss. Climate-smart technologies need to be applied to reduce the impact of climate hazards.

Table 18. Barriers in technology adoption for climate hazards affecting corn production.

Challenge	Description
Financial	High cost of adoption, limited credit sources, long payback periods, lack of financial benefits
Technical	Lack of human capacity, lack of technical capacity, limited technical equipment (machinery)
Behavioral	Differences in climate-change beliefs, short term thinking, conflicts with traditional methods
Informational	Low awareness of climate-smart techniques, lack of climate information services
Institutional	Low institutional support, lack of regulatory framework, weak linkages within the government

Tomato

Not all tomato farmers can afford to adopt climate-smart techniques and purchase the appropriate equipment (e.g. water pump) and facilities to ease the negative impacts of climate hazards (Table 19). There are also a few agencies or individuals who would willingly approve loans from farmers. For crediting agencies that do approve loans for farmers, processing of documents, high interest and processing rates are challenging for most farmers. Furthermore, long payback periods from insurance companies discourage some farmers from applying for a policy. In terms of adopting new or improved climate-smart techniques, farmers perceive that adopting such technologies is more of a financial liability rather than an asset.

Some farmers are also unaware of training on livelihood programs, crop programming, operation of farm machinery, and other new or modern farming technologies that may help mitigate the impacts of climate hazards.

Table 19. Barriers in technology adoption for climate hazards affecting tomato production.

Barrier Type	Description
Financial	High cost of adoption, lack of access to credit, lack of financial benefit, long payback period
Technical	Lack of human capacity, limited access to technical equipment

VI. Conclusion

In the past 10 years, rice production in Ifugao decreased by about 32.92 percent while corn and tomato production have consistently increased which can be attributed to the increase in the production area. Rice, corn and tomato are typically cultivated as a monocrop and the farmers are the main value chain actors involved from the purchase of farm inputs to marketing of products. For tomato farmers, disposers also play a role in providing inputs and marketing their products. Crediting agencies and farmer associations allow farmers to have access to good-quality seeds, fertilizers and equipment that will help them adapt better to climate hazards. The tomato farmers also commonly practice a ‘bayanihan’ system where they help each other in farm activities that are especially strenuous (e.g. land preparation, harvesting and hauling of produce).

The occurrence of strong typhoons and monsoon rains often cause road closures, which could result in the inaccessibility of farmers to critical farm inputs (e.g. seeds, fertilizers) or higher prices of farm inputs sold by nearby farm supplies. Farms in low-elevation areas are often flooded leading to crop damage and low yield. Crop damage coupled with increased pest incidence due to rainfall or hailstorms is a common occurrence. Likewise, crops exposed to prolonged drought are often stunted and ultimately low yield. These impacts from climate hazards may worsen due to underlying factors such as poor road conditions, insufficient or poor irrigation systems, high interest rates from credit agencies, increasing prices of inputs, and others.

The farmers have learned to adapt to the effects of these climate hazards by availing of crop insurance, delaying their planting schedule, using tolerant seed varieties or planting alternative crops, and using water pumps when irrigating, among others. However, due to the barriers to adaption like the high cost of adoption, lack of human capacity, differences in climate-smart belief, low awareness of climate-smart techniques, and low institutional support, not all farmers are practicing these adaptation strategies.

VII. Recommendation

The existing technologies or strategies practiced by farmers to reduce the negative impacts of climate hazards may be improved and showcased to other farmers. The economic benefits of effective adaptation options even with a low degree of adoption may also be analyzed. Other pertinent information from this research could be used to implement programs and policies that will enable all actors in the value chain to improve production and address the consequences resulting from climate hazards.

COST-BENEFIT ANALYSIS OF SELECTED CLIMATE-RESILIENT AGRICULTURE PRACTICES FOR PRIORITY CROPS IN IFUGAO

ABSTRACT

Adaptation options identified and prioritized by farmers and stakeholders in Ifugao for major hazards in rice, corn, and tomato production were subjected to financial profitability and economic analysis. For rice, the use of water pumps and communal irrigation systems were found to result in significantly higher yields and net profits for both wet and dry seasons for rice farmers in the province. Investing in water pumps is an economically viable option for farmers. Planting alternative crops, such as various kinds of vegetables, and planting bamboo on the riverside were also perceived beneficial by farmers and stakeholders, and hence on-farm experiments for optimum cropping sequence, and further investigation of bamboo planting as an adaptation for erosion control during typhoons are recommended. For corn, crop insurance is an adaptation measure that can minimize the possible losses incurred by farmers due to weather-induced calamities. Based on average yields, costs, and prices, corn farming using either *labos* or hybrid seeds in major corn areas in Ifugao was found to generate a positive net profit. For tomato, the profitability analysis indicated that tomato farming is a financially viable enterprise in Ifugao given the average yield and prices received by the respondents from the top three top tomato-growing municipalities in the province. The cost structure presented in this study may be used as a baseline to understand potential areas of interventions for greater impact. Further investigation and technical studies need to be conducted using the revealed knowledge gaps from the perceptions of tomato farmers on the advantages and disadvantages of rainwater harvesting and delayed planting.

I. RATIONALE

Climate-related risks such as “failure to mitigate, failure to adapt to climate change, and disasters from extreme weather events remain the top three most severe global risks over a 10-year period” (World Economic Forum, 2023). The same report put natural disasters and extreme weather events as the top risk in the Philippines. The country is the most sensitive to extreme weather events among Asian countries (Paun et al., 2018). Tropical cyclones, floods, prolonged dry seasons, droughts, and other extreme weather events continue to negatively impact livelihoods and food security in the country.

The agriculture sector is one of the most vulnerable sectors to climate hazards because climate influences the crop itself and the different agricultural activities and processes (Salvacion, 2015). Cropping calendars, production levels and product quality, pest and disease incidence, livestock and also fisheries production, and infrastructure are all affected by climate change. In addition, agriculture directly shapes urban food availability and prices (Alliance of Bioversity International and CIAT & World Food Program, 2021).

With a country predisposed to climate risks and most of its population dependent on agriculture-based livelihood, the development of climate and natural disaster-resilient communities is important. Under the Department of Agriculture’s Adaptation and Mitigation Initiatives in Agriculture (AMIA), climate change adaptation or mitigation strategies need to be evaluated and prioritized before deployment. Also, the Department of Science and Technology funds what they call the S&T Action for Emergencies and Hazards (SAFE) Program, which is their S&T Plan for Climate Change (www.dost.gov.ph). Both programs aim to achieve resilient and adaptive ecosystems and communities. Other government line agencies, local government units, and private foundations are also implementing or on the lookout for strategies, technologies, or innovations to contribute to building resilience amidst climate change and its impacts on the agriculture sector.

Enhancing disaster or climate resilience of communities, however, requires significant resources. Adaptation and mitigation measures need to be planned and implemented at the local level to ensure that context and norms are well understood and considered (ADB, 2023). Only 8% and 10% of the Philippine’s Climate Budget in 2021 and 2022, respectively, were allotted to food security risks due to climate challenges (CCC, 2021, 2022). Hence, it is important to ensure that any investment by line agencies or local government units to scale up adaptation or mitigation options results in positive net returns not only for the investor but also for the society.

II. REVIEW OF LITERATURE

Evaluation of climate-resilient adaptation practices in agriculture has been a subject of research worldwide such as in South Asia (Ahmed and Suphachalasai, 2014), Africa (FAO and UNDP,2022; Tilahun and Charfeddine, 2021; Azumah et al., 2020), and China (Zhang et al., 2018). In the Philippines, the Climate Change Commission is on top of "building the adaptive capacities of women and men and increasing the resilience of vulnerable sectors and natural ecosystems to climate change" through improving adaptive capacity and implementing adaptive actions (Gaddi, n.d.). The national climate change action plan for 2011 to 2028 has as its ultimate outcome enhanced the adaptive capacity of communities, better resilience of natural ecosystems, and sustainability of built areas to climate change (Climate Change Commission, n.d.). Accordingly, the Philippines' Climate Change allocation is 89% for adaptation and 11% for mitigation. This information points to the importance of evaluating adaptation strategies in agriculture. Specifically, they identified as one of the key climate change risks in the Philippines the reduced yield in rice, corn, and other crops due to increased temperature that adversely affect livelihood and food security (Lansigan et al., 2007 and Comiso et al., 2014 as cited in CCC, n.d.)

Climate Resilient Adaptation for Rice Farming

Hussain et al. (2020) reviewed and enumerated adaptation and mitigation strategies in rice production and emphasized the need to prevent greenhouse gas emissions from rice fields and adjust to the adverse effects of climate change on rice production. Some of the mitigating and adaptation strategies listed are related to water management, integrated and diversified farming, precision input use, development and promotion of climate-friendly rice cultivars, and data decision-support-based management options.

However, the effectiveness of adaptation strategies depends highly on geographical and climate risk factors, as well as governance and financial capabilities (GTZ and DENR, n.d.). In mountainous regions, for example, whether there is climate change or not, farmers are adapting to drought at the local level in their own ways (Pradhan et al., 2015). Zhang et al. (2018) found farmers adapt to drought through multiple strategies such as storing and pumping water, using sprinkler irrigation, changing crops, and strengthening community-level water management. On the other hand, in lowland rice areas, water management-related practices were evaluated. Moya et al, (2002) found that in areas where gravity-flow is adequate to meet irrigation water demand, the conjunctive use of surface water and groundwater is economically feasible. The study mentioned that even if pump users incur high fuel costs, they can still get substantial profits from their rice production with conjunctive use of surface water. At 2002 prices, the net return to land and management for pump users is about $593 per hectare (Moya et al., 2002). Launio and Manalili (2015) also found that farms supported by tube wells and gravity irrigation canals yielded significantly higher than purely rainfed areas, but no significant difference was found in the rice production cost across irrigation systems in the wet season. Based on this study, rice production using a deep well pump is profitable in both WS and DS, with net profit at 0.19 and 0.20 for every peso invested. The study also found that yield and input productivity are comparable among farms supported by deep and shallow tubewells in both the wet and dry seasons.

In addition, particularly among indigenous peoples, farmers have cultural systems or cultural consensus knowledge of climate risks or weather patterns (Ruzol et al., 2021), which development workers need to consider even in planning or designing adaptation or climate risk management. As mentioned by Arbuckle, Morton, & Hobbs (2015), beliefs varied with trust, and beliefs in turn had a significant direct effect on perceived risks from climate change. Accordingly, for example, while most farmers support mitigation interventions such as those that reduce greenhouse gas emissions, they prefer interventions with adaptive properties, such as reduced tillage or improved fertilizer management. This literature supports the framework for this program where climate resilient adaptations are based on the farmers' and local stakeholders' experiences and priorities.

Climate Resilient Adaptation for Corn Farming

Climate change impact on corn production

Corn is grown throughout the world, and it is also subjected to a wide variety of climates and the effects of climate change. The projected increase in temperature shifts in rainfall patterns, elevated surface carbon dioxide concentrations from human-caused greenhouse gas emissions, and extreme weather events have affected production cycles and have caused a negative impact on corn production (Gray, 2021).

Climate change will surely affect the corn production in the country. In line with this, a study by Salvacion (2015) has shown that the potential impact of climate change on corn production is the consistent decrease in yield due to a shorter maturity period and an increase in evapotranspiration. An increase in temperature reduces growth and grain filling period, early maturity that leads to less biomass accumulation which causes a reduction in yield, and heat stress can induce sterility problems during the flowering stage. On the other hand, the direct impact of heavy rain, hail, or strong winds on the corn trees may include tree damage, and increased corncob fall, especially near harvest. Indirectly, these hazards may result in soil erosion, landslides, subsidence, wash-away of agrochemical applications, and damages to roads and other infrastructure that increase costs.

Crop Insurance

Crop insurance mitigates risk by providing an opportunity for farmers to cover production cost for the next season, and maintain their income and consumption even if their crops are destroyed or incur loss due to a disaster (Defiesta & Mediodia, 2016; Reyes, 2019). The country's crop insurance program is administered and implemented by the Philippine Crop Insurance Corporation (PCIC), a government-owned and controlled corporation. Figure 1 presents the general process of availing crop insurance until the process of claiming indemnity based on PCIC. The PCIC is mandated to provide insurance protection to farmers against losses arising from natural calamities, plant diseases, and pest infestation of their crops and other agricultural assets.

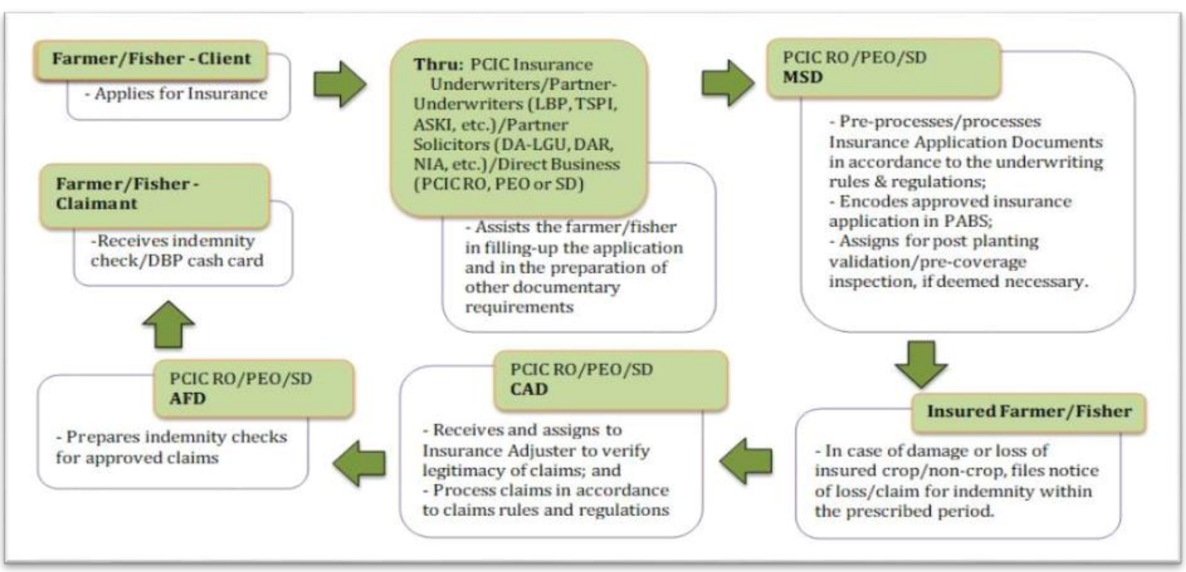

Figure 53. Process Flow Chart of the Philippine Crop Insurance Corporation (PCIC)

Source: Philippine Crop Insurance Corporation

Using appropriate varieties each season

The challenges posed by climate change to food security require maize varieties that are tolerant to both drought and heat amidst the current drought and stress levels in many tropical environments (Tesfaye et al., 2018). The use of appropriate crop varieties during each season such as drought-tolerant varieties can help reduce the negative impacts of climate change on agricultural systems and at the same time ensure stable agricultural production. Moreover, the use of appropriate varieties can reduce the risk of total crop failure. Incorporating drought, heat, and combined drought and heat tolerance into benchmark varieties increased simulated maize yield under the baseline and future climates (Tesfaye et al., 2018).

Delayed planting

Planting is a critical activity in the production of corn and the crucial step to obtaining good yields. Optimum planting dates have become of prime importance for higher crop production. This plays an important role in the growth, development, and yield of crops. Delayed planting or planting later can be an alternative strategy that attempts to avoid heat and moisture stress during the growing season of crops.

Climate Resilient Adaptation for Tomato Farming

Climate change is the biggest threat of the present century and is causing a significant negative impact on tomato production. Several studies point to the susceptibility of tomatoes to the adverse effects of climate change, including lower yields and increased prevalence of pests (Sakya et al., 2020; Guodaar, 2015; Dhanush et al., 2015; Fahim, 2010). In addition, Johkan et al. (2011) as cited by Biratu (2018) indicated that high temperatures during flowering result in poor flowering and flowering problems, poor fruit quality, color disorder, and pollen sterility in tomato plants.

Crop Insurance

Crop insurance is a risk management tool and a key to farmers' stability, enabling them to continue production despite severe weather and other challenges that impact them. The Philippine Crop Insurance Corporation (PCIC), a government-owned and controlled corporation, administered and implemented the crop insurance program in the country. They are mandated to provide insurance protection to farmers against losses arising from natural calamities, plant diseases, pest infestations of their crops, and other agricultural assets. One of the insurance products available at the Philippine Crop Insurance Corporation (PCIC) is high-value commercial crop insurance, which includes cabbage, coffee, tomatoes, and others.

According to the Philippine Crop Insurance Annual Report (2021), under the high-value crop insurance program, there were a total of 295,875 farmers insured, with a total of 292,454 hectares enrolled. The premium generated for the said year was Php 444.125M. But only 33,998 farmers claimed indemnity, for a total of Php 214.111M. Compared to the 2020 results, there is a 3.86% increase in the number of farmers insured this year and an 8.71% decrease in the area enrolled in high-value crop insurance. However, there has been a 19.72% increase in the number of farmers who have received indemnity.

Using appropriate varieties each season

The use of appropriate crop varieties during each season, such as drought-tolerant varieties, can help reduce the negative impacts of climate change on agricultural systems and, at the same time, ensure stable agricultural production. Moreover, the use of appropriate varieties can reduce the risk of total crop failure. Climate adaptation requires farmers to adjust their crop varieties over time and use the right varieties to minimize climate risk (van Etten & de Sousa, 2019).

Delayed planting

The quality of tomatoes depends on climate, growing media, plant nutrition, and other factors (Jankauskieno, 2013). Planting date is an important factor that is directly related to crop production in a specific area. In accordance with this, different planting times may affect crop yield and quality due to varying climatic conditions at different stages of crop growth and development. Planting time can affect plant maturity, harvesting time, yield, and the quality of crops. Moreover, according to Rahman et al., (2020), the yield of tomatoes is significantly influenced by sowing dates and varieties. It has been reported that the effect of transplanting time in relation to changes in the temperature of the environment will be primarily reflected by the plant height (Islam et al., 2017).

The optimal planting date has become of prime importance for higher crop production. This plays an important role in the growth, development, and yield of crops. Delayed planting or planting later can be an alternative strategy that attempts to avoid heat and moisture stress during the growing season of crops.

Use of sprinklers

Irrigation is very important for optimum production, and choosing an efficient method of irrigation can save water and labor. Sprinkler irrigation is the method of applying irrigation water similar to natural rainfall, where water is distributed through a system of pipes by pumping and then sprayed into the air through sprinklers so that it breaks up into small water drops that fall to the ground (Philippine Agricultural Engineering Standards [PAES], 2017).

According to Clements et al., (2011), sprinkler irrigation technology can help farmers adapt to climate change by making more efficient use of their water supply for irrigation in agriculture. This irrigation system is particularly appropriate where there is a limited or irregular water supply for agricultural use. Furthermore, this type of irrigation provides a more even application of water to the cultivated plot, as agreed by Remocal et al., (2021), who stated that irrigating fields with sprinklers allows for cost-effective water use by controlling application uniformity and rate. Clements et al., (2011) also added that sprinkler irrigation can provide additional protection for plants against freezing at low temperatures during the night. Sprinkler irrigation provides good conditions for crop growth to increase production and improve product quality. As an example, the yield of field crops under sprinkler irrigation could be increased from 10% to 20%, while economic and vegetable crops could be increased by 30%, respectively (Yan, 2004; Zou et al., 2012).

Collection of rainwater/Rainwater harvesting.

During the dry season, water availability for irrigation and keeping water available without depending on the season are problems that must be overcome. Rainfall harvesting is one of the alternative solutions because water could be collected in the wet season, stored in tanks or torrents, and applied for irrigation (Bafdal & Dwiratna, 2018). Bafdal and Dwiratna also added that rainwater harvesting technology is appropriate for arid and semi-arid countries affected by global climate change. In Indonesia, rainfall collection is usually done during the wet season, while in the dry season, they can use the stored water for irrigation purposes. According to Breman et al., (2001), rainwater harvesting could help mitigate the impacts of climate change on crop production. It can help in improving agricultural production since it can increase crop production by implementing supplemental irrigation. This is agreed upon by Gao et al., (2001), who state that supplemental irrigation in the critical areas of the crops can significantly improve crop yield and water use efficiency. Furthermore, it appears in the study of Ngigi (2009) that farmers in Ethiopia and other parts of Kenya have shown high adoption rates for farm ponds and other rainwater harvesting technologies. Indeed, rainwater harvesting can offer a partial solution to the issue of climate change.

III. OBJECTIVES

The main objective of this project is to contribute to the identification of economically feasible climate-resilient agriculture practices for the prioritized hazards for rice, corn, and tomato as a basis for developing or prioritizing investment plans. Specifically, it aimed to:

1) determine the costs and benefits of selected climate-resilient agriculture practices for rice farming;
2) determine the costs and benefits of selected climate-resilient agriculture practices for corn farming; and
3) determine the costs and benefits of selected climate-resilient agriculture practices for tomato farming in Ifugao.

Limitations of the project. The project is limited to evaluating using the CBA framework only selected adaptation options, which are deemed technically feasible but are not widely adopted or require substantial investment. For the adaptation options that are already almost being used, adopted, or implemented by most farmers in the province, or have no available secondary or primary quantitative data, perceptions or narratives from focus group discussions were presented to inform future analysis, investment planning, or future feasibility study.

IV. PROCEDURE/METHODOLOGY

This project focused on the three major crops in Ifugao, namely: rice, corn, and tomato planted in various locations and vulnerable to major climate hazards as mapped in Lumbres et al. (2023) and climate-resilient adaptation practices identified and prioritized in Pablo et al. (2023). It used the cost-benefit analysis framework.

Population and Sampling

Table 20 shows the study areas for rice, corn, and tomato, which are the top three rice, corn, and tomato-producing municipalities in the province.

Table 20. Study Municipalities and Surveys Barangays Covered

Commodity	Survey Municipality	Survey Barangays	No. of Survey Respondents
Rice	Alfonso Lista	Brgy. Namillangan, San Quintin, Ngileb, Dolowog, Caragasan, Santa Maria, Calupaan, Pinto and Brgy. Potia	24
	Lagawe	Brgy. Tungngod, Boliwog, Poblacion, and Brgy. Boliwong	10
	Lamut	Brgy. Panopdopan, Pieza, and Brgy. Lawig	30
Corn	Alfonso Lista	Brgy. Busilac, Calupaan, Caragasan, Dolowog, Kiling, Namillangan, Ngileb, Pinto, San Quintin, Sta. Maria and Sto. Domingo	47
	Aguinaldo	Brgy. Posnaan	13
	Lamut	Brgy. Hapid and Brgy. Lawig	9
Tomato	Asipulo	Brgy. Liwon, Brgy. Antipolo, Brgy. Namal	5
	Hungduan	Brgy. Abatan and Brgy. Bangbang	14
	Tinoc	Brgy. Ap-apid, Binablayan, Gumhang, Impugong and Brgy. Poblacion	67

Profile of Rice Farmers Respondents

The age profile of respondents is quite distributed with mean at 54 years old although 31% are senior citizens (Table 21). Most of the respondents are high school graduates and

17% are college graduates implying that most farmers in the area are functionally literate. However, in terms of farmers being member with an association, 14% are not members in any kind of organization, especially farmer/irrigators association. These results imply that there is still room for social preparation among the respondents in terms of encouraging the 17% to join associations. Government benefits, including the deployment of potential smart-agricultural practices, can only be accessed via farmers/irrigators associations or cooperatives.

Table 21. Respondents Profile, Rice Farmers, Ifugao

	Rainfed (n=21)		Irrigated (n=33)		Water Pump Users (n=10)		Pooled (n=64)	
	f	%	f	%	f	%	f	%
Sex								
Male	14	66.67	24	72.73	9	90.00	47	73.44
Female	7	33.33	9	27.27	1	10.00	17	26.56
Age								
20-30	-	-	1	3.03	-	-	1	1.56
31-40	2	9.52	2	6.06	1	10.00	5	7.81
41-50	6	28.57	9	27.27	3	30.00	18	28.13
51-60	8	38.10	10	30.30	2	20.00	20	31.25
61 and above	5	23.81	11	33.33	4	40.00	20	31.25
Farming Experience								
10 years and below	1	4.76	3	9.09	2	20.00	6	9.38
11-20	6	28.57	14	42.42	5	50.00	25	39.06
21-30	4	19.05	7	21.21	0	-	11	17.19
31-40	7	33.33	7	21.21	2	20.00	16	25.00
41 years and above	3	14.29	2	6.06	1	10.00	6	9.38
Educational Attainment								
Elementary Undergraduate	5	23.81	8	24.24	1	10.00	14	21.88
Elementary Graduate	1	4.76	3	9.09	1	10.00	5	7.81
High School Undergraduate	2	9.52	6	18.18	0	-	8	12.50
High School Graduate	6	28.57	8	24.24	2	20.00	16	25.00
College Undergraduate	5	23.81	3	9.09	-	-	8	12.50
College Graduate	1	4.76	5	15.15	5	50.00	11	17.19
Vocational Graduate	1	4.76	-	-	1	10.00	2	3.13
Organizational Membership								
Irrigators Association	3	14.29	13	39.39	2	20.00	18	28.10
Farmers Association	17	80.95	17	51.52	7	70.00	41	64.06
Cooperatives	6	28.57	-	-	1	10.00	7	10.94
Others	-	0.00	-	-	-	-	-	-
None	2	9.52	6	18.18	1	90.00	9	14.06

Profile of Corn Farmer-Respondents

The demographic profile of the respondents is shown below (Table 22). It shows that the majority of the respondents are male and 41 years old or older. The majority of them have been into farming for more than a decade. In terms of education, all of the farmers have at least attended some formal education. As regards membership in organizations, the majority of the farmers are members in at least one or more organizations such as farmers and irrigators associations and cooperatives among others. This implies the important roles of the various organizations in contributing to the needs of the farmers. However, few of them are not affiliated with any association which means that these farmers may have not yet recognized the importance of being part of an organization. For instance, there are government programs that would require farmers to organize themselves so they can access the various forms of assistance being offered. Government services such as crop insurance can be easily accessed via farmer associations or cooperatives. According to Araullo (2006) & Deriada (2005), cooperatives and associations act as a means by which farmers can access services from government institutions such as extension services, formal credit, and insurance programs.

Table 22. Respondents Profile, Corn Farmers, Ifugao

Item	Beneficiary (n=38)		Non-Beneficiary (n=31)		Total (n=69)	
	n	%	n	%	n	%
Sex						
Male	18	47.37	19	61.29	37	53.62
Female	20	52.63	12	38.71	32	46.38
Age (mean)	**47**		**42**		**45**	
20-30	2	5.26	8	25.81	10	14.49
31-40	10	26.32	7	22.58	17	24.64
41-50	14	36.84	6	19.35	20	28.99
51-60	6	15.79	8	25.81	14	20.29
61 and above	6	15.79	2	6.45	8	11.59
Farming Experience (mean)	**24**		**14**		**19**	
10 years and below	8	21.05	16	51.61	24	34.78
11 - 20	13	34.21	9	29.03	22	31.88
21-30	9	23.68	2	6.45	11	15.94
31-40	2	5.26	3	9.68	5	7.25
41 years and above	6	15.79	1	3.23	7	10.14
Educational Attainment						
Elementary Undergraduate	3	7.89	6	19.35	9	13.04
Elementary Graduate	1	2.63	0	0.00	1	1.45
HS Undergraduate	7	18.42	6	19.35	13	18.84
HS Graduate	11	28.95	5	16.13	16	23.19
College Undergraduate	6	15.79	5	16.13	11	15.94
College Graduate	9	23.68	9	29.03	18	26.09
Vocational Graduate	1	2.63	0	0.00	1	1.45
Organization Membership						
Irrigators Association	3	7.89	3	9.68	6	8.70
Farmers Association	28	73.68	10	32.26	38	55.07
Cooperatives	11	28.95	1	3.23	12	17.39
Others	3	7.89	1	3.23	4	5.80
None	4	10.53	17	54.84	21	30.43

The average area cultivated by beneficiaries of crop insurance is 2.48 hectares while the non-beneficiaries cultivate an average area of 2.71 hectares (Table 23). The most common cropping pattern practiced by all of the farmers is corn-corn. The area allows two cropping seasons, planting for the wet season starts from May to June and harvesting is from September to October while for the dry season, planting occurs between November to December and harvesting happens between March to April. Furthermore, all of them rely on rain as their source of irrigation.

Table 23. Farm Profile and Farming Characteristics of Corn Farmers, Ifugao

Item	Beneficiary		Non-Beneficiary		Pooled	
	Mean	Range	Mean	Range	Mean	Range
Area (ha)	2.48 (1.53)	0.75-8	2.71 (2.32)	0.5-10	2.58 (1.91)	0.50-10
Distance of Parcel to water source (km)	-	-	-	-		
Distance of Parcel to water source (mins)	-	-	-	-	-	-
Distance from parcel to house (mins)	28.49 (46.36)	1-240	15.36 (17.91)	2-30	22.65 (36.90)	1-240
Distance from parcel to nearest market (mins)	32.32 (28.30)	3-120	32.52 (17.76)	3-90	32.42 (23.38)	3-120

Profile of Tomato Farmers Respondents

The profile of respondents in the study of the cost-benefit analysis of tomatoes in Ifugao reveals interesting patterns, particularly in terms of sex, age, educational background, and membership in an organization (Table 24). Based on the results, crop insurance beneficiaries are predominantly female, whereas non-beneficiaries are mostly male. Doss (2001) discusses how various socio-economic factors, including the role of women in agriculture and their access to resources, might contribute to this gender disparity. Furthermore, the study indicates that both beneficiary and non-beneficiary farmers, who are within the middle age range, actively engage in tomato farming in Ifugao. This aligns with findings from agricultural studies, such as those by Feder et al. (2001), emphasizing the significant role of middle-aged farmers in the agricultural sector.

The two groups have different levels of education. Most of the beneficiaries have graduated from high school, while most of the non-beneficiaries have only finished primary school. Education plays a crucial role in farmers' decision-making processes, as educated farmers are often better equipped to adopt new technologies and engage in more sophisticated farming practices (Foster and Rosenzweig, 2010). The study's results imply that there may be a connection between the level of education and the adoption of new technologies in agriculture. Furthermore, the fact that almost all respondents, whether beneficiaries or not, are members of an organization and are mostly members of farmer associations shows how important it is to them in the farming community to work together and take action as a group. Barrett's (2008) studies stress that farmers' associations are very important for enhancing agricultural productivity and helping farmers deal with common problems they all face.

Table 24. Respondents Profile, Tomato Farmers, Ifugao

Items	**Crop insurance Beneficiary (n=37)**		**Non-Beneficiary (n=49)**		**Total (n=86)**	
	n	%	n	%	n	%
Sex						
Male	14	37.84	26	53.06	40	43.96
Female	23	62.16	23	46.94	46	50.55
Age						
20-30	6	16.22	8	16.33	14	15.38
31-40	8	21.62	16	32.65	24	26.37
41-50	15	40.54	11	22.45	26	28.57
51-60	8	21.62	12	24.49	20	21.98
61 and above	0	0.00	2	4.08	2	2.20
Farming Experience						
10 years and below	13	35.14	22	44.90	35	38.46
11 - 20	14	37.84	14	28.57	28	30.77
21-30	5	13.51	9	18.37	14	15.38
31-40	5	13.51	3	6.12	8	8.79
41 years and above	0	0.00	1	2.04	1	1.10
Educational Attainment						
Elementary Undergraduate	4	10.81	10	20.41	14	15.38
Elementary Graduate	4	10.81	14	28.57	18	19.78
HS Undergraduate	2	5.41	7	14.29	9	9.89
HS Graduate	11	29.73	6	12.24	17	18.68
College Undergraduate	7	18.92	4	8.16	11	12.09
College Graduate	8	21.62	8	16.33	16	17.58
Vocational Graduate	1	2.70	0	0.00	1	1.10
Organization Membership						
Irrigators Association	3	8.11	6	12.24	9	9.89
Farmers Association	27	72.97	26	53.06	53	58.24
Cooperatives	10	27.03	19	38.78	29	31.87
Others	6	16.22	4	8.16	10	10.99

None	5	13.51	11	22.45	16	17.58

Data Collection

The study used survey data of beneficiaries or users and non-beneficiaries or counterfactual farmer practices. The quantitative data was supplemented by qualitative data based on open-ended questions in the survey with probing, focus group discussions (FGDs), and key informant interviews with groups or individuals relevant to the identified adaptation practices. FGDs were conducted with user groups, and key informants are the farmers' presidents and LGU personnel.

For the evaluation of the adaptation practices for rice farming, farmers using water pumps, rainfed farmers, and farmers with irrigated rice farms were purposively sampled. The inclusion criteria for the respondents are: 1) the farmer is planting rice in at least one farm parcel; 2) their rice farm is located in the top three rice-producing barangays in the municipality; and 3) at least one of their parcels was supported with an irrigation system or water pump in the reference cropping seasons 2021 wet and dry seasons. For the counterfactual sample, purely rainfed farmers whose farms are purely rain-dependent in the said cropping calendar. The final number of respondents interviewed is 24 from the municipality of Alfonso Lista (8 farmers with irrigated rice fields, 9 rainfed, 7 water pump-users), 10 from Lagawe (5 farmers with irrigated rice fields, 5 rainfed farmers), and 30 from Lamut (20 farmers with irrigated rice farms, 7 rainfed, and 3 pump users).

In the case of corn farming, at least 69 farmers were interviewed using an interview schedule from the top three-corn producing municipalities. The inclusion criteria for the respondents are: 1) their farm is located in the top corn-producing areas in the municipality; 2) they are availing crop insurance for at least one of their farm parcels during the reference copping seasons 2021 wet and dry seasons. For the counterfactual sample, corn farmers that never or did not avail crop insurance for the said reference cropping season. The final number of respondents interviewed is 38 crop insurance beneficiaries and 31 non-beneficiaries.

In the case of tomato farming, at least 86 tomato farmers were interviewed from the top three-tomato producing municipalities. The inclusion criteria for the respondents are: 1) their farm is located in the top tomato-producing areas in the municipality; 2) they are availing crop insurance for at least one of their farm parcels during the reference copping seasons 2021 wet and dry seasons. For the counterfactual sample, tomato farmers that never or did not avail crop insurance for the said reference cropping season. The final number of respondents interviewed is 37 crop insurance beneficiaries and 49 non-beneficiaries.

The interview was done face-to-face using an interview schedule, which was pretested in a previous study under the same program area by the same researchers (see Launio et al., 2022) and modified and supplemented based on the identified adaptation practices. Respondents were informed about the project and consent through signature was sought before the interview. Validation of the survey data was done through recall to survey respondents by phone, and through focus group discussion with crop stakeholders in the study areas. Invited participants during the validation are farmer leaders in the relevant municipalities, agricultural extension workers, and other key stakeholders and informants in relation to the adaptation being evaluated.

Data Analysis

Depending on the type and the adoption status of the climate resilient adaptation practices identified by Pablo et al. (2023) for the identified priority hazards for the province in Lumbres et al. (2023), cost and return analysis, and cost-benefit analysis (CBA) were used to analyze the financial and economic feasibility of the climate resilient adaptation practice relative to farmer practice or the counterfactuals. ANOVA and T-test (parametric or non-parametric) were used to analyze whether differences between adopters and non-adopters or between adaptation and counterfactual were significant.

For corn and tomato adaptation practices, CBA and CRA were used to determine the economic feasibility of availing crop insurance. Net effects were calculated to determine the financial gain or loss from adopting wherein a positive change in income indicates a net financial gain to farmer-adopter. The CBA assumptions were based on the actual data generated from the survey and data and information from key informant interviews. Also, coding and recoding were done to arrive at the most common farmer's perceptions of the advantages and disadvantages of the adaptation strategies.

For the cost-benefit analysis, net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR), and payback period (PP) were used as economic indicators. The NPV is the value of the discounted future net benefits. In this study, the net benefits of intervention were computed as the difference or change in the net benefits when using the climate-resilient adaptation (e.g., rice production with water pump) compared to the counterfactual (rain-dependent rice production). If the resulting NPV of the adaptation practice considering the assumed project duration is greater than zero, it is viable and would be profitable for the farmers to use. Otherwise, an intervention with an NPV<0 should not be promoted. BCR is calculated by dividing the total discounted benefits by the total discounted costs, while the internal rate of return (IRR) is the discount rate that makes the NPV=0. The intervention is deemed worthwhile to invest in if the BCR>1. For the IRR, the decision rule is that the adaptation practice is worth implementing if the calculated IRR is greater than the acceptable discount rate. The discount rate used in this study is 10%, which is the NEDA-ICC recommended rate. While the evaluation framework is largely using the "with and without", this was not possible for some of the prioritized adaptation practices, so only qualitative perceptions were gathered. For those with substantial data, coding and recoding were done to arrive at the most common farmer's perceptions of the advantages and disadvantages of the adaptation strategies.

IV. RESULTS AND DISCUSSION

Economic Viability of the Prioritized Adaptation Practices for Rice Production in Ifugao

Use of Water Pump as an Adaptation for Drought

Comparative Farm Profile

Farmer respondents with irrigated rice farms cultivate an average area of 1.18 hectares, while farmers with water pumps cultivate an average of 1.55 hectares and rainfed farmers cultivate an average area of 1.19 hectares (Table 25). This average area cultivated for rice by respondents is much higher than the average farm size in Ifugao based on the Census of Agriculture in 2012, which is 0.46 hectares per farm parcel (https://openstat.psa.gov.ph). The average irrigated farm holding in Ifugao is recorded at 0.49 ha per parcel for rainfed, and 0.41 for irrigated.

Table 25. Farm Profile and Farming Characteristics

	Rainfed		Irrigated		Water Pump Users		Pooled	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Area (ha)	1.19 (1.27)	0.3-6	1.18 (1.05)	0.25-5	1.55 (1.32)	0.5-5	1.24 (1.16)	0.25-6
Distance of Parcel to Water Source (km)	1.29 (1.21)	0.15-3	0.75 (1.14)	0.001-4	0.21 (0.35)	0.015-1	0.71 (1.07)	0.001-4
Distance of Parcel to Water Source (mins)	31.67 (24.66)	15-60	20.51 (27.19)	0.20-60	7.86 (7.03)	1-20	18.79 (20.39)	0.2-60
Distance of parcel to house (mins)	11.24 (8.24)	2-30	13.45 (14.85	0.5-60	11.22 (8.79)	1-25	12.38 (12.07)	0.5-60
Distance of parcel to nearest market (mins)	35.83 (19.40)	5-60	24.36 (17.53)	1-60	39 (29.24)	15-90	31.16 (20.64)	1-90

Perceived Changes as a Result of Using Water Pumps

Table 26 itemizes the farmers' perceptions of the changes in rice farming as a result of using water pumps for their rice production. The top perceived impact for farmers is that it increases their yield, especially during the dry season. This perception is confirmed in the observed data based on the before and after data of water pump users interviewed for this project. On the other hand, the only disadvantage mentioned by the farmers is the much higher fuel cost, especially since fuel prices are increasing. As analyzed by Reyes et al. (2008), the increase in fuel prices would affect sectors that are dependent on fuel such as agriculture-related industries, especially those farmers who are poor.

Table 26. Farmer's perceptions on the advantages of having/using a water pump in Ifugao (n=15)

Item	Frequency	%
Increase in yield	7	46.67
We can now supply water to our rice farm	5	33.33
Can be used as supplemental for irrigation	3	20.00
Our rice farm is not affected by drought	2	13.33
Can now plant during dry season	1	6.67
Easy irrigation during dry season	1	6.67
No answer	1	6.67

Observed Changes in Cropping Intensity, Yield, and Income

Cropping Intensity. Farmers supported by water pumps and communal irrigation systems usually plant rice-rice cropping systems, while the majority of rainfed farmers plant rice only once during the wet season (Table 27). The wet season rice is usually planted from June to July and harvested from September to October, while dry-season rice is planted from January and harvested from April to May. This result confirms the conclusion of many studies on the influence of improvement of irrigation on land productivity, particularly on cropping intensity (Karunakaran and Palanisami, 1998; Mondal and Sarkar, 2021; Launio and Abyado, 2022). Thapa and Scott (2019) also underscored the benefits of structural adaptation practices, such as expanding water sources in highly water-stressed rice areas with farmer-managed irrigation systems. They found that a cropping intensity of around 2.8 is maintained in systems that implemented some form of adaptation actions.

Table 27. Cropping Intensity of Rice Farmers

Cropping Pattern	**Rainfed**		**Irrigated**		**Water Pump Users**		**Pooled**	
	n	%	n	%	n	%	n	%
Rice-Fallow	12	57.14	1	3.03	1	10	14	21.88
Rice-Rice	8	38.10	31	93.94	8	80	47	73.44
Rice-Vegetables	1	4.76	1	3.03	1	10	3	4.69

Change in Input Use. Average input-use often differs between rainfed and irrigated rice ecosystems. In the case of rice farming in Ifugao, the application of urea and complete (14-14-14) fertilizers was found higher for farms supported with water pumps or CIS (Tables 28 and 29). In addition, herbicide-use was also higher for rainfed farmers and during the dry season. This is contrary to the result of Beltran et al. (2013) in which herbicide-use is significantly higher in irrigated rice arguing that the application of herbicides is more effective if water is controlled. Donayre et al. (2022) reported experiments in dry-seeded-drip-irrigated rice showing that the effect of season and weed control technique treatments was significant on weed density and biomass, where higher weed density was observed during the dry season. In the case of molluscicide use, results in Ifugao show similar use of molluscicide in irrigated farms, while Lumbres et al. (2023) showed that molluscicide-use is higher in irrigated rice compared to rainfed in the case of Apayao.

Table 28. Average Input use for Conventional Rice Farming in Ifugao for Wet Season of 2021.

Item	Rainfed Farmers	Water pump Users	CIS-Irrigated	Pooled
Urea (kg/ha)	96.99	137.50	163.12	137.42
Triple 14 (kg/ha)	93.94	112.92	137.86	119.00
Ammonium Phosphate (kg/ha)	30.67	38.75	30.06	31.62
Foliar (L/ha)	1.39	1.60	1.51	1.48
Herbicide (L/ha)	1.66	0.81	1.15	1.26
Pesticides (L/ha)	1.00	1.12	1.41	1.23
Fungicides (kg/ha)	0.20	0.42	0.07	0.17
Molluscicide (kg/ha)	0.53	0.51	0.51	0.48

Table 29. Average Input use for Conventional Rice Farming in Ifugao for Dry Season of 2021.

Item	Rainfed Farmers	Water pump Users	CIS-Irrigated	Pooled
Urea (kg/ha)	78.13	147.92	143.33	133.23
Triple 14 (kg/ha)	96.88	123.44	119.26	116.22
Ammonium Phosphate (kg/ha)	43.75	30.73	32.05	33.78
Foliar (LL/ha)	1.50	1.23	1.70	1.59
Herbicide (li/ha)	1.69	1.52	1.48	1.52
Pesticides (li/ha)	2.32	1.25	1.87	1.84
Fungicides (kg/ha)	-	0.38	0.36	0.30
Molluscicide (kg/ha)	0.63	0.62	0.62	0.62

Increase in yield. Figures 54 and 55 roughly show the difference in the on-farm paddy yield distribution between rainfed farmers and farmers with water pumps. Figure 54 shows that most of the rainfed farmers' yields ranged from 3.1 to 4 tons/ha while farmers supported with water pumps and communal irrigation systems had yields ranging from 4.1 to 6 tons/ha. Some water pump users and farmers with irrigated rice farms even reached the range from 6.1 to 7 tons/ha and 7.1 to 8 tons/ha. However, for the dry season, most of the rainfed farmers' yields ranged only from 2.1 to 3 tons/ha, while farmers with water pumps had yields ranging from 3.1 to 4 tons/ha and could reach a maximum of 6.1 to 7 tons/ha (Figure 55). Farmers supported with CIS yielded 5.1 to 6 tons/ha and can reach a maximum of 7.1 to 8 tons/ha.

In terms of the mean difference between rainfed, use of water pump, and CIS-supported rice farms, the mean differences among the three groups are highly significant based on ANOVA (F-value of 6.24). The yield of farms supported with water pumps is almost 2 tons/ha higher than rain-dependent rice farms. Rice yield in CIS-supported farms was not significantly different from yields in farms using water pumps. Moya et al. (2002) also reported no differences in yields or input use between farms irrigated by pumps or by gravity except for water-use. Other previous studies in the Philippines point to the yield advantage of using small-scale irrigation in rice. Launio and Malasa (2014) using data from 33 major rice-producing provinces in the Philippines indicated that CIS users have rice yields 18% higher than rainfed, while pump users have 8% higher yields than rainfed farms. Also, farms supported by tube wells and gravity irrigation canals yield significantly higher than purely rainfed areas based on the case of Central Luzon, but no significant difference was found in the rice production cost across irrigation systems in the wet season (Launio and Manalili, 2015). These results were similar to the case of Apayao where farmers who used water pumps had a significant yield advantage of 1,225kg/ha compared to rain-dependent farmers, which resulted in higher income or a difference of PhP 13,529.39 per hectare (Lumbres et al., 2023). In other developing countries, Bhandari and Pandey found that in Nepal, the average yield of shallow tubewell owners was 25% and 86% higher than that of the water purchasers and rainfed farmers, respectively.

It is established by several studies that the climatic yield potential of rice is higher during summer or when radiation levels are high, but that also to realize this higher yield, fertilizer application also needs to be higher (Bouman et al., 2007). One of the limitations of this study is that we only looked at the socioeconomic indicator. Mondal and Saleh (2002) presented a study where they also used hydraulic and agricultural indicators along with socioeconomic indicators. They also concluded that in the case of rice farming in Bangladesh, both deep and shallow tubewells were financially viable and sustainable.

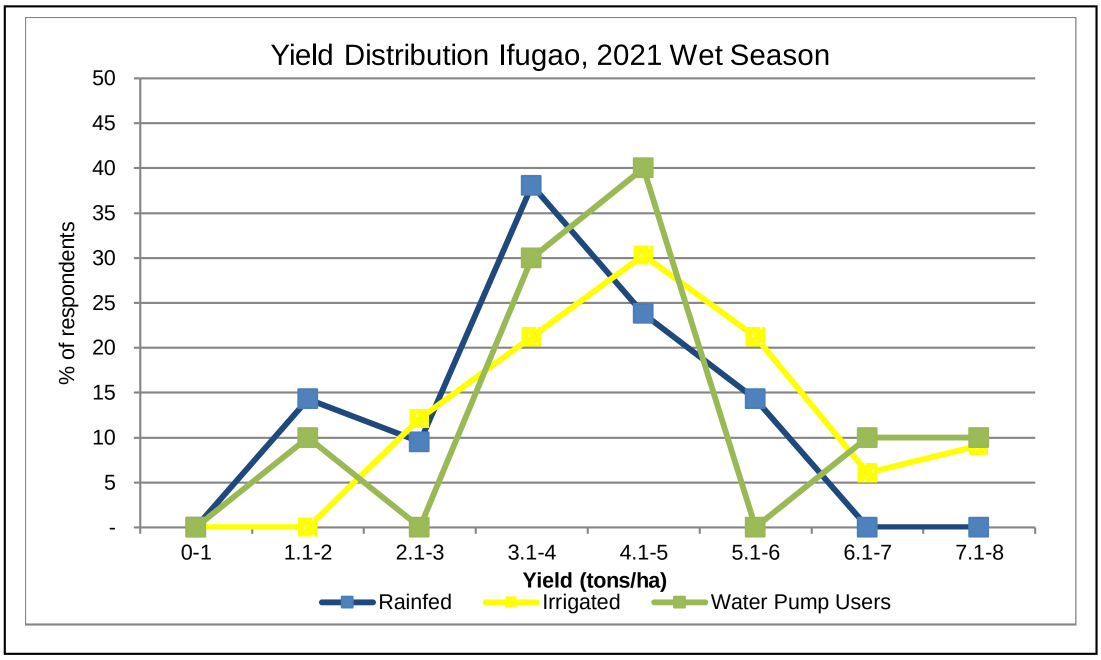

Figure 54. Yield Distribution of Ifugao Rice Farmers, 2021 Wet season

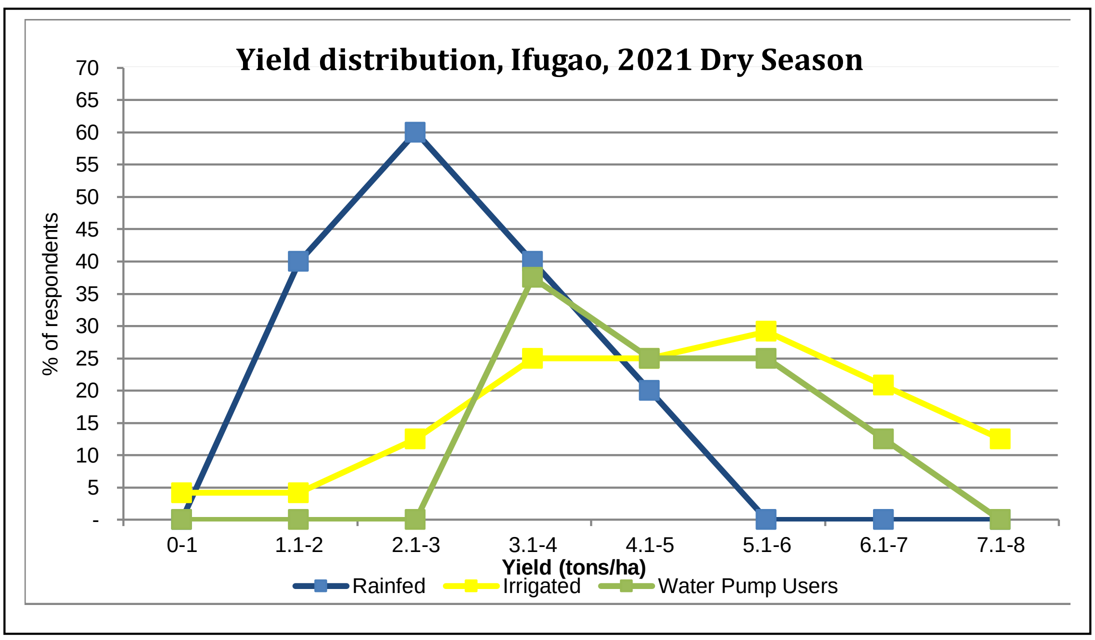

Figure 55. Yield Distribution of Ifugao Rice Farmers, 2021 Dry season

Change in income. Tables 30 and 31 present the detailed cost and return analysis of conventional rice production in Ifugao during the 2021 wet and dry seasons, respectively comparing farmers who are rain-dependent, farmers with irrigated rice farms, and farmers using water pumps. For the WS in terms of their total production cost farmers with irrigated rice farms and farmers using water pumps almost have the same production cost while rainfed farmers had a lower production cost also not significant which can be associated with their fertilizer cost and pre-harvest labor. During the dry season, the mean differences in total production cost among the three groups were highly significantly different ($p < 0.004$), which can be explained partly by the significantly different mean fertilizer costs.

In terms of economic profitability when all non-cash costs and imputed costs are considered, farmers with irrigated rice farms and farmers with water pumps appear to be economically profitable, unlike rain-dependent farmers that are almost just getting a breakeven with a net profit of Php 730.61 per hectare during the wet season. ANOVA tests show that yield, gross return, and land rental per hectare were significantly different among the three groups at a 5% level of significance (F-value of 3.8, 3.8, and 3.3, respectively). Results also show a 5% level of significance for net income among the three groups with an F-value of 3.44. In terms of net returns to land management the rain-dependent, water-pump users, and irrigated rice farmers were significantly different at 10% level of significance (F-value of 6.5).

Similarly, during the dry season, the mean differences in yield and gross returns were significantly different among the three groups at 1% level of significance (Table 30). During the DS, the majority of farmers who were rain-dependent were not able to plant, with only eight farmers able to plant. Those who were able to plant incurred a loss of Php 4,124.45 per hectare or a net-profit cost ratio of -0.08 considering imputed costs. Assuming that their operator and family labor and the returns to owned land are considered income, they get Php 8,322.78 per hectare. Farmers with irrigated farms and farmers using water pumps during the DS of 2021 are getting positive net profits assuming the significant yield difference of almost double compared to the purely rainfed farmers. The total cash production costs were highest when using water pumps, because of the high fuel cost to be able to supply sufficient water to their farm. Rice production using water pumps in Ifugao during the dry season resulted in an estimated net profit-cost ratio of 0.18, which was also supported by previous studies as mentioned earlier. ANOVA shows that the mean yield difference of the water pump-users, irrigated rice farms, and rain-dependent farmers were significantly different at 10% level of significance (F-value= 6.24). Gross returns, cash costs, and total production costs also significantly differ among the three groups at a 10% level of significance (F-value of 6.24, 6.24, and 5.75, respectively). The fuel costs among farmers using water pumps, irrigated areas, and rain-dependent farmers were significantly different at 5% level of significance.

Table 30. Cost and Return Analysis of Conventional Rice Production in Ifugao for Wet Season 2021.

	(1) Rainfed (n=21)	**(2) Irrigated (n=33)**	**(3) Water Pump Users (n=10)**	**Diff. (2)-(1)**	**Diff (3)-(1)**	**Sig.**
Average Area Cultivated (ha)	1.19	1.18	1.55	(0.01)	0.36	
GROSS Returns (Php ha^{-1})	59,707.24	76,714.06	70,392.50	17,006.82	10,685.26	**
Total harvest (kg ha $^{-1}$)	3,701.63	4,755.99	4,364.07	1,054.36	662.45	**
Price (Php kg $^{-1}$)	16.13	16.13	16.13	-	-	
COSTS (Php ha^{-1})						
CASH COST						
Seed/Planting Material	561.90	264.85	600.00	(297.06)	38.10	
Fertilizer	10,704.64	15,303.80	14,851.92	4,559.16	4,147.27	**
Herbicides	1,341.75	1,377.27	1,736.17	35.51	394.41	
Pesticides	2,209.95	2,563.07	1,947.17	353.11	(262.79)	
Preharvest Labor	9,278.50	13,198.32	13,834.33	3,919.82	4,555.83	
Harvesting	9,862.60	11,189.32	9,240.19	1,326.71	(622.41)	
Land Rental	3,141.71	586.61	655.28	(2,555.10)	(2486.43)	
Food Cost	6,248.37	6,182.87	5,087.50	(65.50)	1,160.87	
Fuel Cost	1,634.80	1,179.64	1,819.17	(455.17)	184.36	
Transportation Cost	882.34	47.18	292.50	(835.16)	(589.84)	
Other Production Cost	1,139.33	974.40	1,240.83	(164.93)	101.50	
Total Cash Costs	47,005.90	52,567.31	51,305.05	5,861.40	4,299.15	
Non-Cash Costs						
Seed	3,021.43	3,345.45	3,000.00	324.03	21.43	
Preharvest Labor	4,349.27	3,878.14	2,291.42	(471.12)	(2057.85)	
Harvesting	1,044.44	481.46	87.81	(562.99)	(956.63)	
Land Rental	3,235.09	6,760.44	6,748.76	3,525.35	3,513.67	**
Depreciation Cost	320.50	71.34	105.42	(249.16)	(215.09)	

Total Non-cash Costs	11,970.73	14,536.84	12,233.40	2,556.10	262.67	
Total Production Costs	58,976.64	67,404.14	63,538.46	8,427.51	4,561.82	
Net Profit P/ha	730.61	9,309.92	6,854.05	8,579.31	6,123.44	
Net Profit Cost-Ratio	0.01	0.14	0.11	0.13	0.10	
Net Returns Land & Management	12,701.34	23,846.76	19,087.45	11,145.42	6,386.11	***

***,**,*means significant at 1%,5%, and 10%, respectively

Even with the highly significant production costs, the net income and returns to labor and management are also significant among the three groups. The profitability of using irrigation is even higher when the payment for operator and family labor and own land rent are considered income. These results are somewhat similar to the case of Apayao conducted by the same project with the same cropping calendar showing that the net profit-cost ratio of rice farmers using water pumps is higher by 0.04 or an additional income of 4 centavos for every peso invested for wet season cropping compared to rain-dependent farms, and a difference of 0.26 net-profit cost ratio for dry season for the same cropping year (Lumbres et al., 2022). Moya et al, (2002) found that even with the high cost of fuel for pumping water, pump users still get substantial farm profits from their rice production although not as much as those with good access to gravity irrigation. In 2002 prices, the net return to land management for pump users was about $593 per hectare (Moya et al.,2002).

Table 31. Cost and Return Analysis of Conventional Rice Production in Ifugao for Dry Season 2021.

	Rainfed (n=8)	**Irrigated (n=32)**	**Water Pump Users (n=8)**	**Diff. (2)-(1)**	**Diff (3)-(1)**	**F-value Sig.**
Average Area Cultivated (ha)	0.98	1.19	1.66	0.22	0.69	
GROSS Returns (Php ha^{-1})	44,853.23	80,199.16	77,882.71	35,345.94	33,029.48	***
Total harvest (kg ha^{-1})	2,698.75	4,825.46	4,686.08	2,126.71	1,987.33	***
Price (Php kg^{-1})	16.62	16.62	16.62	-	-	
COSTS (Php ha^{-1})						
CASH COST						
Seed/Planting Material	-	748.44	1,687.50	748.44	1,687.50	
Fertilizer	9,675.31	13,451.14	14,696.15	3,775.83	5,020.83	
Herbicides	1,351.88	1,526.14	1,933.54	174.83	581.67	
Pesticides	2,647.19	2,390.04	1,890.00	(257.15)	(757.19)	
Preharvest Labor	6,856.25	13,275.65	12,543.61	6,419.40	5,687.36	
Harvesting	6,105.16	10,494.16	8,757.30	4,389.01	2,652.14	
Land Rental	1,490.61	1,185.20	908.91	(305.41)	(581.70)	
Food Cost	6,375.00	5,273.06	6,145.83	(1,101.94)	(229.17)	
Fuel Cost	1,093.75	1,552.72	7,251.04	458.97	6,157.29	**
Transportation Cost	454.06	56.25	256.25	(397.81)	(197.81)	
Other Production Cost	481.25	986.63	968,75	505.38	487.50	
Total Cash Costs	36,530.45	50,939.43	57,038.87	14,408.98	20,508.42	***
Non-Cash Costs						
Seed	4,087.50	2,493.75	2,437.50	(1,593.75)	(1,650.00)	
Preharvest Labor	4,287.19	4,011.87	1,396.35	(275.32)	(28290.83)	
Harvesting	1,378.13	809.23	62.89	(568.90)	(1,315.23)	
Land Rental	2,664.39	6,892.22	6,879.36	4,227.83	4,214.97	
Depreciation Cost	30.02	55.27	176.58	25.25	146.55	
Total Non-cash Costs	12,447.68	14,262.34	10,952.69	1,815.11	(1,494.54)	
Total Production Costs	48,977.68	65,201.77	67,991.56	16,224.09	19,013.88	***
Net Profit P/ha	-4,124.45	14,997.39	9,891.15	19,121.85	14,015.60	*
Net Profit Cost-Ratio	-0.08	0.23	0.15	0.31	0.23	
Net Returns Land & Management	8,322.78	29,259.74	20,843.83	20,936.96	12,521.06	*

Cost-Benefit Analysis of Using Water Pump

The following assumptions were considered:

a. The investment cost is based on the average cost of a 7HP, diesel, 2''diameter water pump with a market price of Php16000 and 90m thermoplastic rubberized hose that costs Php6000 for a total of Php22,000;
b. The assumed repair cost is 10% of the investment cost (1,600) with a 1,000 Regular maintenance cost yearly;
c. Estimated labor cost during irrigation (Php11,200.00); labor is assumed unskilled
d. Pump lifespan is 5 years.
e. The identified benefits were based on the survey and validated during focus group discussions are: increase in yield both during wet and dry seasons;
f. The discount rate is 10% based on NEDA-ICC recommendation
g. For the economic analysis, the adjustments of tradable goods from financial prices are considered by using SERF=1.20, and SWRF 0.60 for unskilled labor.

Given the above assumptions, the estimated NPV is positive at Php82,855 with a BCR of 1.93 and a payback period of 0.95 or around one year. The results imply that investing in a surface water pump is a worthwhile undertaking for a farmer. Similar studies arrived at this conclusion such as Purandare and Bajaj (2017) taking the case of lift irrigation in India, and Bhandari and Pandey (2017) taking the case of groundwater irrigation and shallow tubewell (STW) in Nepal. The use of STW generated significant positive effects on rice yield and farmers' incomes (Bhandari and Pandey, 2017). The use of water pumps contributed not only to the increased income of farmers but also to increased food production. Farmers also mentioned that having a water pump gives them confidence in planting during the dry season, given the effects of climate change that gives them unpredictable weather that sometimes causes them to delay their planting schedule in the absence of rain. With the use of a water pump, farmers can plant on their target planting time and ensure two croppings per year. Some farmers can even plant three times a year. The limitation of this study is that only the cropping intensity and average profitability were assumed and the optimum farm size for the use of the pump was not simulated. Masuku and Manyatsi (2013) also studied irrigation as an adaptation strategy in the case of corn and found that the NPV for farms using fuel engines to supplement rainfall during the planting season is higher than those that are not irrigating. They added that households need government intervention as the cost of irrigation is high.

Construction, Maintenance, and Clearing of Canals and Drainages and Control of Irrigation Water

Aside from specifically suggesting the use of a water pump, other irrigation-related identified adaptations are construction, maintenance, and clearing of canals and drainages, and control of irrigation water. Based on narratives during the validation, constructing and maintaining canals and drainages result in substantial yield advantage that can be gained which may translate to substantial positive net benefit by only ensuring that canals are maintained or drainages are cleared.

For the case of larger irrigation systems, data from NIA indicate that the service area of communal irrigation systems in Ifugao is 12,253.39 hectares (www.nia.gov.ph). This figure includes the other CIS established by other government agencies such as the Department of Agriculture. The latest case in Ifugao is the construction of the Hapid Irrigation System located in Lamut, Ifugao. Per program design, it covers 11 barangays with an estimated target service area of 1040 hectares during the wet season crop and a project cost of around Php70 million.

Planting Alternate Crops (for dry season crops)

Out of 23 rain-dependent farmers 11 farmers are planting alternative crops such as string beans, eggplant, corn, green peas, flowering peachy, mungbean, and others. However, these alternate crops were just planted in some portion of their area meaning they were not able to plant their whole area for example if they have a half hectare planted by rice during the wet season, and they can just plant less than 1000sqm and then the remaining 4000sqm will be fallow given that planting vegetables needed more management. That is why most of their vegetables are usually for home consumption, although few farmers are selling their vegetables and have mentioned that they can have an estimated net benefit of Php3000 for the dry season for selling their vegetables, given that their own land and family labor and management are not accounted for. Crop diversification is suggested in the literature as a beneficial coping mechanism for those who experienced extreme weather events (Ji-kun et al., 2014). In a study conducted by Williams, et al. (2020) on the CBA in the adoption considerations of five climate adaptation practices in two horticulturally focused municipalities in Ghana, one of the most notable adaptations are mixed cropping and crop rotation, which exhibited high IRR, low implementation costs, and a reduction in the amount of inputs used, making them the most suitable options for immediate adoption by farmers in Ghana. John (2009) as cited by Mohammed, et al .b(2013) also reported that mixed cropping had the highest gross margin among the drought-coping strategies practiced by crop farmers in Borno State, Nigeria. While it is also a climate adaptation, crop diversification also has other traditional benefits as a cropping system, especially when faced with market price volatility and physical environment (Ngoc Chi and Van Chin, 2003) and in the Philippines, given the issue of Rice Tariffication law (Dawe et al., 2006).

Planting Bamboo Along or Near Riverbanks and Erosion-Prone Areas

For farmers near the Lamut River not reached by the river control, they identified the planting of bamboo along or near the river banks or landslide-prone areas as potential and preferred adaptation for erosion control during strong typhoons. According to one farmer leader, one of their risk is the siltation of their irrigation canals and erosion of their rice fields. As mentioned by one respondent, *dagiyay daga nga magapu idiay ngatu gaburan na diay pagnaan ti danum, maianud maiselsel amin nga bato, darat ken daga* (Farmer leader key informant). The planting of bamboo is suggested in the upper area: *ditoy ngatu kuma ta dagidiay bato ken daga haan koma nga mai*-roll *nga mapan ladta idiay karayan ta inut-inot dayta gaburana diay baba.* Another respondent mentioned that *maianod talon nu awan ti bamboo nga nakamula*-R2 (Rice fields are eroded if there are no bamboos planted).

During the FGD to validate this adaptation, the key informants mentioned the lower barangays on both sides of the Lamut river–Panno, Lucban, Pisa, Babato, and some part of Magolon and Umilag are affected. Accordingly, both sides of the Lamut river are rice fields. The adaptation was conceptualized because according to a farmer leader, there was a provincial agriculture project in 2021 that promoted the planting of bamboo in the erosion-prone areas near the rivers in the municipality of Lamut. Unfortunately, not all of those who were given planted the bamboo.

The implied benefits of planting bamboo are the reduced desiltation and clearing costs, erosion and landslide control and prevent siltation of the river, and protection of the irrigation dams and rice farms:*"Nu malpas bagyo, apan da linisan manen; ket diay medyo narigat ket agusar da backhoe ta a agdesilt da ta syempre dagita daga dagiyay maianud nga kuwa maiselsel idiay irigasyon."* Accordingly, the cost of using backhoe for desilting is Php1500 to Php2000 per hour or, if manual labor and if around 50 meters need to be cleared, it will need 30 persons to do it manually for one day.

The uses of bamboo as an adaptation as identified by the Ifugao farmers support the results of Atmanto et. al. (2023) and Goswani et al. (2022) that planting bamboo is an inexpensive option to control erosion and preserve riverbanks. Bamboo plants possess ecological benefits due to their ability to absorb rainwater which can reduce soil erosion (Atmanto et al. (2023). Deep roots of bamboo plants facilitate water absorption which is also beneficial in water conservation.

Use of hybrid corn seeds

The corn farmers in the province used hybrid corn seeds since it is believed that hybrid corn seeds offer an improved yield potential, uniformity in crop performance, and resistance to pests and diseases among others. The hybrid corn seeds used by corn farmers are derived from various sources. Most of the farmers who are producing corn during the wet and dry seasons sourced their corn seeds from farm supplies available in the area. While there are some corn seeds provided by the Department of Agriculture, other farmers obtained their seeds from financers and from their own produce.

Table 32. Sources of corn seeds used by Ifugao corn farmers, 2021

	Wet season (n=69)	%	Dry Season (n=67)	%
Farm Supply	61	88.41	57	85.07
DA	3	4.35	6	8.96
Own Produce	1	1.45	1	1.49
From Financer	4	5.80	3	4.48

Yield advantage

The yield of corn farming when hybrid seeds are used in planting is higher compared to “labos” seeds (Figure 56 and Figure 57). “Labos” is the farmer’s term for corn seeds that are usually mixed varieties from their harvest that can be replanted for the next season. The figure shows that the yields of farmers using hybrid seeds are mostly in the range of 4-5 tons while 3-5 tons for “labos” seeds users, both wet and dry seasons. This corresponds to the study of De Jonge et al., (2021) wherein they stated that hybrid maize varieties may reach yields of 8 tons per hectare (Bertomeu,2012; Manila Bulletin, 2020; Pioneer, 2012) while sige-sige varieties (maize OPV) tend to peak at 5 tons per hectare. In terms of mean difference, Tables 15 and 16 show that the average mean yield advantage of farmers planting hybrids was 580 kg/ha and 1391 kg/ha for wet and dry season, respectively. These yield differences of planting hybrid corn over *labos* were found highly significant.

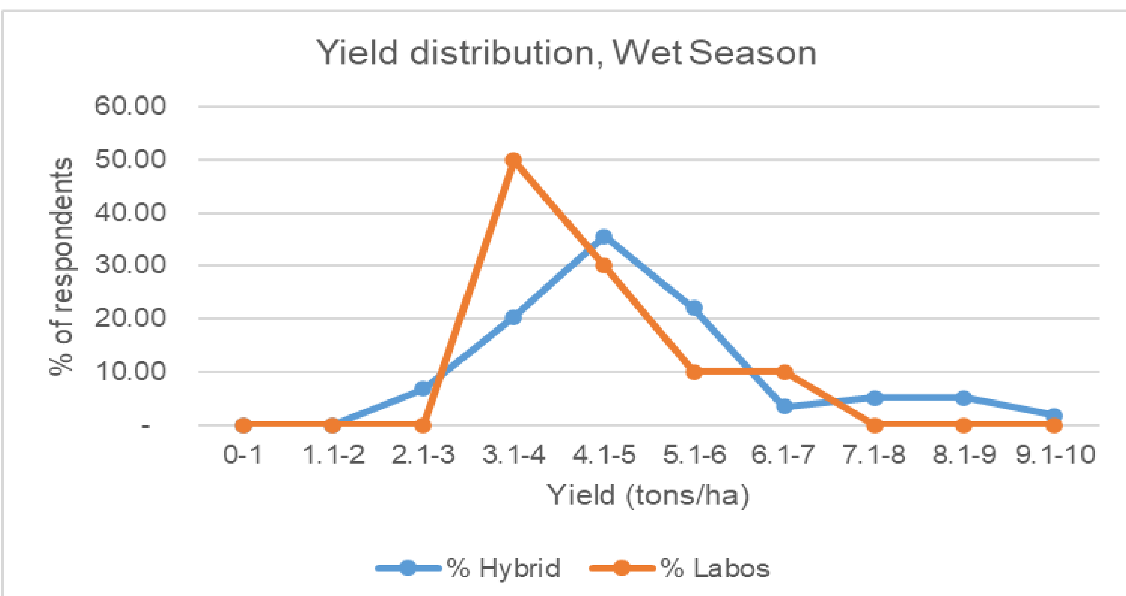

Figure 56. Yield Distribution of Hybrid and "Labos" seeds, 2021 WS

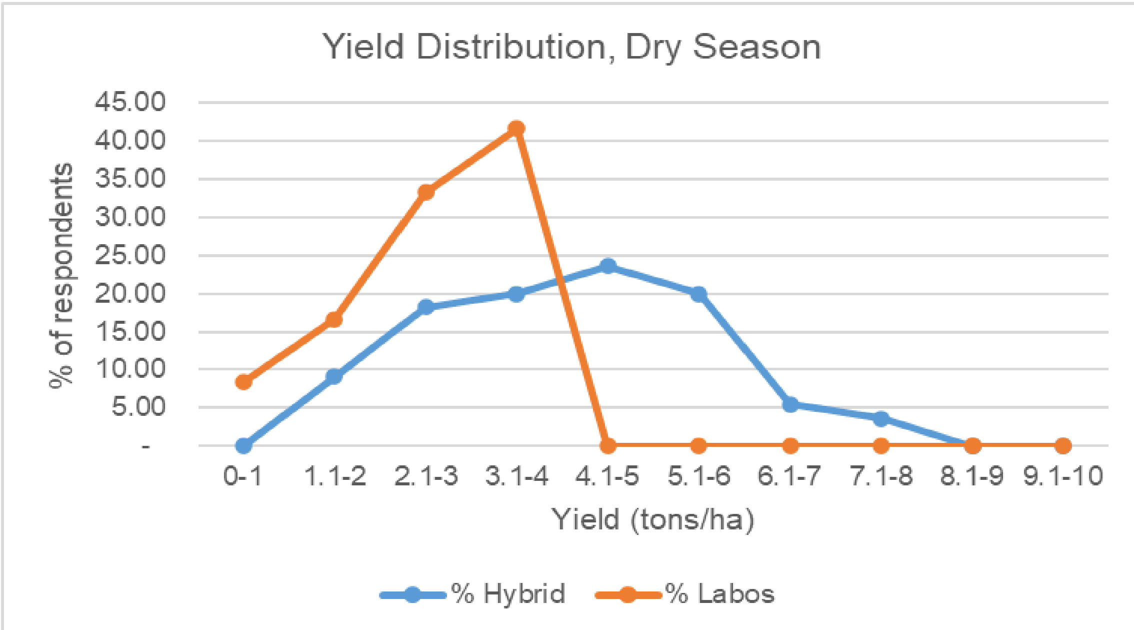

Figure 57. Yield Distribution of Hybrid and "Labos" seeds, 2021 DS

Difference in Average Input-Use

Corn production requires various farm inputs regardless of the planting season. The inputs like fertilizer, pesticides, and herbicides influence the overall success and productivity of the crop. Farmers should consider the quantity, quality, and timing of the application of the different inputs to ensure the effectiveness and efficiency of these inputs. Generally, as observed in Table 33 the dry season requires a higher amount of fertilizer for both hybrid and *labos* users. Hybrid seeds require more fertilizer than the *labos* seeds. However, in terms of herbicides and pesticides, the wet season requires a higher amount. In a report comparing the farm cost of production in the provinces of Cagayan and Isabela, the wet season indicated a higher farm cost (DA-BAR, 2022).

Table 33. Average Input-Use in Corn Production in Ifugao, 2021 Wet and Dry Seasons

Item	Hybrid Users	"Labos" Users	Pooled
WET SEASON			
Urea	265.58 kg/ha	181.73 kg/ha	253.43 kg/ha
Triple 14	237.61 kg/ha	152.28 kg/ha	226.24 kg/ha
Ammonium Phosphate	127.29 kg/ha	103.93 kg/ha	123.69 kg/ha
Foliar	1.22 L/ha	1.13 L/ha	1.21 L/ha
Herbicides	8.21 L/ha	8.97 L/ha	8.32 L/ha
Pesticides	0.39 L/ha	0.4 L/ha	0.39 L/ha
DRY SEASON			
Urea	261.59 kg/ha	208.4 kg/ha	252.06 kg/ha
Triple 14	235.76 kg/ha	188.69 kg/ha	228.27 kg/ha
Ammonium Phosphate	139.97 kg/ha	99.31 kg/ha	130.93 kg/ha
Foliar	1.2 L/ha	1.3 L/ha	1.22 L/ha
Herbicides	8.13 L/ha	7.9 L/ha	8.09 L/ha
Pesticides	0.46 L/ha	0.51 L/ha	0.47 L/ha

Difference in Net Profits

Table 34 & Table 35 presents the detailed cost and return analysis of corn production using hybrid seeds and *"labos"* seeds, for both wet and dry seasons. Both varieties of seed planted during wet and dry seasons appear to be economically profitable when all non-cash and imputed costs are considered as indicated by the values of the net profit-cost ratio which determines the amount of net profit generated considering the total cost incurred. For the wet season, hybrid seeds yield a 40% net profit-cost ratio while "*labos"* seeds yield a 41% net profit-cost ratio. This means that the corn farmers gained 40 centavos for every peso generated for hybrid seed and 41 centavos for every peso generated *"labos"* seeds. However, during the dry season, farmers using hybrid seeds have a higher net profit-cost ratio of 19% compared to the 2% of *"labos"* seed users. This implies that for every peso generated, the corn farmers earned 19 centavos for hybrid seed users and 2 centavos for *"labos"* seed users. The difference in net profit between hybrid and *"labos*" seed users can be associated with the difference in the total production cost wherein higher production costs can be seen under the farmers who use hybrid seeds. This can be associated with the higher seed and fertilizer costs of hybrid seed users during both wet and dry seasons as shown in Table 34 & Table 35. According to the farmers during the data validation, the seed cost difference between hybrid and *"labos"* is 5:1, for example, Php 5,000 for hybrid and Php 1,000 for "labos". In accordance, the Philippine Yellow Corn Industry Roadmap 2021-2040 (2022) stated that hybrid seeds have a higher yielding ability and uniformity thus higher price. Moreover, De Jonge et al., (2021) mentioned that farmers using maize OPV need only 50% of fertilizers needed for hybrid seeds thus making OPV's production costs much lower.

Table 34. Cost and Return Analysis of Corn Production, Wet Season, Ifugao 2021

	Wet Season (n=69)		
Item	Hybrid (n= 59)	Labos (n=10)	Difference
Average Area Cultivated (ha)	2.81	1.25	1.56
Returns			
Total harvest (kg ha-1)	4,979.14	4,399.15	579.98***
Price (P kg-1)	18.22	18.22	
Gross Returns (P/ha)	90,719.91	80,152.60	10,567.31***
CASH COSTS			
Seed/Planting Material	7,891.89	2,950.48	4,941.41
Fertilizer	23,841.53	17,943.19	5,898.34
Herbicides	3,314.74	3,750.68	-435.94
Pesticides	393.65	150.00	243.65
Pre-harvest Labor	8,756.23	6,262.86	2,493.37
Harvesting	6,217.23	8,712.54	-2,495.31
Land Rental	2,983.33	3,016.00	-32.67
Food Cost	4,577.44	6,463.69	-1,886.25
Fuel cost	1,806.23	165.00	1,641.23
Transportation Cost	1,350.37	1,133.75	216.62
Repair and Maintenance cost	1,241.84	1,175.00	66.84
Other Production Cost	217.57	291.21	-73.64
Total Cash Costs	62,592.05	52,014.40	10,577.65***
NON-CASH COSTS			
Pre-harvest Labor	1,762.86	3,978.21	-2,215.35
Harvesting	428.81	682.50	-253.69
Depreciation Cost	54.34	31.97	22.36
Total Non-Cash Costs	2,191.68	4,660.71	-2,469.04**
Total Production Costs	64,783.73	56,675.12	8,108.61**
Net Profit P/ha	25,936.18	23,477.48	2,458.70
Net Profit Cost-Ratio	0.40	0.41	-0.01
Net returns to land & management	28,127.86	28,138.20	-10.34

Table 35. Cost and Return Analysis of Corn Production, Dry Season, Ifugao 2021

	Dry Season (n=67)		
Item	Hybrid (n= 55)	Labos (n=12)	Difference
Average Area Cultivated (ha)	2.84	1.50	1.33
Returns			
Total harvest (kg ha-1)	4,164.31	2,772.99	1,391.33***

Price (P kg-1)	18.32	18.32	
Gross Returns (P/ha)	76,297.09	50,805.66	25,491.43***
CASH COSTS			
Seed/Planting Material	7,819.59	3,061.11	4,758.47
Fertilizer	23,865.16	19,409.86	4,455.30
Herbicides	3,465.94	2,716.56	749.38
Pesticides	473.31	243.06	230.26
Pre-harvest Labor	9,217.66	5,527.08	3,690.57
Harvesting	6,123.87	3,553.61	2,570.26
Land Rental	2,801.45	2,731.25	70.20
Food Cost	4,639.11	3,867.36	771.75
Fuel cost	373.78	59.72	314.05
Transportation Cost	1,152.77	717.08	435.68
Repair and Maintenance cost	1,947.31	2,326.39	-379.08
Other Production Cost	156.83	171.39	-14.56
Total Cash Costs	62,036.77	44,384.48	17,652.29***
NON-CASH COSTS			
Pre-harvest Labor	1,684.48	4,117.50	-2,433.02
Harvesting	237.27	1,090.28	-853.01
Depreciation Cost	20.39	200.14	-179.75
Total Non-Cash Costs	1,921.76	5,207.78	-3,286.02**
Total Production Costs	63,958.52	49,592.26	14,366.27**
Net Profit P/ha	12,338.56	1,213.40	11,125.16
Net Profit Cost-Ratio	0.19	0.02	0.17
Net returns to land & management	14,260.32	6,421.18	7,839.14

Availing of Crop Insurance

Area and No. of Farmers Availing Crops Insurance

Table 36 presents the total area cultivated for corn in Ifugao. It further shows that the number of farmers has remained the same since 2018, while the total number of beneficiaries increases each year except for 2022 where a slight decrease was recorded. There has been an increase in the number of farmers who availed of crop insurance starting in 2019. This can be associated with the calamity that happened in 2018 which may have prompted the farmers to apply for crop insurance considering its benefits to them. According to Philippine Yellow Corn Industry Roadmap 2021-2040 (2022), Typhoon Ompong which hits the country in 2018 affected 214,546 hectares of corn farms. The total area insured differs from the total area cultivated for corn since some of the farmers are paying a premium for their farm area that exceeds the qualified area covered by the subsidized insurance.

Table 36. Area and number of corn farmers with crop insurance in Ifugao from 2018-2022

Year	Total Area	Total No. of Farmers	Total Beneficiaries	% of Farmers under Crop Insurance	Total Area with Crop Insurance	Area % under Crop Insurance
2018	25,986.27	13,721.00	1,974	14.39	4,702.42	18.10
2019	25,986.27	13,721.00	2,532	18.45	4,554.42	17.53
2020	25,986.27	13,721.00	2,556	18.63	2,796.65	10.76
2021	25,986.27	13,721.00	2,826	20.60	5,518.42	21.24
2022	25,986.27	13,721.00	2,808	20.46	4,933.43	18.98

Table 37 shows the total number of corn farmers who received indemnity payments in Ifugao province. As mentioned, more farmers availed of crop insurance after 2018 because of calamities that happened in 2018. Further, more farmers from Alfonso Lista, Aguinaldo, and Lamut were availing of crop insurance since they are the top corn-producing municipalities in the province. As seen from the table, the number of farmers who availed crop insurance does not jive with the number of farmers who received indemnity payments. This implied that not all those who availed of crop insurance were affected or that they were not qualified to receive indemnity. There are some of the farmers who claimed to have been affected or have experienced damage but were not able to receive payment since they were not able to meet the requirements. Accordingly, the farmers were constrained by the requirements, moreover, they added that there was improper validation since some areas were not monitored/validated properly or validation was not conducted totally in their area. Before an indemnity will be paid to them, they need to document the damaged crop and submit a written report to the insurance company. This will be the basis for the insurance company to monitor and or validate the given report in their area to get the actual damage to the farmer's crop. Furthermore, the amount of the indemnity paid to them varies based on the percentage of crop damage.

Table 37. Total number of farmers who received indemnity payment in Ifugao Province form 2018-2020

	2018				2019				2020			
Municipality	Availed	Received Indemnity	Average Indemnity Payment (Php)	Total area that received indemnity	Availed	Recei-ved Indemnity	Total area that received indemnity	Average Indemnity Payment (Php)	Availed	Recei-ved Indemnity	Total area that received indemnity	Average Indemnity Payment (Php)
Aguinaldo	652	149	4,340.95	193	817	351	452.1	6,277.73	724	32	33.25	5,905.41
Alfonso Lista	1229	330	9,961.13	553.45	1439	761	1238.71	9,160.65	1473	125	184.5	11,744.43
Asipulo	-	-	-	-	3	-	-	-	1	-	-	-
Banaue	-	-	-	-	-	-	-	-	-	-	-	-
Hingyon	-	-	-	-	-	-	-	-	1	-	-	-
Hungduan	-	-	-	-	-	-	-	-	-	-	-	-
Kiangan	-	-	-	-	-	-	-	-	-	-	-	-
Lagawe	27	-	-	-	69	1	1.5	5,472.00	38	6	6	4,885.00
Lamut	61	-	-	-	191	50	36.5	3,549.38	283	4	4	5,139.00
Mayoyao	-	-			12	-	-	-	35	-	-	-

Farmers' Understanding and Perception about Crop Insurance

The understanding of farmers about crop insurance is shown in the table below (Table 38). Both the beneficiaries and non-beneficiaries have a similar understanding of crop insurance. Primarily, the beneficiaries claimed that crop insurance provides assistance or support in case of calamities like typhoons and drought or when the crop is infested with pests and diseases. Specifically, the farmers stated that *"nu matamaan kalamidad ti mula ket ada maala mi nga tulong"*. On the other hand, the majority of non-beneficiaries are not aware and have no idea about crop insurance which may have influenced their decision not to avail crop insurance. Interestingly, many of the non-beneficiaries claimed that crop insurance provides some form of assistance during calamities and that it is helpful.

Table 38. Farmers' Perceived Understanding of Crop Insurance

Item	Frequency	Percentage
Beneficiaries		
Availability of assistance during calamity	20	52.63
Provides support on damage incurred during typhoons, drought, plant diseases, or pest infestation	5	13.16
Offers cash/financial assistance	2	5.26
Security of crop	1	2.63
Provides cash assistance		
No answer/ No response	10	26.32
Total	**38**	**100.00**
Non-Beneficiaries		
No idea	17	54.84
It provides assistance if crops are damaged/destroyed due to a typhoon	7	22.58
Financial assistance for those affected by calamities	3	9.68
Assistance from the government	2	6.45
Security of crops in case of occurrence of disaster	1	3.23
Crop insurance is helpful	1	3.23
Total	**31**	**100.00**

Table 39 shows the perception of corn farmers in terms of availing crop insurance. The majority of the beneficiaries did not provide any answer. While the majority of them understand that crop insurance provides some kind of assistance during calamities, the experience of some of the farmers of not being able to receive indemnity during calamities may have influenced their perception of the actual benefits of crop insurance. Furthermore, the perceptions of the non-beneficiaries were consistent with their understanding of crop insurance. Majority of them have no idea about crop insurance hence they were unable to discuss any benefits.

Table 39. Perceived Benefits of Availing Crop Insurance

Item	Frequency	Percentage
Beneficiaries		
No answer	24	63.16
There is assistance given	7	18.42
Assistance given are used as capital to buy inputs for the next cropping season	3	7.89
Financial assistance given	2	5.26
Can help in financial needs use to pay loans incurred during production	1	2.63
There is assurance that if your crop is damaged there will be assistance given	1	2.63
Total	**38**	**100.00**
Non-Beneficiaries		
No idea/no answer	23	74.19
Can help financially when affected by typhoons, drought, pest infestation	3	9.68
You can received subsidy if your crop is damaged by drought/typhoon	2	6.45
Assistance to farmers	1	3.23
Provision of seeds and cash assistance for breakeven	1	3.23
In terms of calamities there is help from PCIC	1	3.23
Total	**31**	**100.00**

Table 40 enumerates the various constraints as perceived by the beneficiaries when availing of crop insurance. A higher number of beneficiaries stated that they had not encountered any constraints in availing crop insurance which means they have complied with the requirements and have received an indemnity payment for their damaged crop. Specifically, the farmers mentioned the following: *"awan ti pagmadian na basta agcomply ka ejay papers", "awan ta isuda met piman umay dituy ayan mi nga agpainsure ken libre met piman".* As for the other beneficiaries who were constrained in any form, some of the farmers cited issues related to indemnity. Some claimed that they have not received any indemnity while others stated that the payment received is not enough or is not fair given the area affected. Almost all of the farmers have availed of the subsidized insurance program through their registration with the RSBSA. Other farmers were constrained by the improper validation of their area affected or the processing of claims is time-consuming.

Table 40. Perceived Constraints of Availing Crop Insurance (Beneficiaries)

Item	Frequency	Percentage
None	27	69.23
No indemnity payment received	3	7.69
Indemnity not enough	2	5.13
Indemnity is same for all land area	1	2.56
Not enough information about the rules and regulations	1	2.56
Not fair in giving indemnity because of improper validation	1	2.56
Limited area to subsidized (free subsidized)	1	2.56
No indemnity will be given if no calamity is forecasted (even if calamity occurred)	1	2.56
Improper validation (some areas are not monitored/validated properly)	1	2.56
Processing is time consuming	1	2.56
Total	39	100.00

Table 41 describes the reasons why the non-beneficiaries never availed of crop insurance. Many of them have no response or have no idea about the crop insurance program and thus never availed of it. Aside from those who stated that they did not have time to apply, some non-beneficiaries never availed of crop insurance because the processing and waiting takes a long time. Moreover, some also stated that they never availed of crop insurance because they were disappointed since even if there are supplies from DA, not all are given, and also because they heard that some farmers are not given indemnity payments.

Table 41. Perceived Reasons of non-beneficiaries why never availed crop insurance

Item	Frequency	Percentage
No response/ No Answer	10	32.26
No idea/not aware about crop insurance/ program	10	32.26
No time to go apply/Busy	3	9.68
Long-time processing and waiting	3	9.68
Disappointed, because if there are supplies from DA not all are given	2	6.45
Disappointed because some farmers are not given indemnity payment as mentioned by co-farmers	1	3.23
Failed to report/ensure at the municipal office	1	3.23
Not eligible	1	3.23
Total	**31**	**100.00**

Cost-Benefit Analysis of Availing Crop Insurance

Table 42 illustrates the cost and benefit analysis of purchasing crop insurance, taking into account the financial benefits to a corn farmer purchasing crop insurance and the numerous potential scenarios surrounding the occurrence of typhoons and drought. Crop insurance is an adaptation strategy adopted by corn farmers in the area to mitigate the risk of climate change. Cost-benefit analysis is an examination of the adaptation strategy to evaluate the acceptability of the technology. As reported in Table 42, all the NPV values are positive which implies the economic benefit of corn farming, however, the NPV is significantly greater under the scenario when typhoons and drought damage occur annually. This means that it is beneficial for a farmer to get insurance to secure their crop in case of the occurrence of natural calamities such as typhoons and droughts. According to Pulhin et al., (2017), taking the case of Laguna, similarly concluded that investment in crop insurance is useful when catastrophic climate events are known with certainty. The indemnity provides readily available cash for the farmers during calamities especially when there is crop damage or losses. These benefit-cost estimates are limited to the indemnity benefits. They do not factor in other potential benefits such as reduced farms; reliance on short-term debt after a calamity and the production impacts of subsidized agricultural insurance in developing countries (Cai, 2016; Cole et al., 2017). In terms of the BCR, the case where there is annual damage yields the highest value which justifies the benefits of crop insurance.

Table 42. Summary results of cost-benefit analysis of corn farmers enrolling crop insurance, 5-yr period, 10% discount rate

Typhoon	Crop Insured Farmer			Uninsured Farmer
Parameters	Actual Damaging typhoon occurrence	With Yearly Damage	Without typhoon Damage	
Net Present Value (NPV)	102,805.43	120,931.48	92,521.09	93,658.32
PV of Benefits	334,154.97	352,281.02	323,870.62	323,870.62
PV of Costs	231,349.54	231,349.54	231,349.54	230,212.30
Benefit-Cost Ratio	1.44	1.52	1.40	1.41

Drought	Crop Insured Farmer			Uninsured Farmer
Parameters	Actual drought occurrence	With Yearly Damage	Without Drought Damage	
Net Present Value (NPV)	41,646.68	52,959.46	24,549.07	25,686.30
PV of Benefits	258,007.31	269,320.09	240,909.70	240,909.70
PV of Costs	216,360.63	216,360.63	216,360.63	215,223.40
Benefit-Cost Ratio	1.19	1.24	1.11	1.12

Delayed Planting

Perceived Advantages and Disadvantages of Delayed Planting in Corn Production

The following tables below describe the advantages and disadvantages of delayed planting as perceived by the corn farmers. Farmers should understand the possible impacts associated with delayed planting it poses on their crops before adopting such a kind of management practice. Specific circumstances like the local climate and soil conditions must be assessed to determine its suitability. As shown in Table 43, the majority of farmers practicing delayed planting in corn production stated that there are no advantages in delaying the planting of corn. However, some of them answered that one advantage of practicing such is that in case the other parcels are affected by drought, the other parcels that were planted later can still recover. Moreover, some of the reasons why they practice delayed planting is to wait for the rain or wait for the continuous rain to stop to ensure that the crop will thrive. They stated, *"iuray mi ti tudo tapnu haan matikagan ti mula"*. The advancement of agricultural technology may provide solutions to address the challenges associated with delayed planting.

Table 43. Farmer's Perception on the Advantages of Delayed Planting in Corn Production

Advantages	Frequency	Percentage
None/No answer	5	62.5
"Machambaan ti tudo"	1	12.5
"Incase nga matikag day maysa nga parcel ket mabalin nga bumawi ijay dadduma nga parcel"	1	12.5
Can catch up for higher price for corn	1	12.5

Table 44 enumerated the disadvantages of delayed planting according to the farmers practicing this. Half of them stated that there are no disadvantages in delaying the planting of corn. However, some of them answered that this practice results in pest infestation susceptibility. Others also stated that if they delay the planting, there is a chance that they will catch up with the drought or rainy season which can result in low harvest. In a stduy, delayed planting shortens the effective growing season for corn and it increases the risk of exposure to cold temperatures late in the season before grain maturation (Nielsen et al., 2002).

Table 44. Farmers' Perception on the Disadvantages of Delayed Production in Corn Production

Disadvantages	Frequency	Percentage
None/No answer	4	50
Susceptible to pest infestation	3	37.5
Maabutan ti drought/rainy season	2	25
Low harvest	1	12.5

The farmers claimed that one of the benefits of delayed planting is that they can take advantage of higher prices. An increase of P5.00 per kilogram can benefit the farmer however there are some instances where farmers will experience drought or rainy season resulting in a decrease in their yield by at least 25%. In spite of the reduced yield, the increase in price can cover the loss as shown in Table 45. Further study or experiments are needed to ascertain these results. According to one validation participant, while the price may be greater, a big concern in delayed planting is the problem of pest and disease infestation.

Table 45. Preliminary partial budget analysis of delayed planting as practiced by corn farmers as an adaptation to climate change

Added Benefit		**Reduced Benefit**	
Increase in price @5.00 per kg, Hence, for 1 ha average yield is 85 bag x 57 kg x P23.22	P112,500.90	Decrease in yield by 25% (For 1 ha @ 85 bags - 21.25 bags = 63.75 bags x 57 kg x 23.22)	P84,375.68
Total (A)	P112,500.90	**Total (B)**	P84,375.68
Net Benefit (A-B)	**P28,125.23**		

Economic Viability of the Prioritized Adaptation Practices for Tomato Production in Ifugao

Input-Use for Tomato Production in Ifugao

Varieties Used. The most common variety that was used for tomato farming in Ifugao was Diamante Max F1 for both wet and dry season (Table 46). According to farmers, *"Diamante ket haan unay nga mablight/kulot".* On the other hand, during dry season, almost 40% of tomato farmers used Avatar since according to them, *"maymayat nu summer ti Avatar"*. Although few farmers also used the variety Garnet and Jewel.

Table 46. Varieties used in Ifugao tomato farming

Varieties	Wet Season	%	Dry Season	%
Diamante Max F1	28	68.29	29	50.00
Garnet	8	19.51	8	13.79
Avatar	6	14.63	23	39.66
Jewel	3	7.32	1	1.72

Average input-use. A variety of essential components contribute to the entire cultivation activity in tomato production in Ifugao. The inputs considered are urea, complete fertilizer, chicken manure, foliar fertilizer, herbicides, pesticides, fungicides, and trellis. Analyzing input use indicates changes in the practice between the two seasons and may explain to some extent the yield and income differences. Table 47 shows that there is not much difference in the average input-use during the wet and dry season except for the expected higher use of pesticide during the wet season. The recorded trend of greater input utilization during the wet season corresponds to the heightened demands and challenges that this period presents. During periods of rapid growth, sufficient supplies of nutrients are vital, making the use of urea, complete fertilizer, and foliar fertilizer more important. The regular usage of chicken dung throughout the seasons demonstrates its organic character, which is helpful to soil health. Heavy rainfall during the wet season may reduce herbicide use, possibly lowering weed pressure. This season-specific input variation highlights the adaptability nature of agricultural processes, in which farmers shift input methods in response to weather conditions.

Table 47. Average input use of tomato production in Ifugao.

Item	Wet Season	Dry Season
Urea	120.71kg/ha	120.52kg/ha
Complete Fertilizer	405.32kg/ha	404.23kg/ha
Chicken Dung	5,863.19kg/ha	6,956kg/ha
Foliar Fertilizer	6.92L/ha	7.61L/ha
Herbicide	12.16L/ha	15.29L/ha
Pesticide	15.69L/ha	11.95L/ha
Fungicide	66.87L/ha	65.63L/ha
Trellis	10,222pcs	8,252pcs

Profitability of Tomato Production in Ifugao

Table 48 shows the detailed cost and return analysis of tomato farming in Ifugao during the wet and dry seasons of 2021. When considering the average price and all the cash and non-cash costs of growing tomatoes, the results demonstrate that tomato production is financially viable in both seasons, contributing positively to helping local farmers make a living. The primary indicator of profitability is the net-profit cost ratio, and the analysis shows significant differences between the dry and wet seasons. More specifically, tomato farming during the dry season has a higher net-profit cost ratio of 0.92 compared to 0.61 in the wet season. This means that tomato farmers make 92 centavos in net profit for every peso they invest on their farms during the dry season and 61 centavos for every peso they invest on their farms during the wet season. This difference in net-profit cost ratios implies that tomato farming generates greater profit during the dry season, as indicated by the significant increase in net income to PHP 775,961.24. The dry season's higher ratio implies that farmers are achieving greater returns relative to the total costs incurred. In addition, accounting for returns to own land, labor, and management, as well as family labor and own land rent as income, further emphasizes the positive net income at the average price received during the survey reference period.

Table 48. Cost and return analysis of Tomato Production, Ifugao, 2021

Items	**Wet Season (n=41)**	**Dry Season (n=58)**
Average Area Cultivated (ha)	0.68	0.68
Total Harvest small	2,341.25	4,338.18
Price (P kg-1)	9.35	9.38
Total Harvest Medium	4,239.97	8,020.92
Price (P kg-1)	17.75	14.81
Total Harvest Large	8,879.26	16,583.39
Price (P kg-1)	23.44	23.43
Total Harvest MIX	27,000.00	29,630.00
Price (P kg-1)	19	18.20
Gross Returns (P/ha)	**818,326.46**	**1,087,287.88**
CASH COSTS		
Seed/Planting Material	9,197.99	8,846.44

Fertilizer	58,389.25	64,405.41
Herbicides	7,352.18	10,210.83
Pesticides	44,285.21	52,596.45
Other Costs (Trellis&Liting)	26,122.63	22,574.47
Pre-harvest Labor	32,896.08	20,641.24
Harvesting	13,011.55	10,053.27
Land Rental	9,503.52	17,943.39
Food Cost	24,168.11	33,742.94
Fuel cost	4,294.19	6,424.76
Transportation Cost	45,566.26	54,513.37
Depreciation Cost	136.60	135.07
Repair and Maintenance cost	1,145.53	283.55
Other Production Cost	8,092.27	8,955.45
Total Cash Costs	284,161.37	311,326.63
NON-CASH COSTS		
Pre-harvest Labor	81,530.13	99,613.96
Harvesting	143,458.69	155,164.29
Total Non-Cash Costs	224,988.82	254,778.26
Total Production Costs	509,150.20	566,104.89
Net Profit P/ha	309,176.26	521,182.99
Net Profit Cost-Ratio	0.61	0.92
Net returns to land & management	534,165.09	775,961.24

Variations in the total harvest between dry and wet seasons can explain the difference in net income observed. Factors such as weather conditions, water availability, and pest control measures may influence the yield, impacting the overall profitability of tomato farming. The dry season, characterized by more stable weather patterns, may have potential advantages in pest management and contribute to a more favorable economic outcome for tomato farmers in Ifugao. Previous research on how agricultural productivity changes with the seasons support this. The study by Lobell and Asner (2003) emphasizes how important it is to understand how weather conditions affect crop yields and, consequently, economic returns for farmers. Further, Table 48 shows the results, which not only show if growing tomatoes in Ifugao is profitable but also contribute to the broader discourse about the seasonal dynamics of agricultural production.

Availing Crop Insurance

Comparative Profile of Beneficiaries and Non-Beneficiaries. The cost-benefit analysis helps examine the actual and operational aspects of tomato farming in Ifugao, and it specifically considers the total area tilled by respondents, the distance from the water source, and the proximity of the tilled area to both respondents' homes and the nearest market. These factors play a crucial role in making tomato farming economically viable and its farming adaptation sustainable.

The total area tilled for tomato farming plays a critical role in the cost-benefit analysis. Areas that are bigger may have higher operational costs but may also produce greater returns. Knowing the distance of these farming areas from the water source is important, as it affects their irrigation methods and, consequently, the productivity of their crops (Perry and Steduto, 2017). The cost-benefit analysis can help figure out the cost-effectiveness of water use, the effect on crop yields, and the total economic viability of tomato farming in relation to the spatial dynamics of the farming area.

One important factor that affects labor efficiency and costs is the distance between the farming area and the respondents' homes. Longer distances may mean increased labor time and higher transportation costs. Moreover, the distance from the farming area to the nearest market is a key consideration for the cost-benefit analysis. Traveling to the market for a longer time may result in increased transportation expenses and potential post-harvest losses (Devi et al., 2020). Understanding these spatial connections is important for optimizing resources, keeping costs low, and maximizing profit.

Table 49. Farm Profile and Farming Characteristics of Tomato Farmers, Ifugao

Item	Beneficiary (n=37)		Non-Beneficiary (n=49)		Pooled (n=86)	
	Mean	Range	Mean	Range	Mean	Range
Area (ha)	0.80 (0.56)	0.13-2	0.64 (0.74)	0.13-5	0.71 (0.67)	0.13-5
Distance of Parcel to water source (km)	2.76 (8.89)	0.001-50	1.28 (1.41)	0.020-5	1.91 (5.90)	0.001-50
Distance of Parcel to water source (mins)	39.97 (56.09)	1-300	89.45 (155.46)	2-720	67.46 (123.54)	1-720
Distance from parcel to house (mins)	33.42 (32.21)	1-120	18.95 (16.56)	1-60	25.46 (25.72)	1-120
Distance from parcel to nearest market (mins)	316.35 (82.72)	5-420	300.24 (108.39)	6-480	307.51 (97.41)	5-480

As a way to control risk, crop insurance can significantly affect a farmer's finances, especially if something unexpected happens, like crop damage or a calamity. This is the main reason why the respondents included this as one of their adaptations, as revealed in the study by Pablo et. al. (2023). Beneficiaries, who have opted for crop insurance, likely incorporate the associated costs into their overall operational expenses. They may incur additional costs for insurance premiums, but the potential reduction in financial risk can positively impact overall profitability. In contrast, non-beneficiaries might face higher risk exposure, affecting their net income and the economic sustainability of tomato farming. Crop insurance plays a pivotal role in risk management for farmers, providing financial protection against potential losses due to adverse weather events, pests, or other calamities (Barnett et al., 2015).

In addition, the relevance of including crop insurance in the study is important because it can help tomato farmers mitigate losses and enhance their overall economic resilience. Furthermore, as shown in Table 50, the majority of beneficiaries expressing awareness of potential financial support in the event of crop damage suggests a positive impact of crop insurance, thus they have confidence in the support mechanisms that crop insurance provides. On the other hand, the lack of response or awareness among most of the non-beneficiaries may indicate a potential gap in information dissemination, they do not fully understand it or a missed opportunity to engage farmers in risk-mitigation strategies.

Perceptions about about crop insurance. How farmers think about the benefits of crop insurance can have a big effect on the choices they make. Farmers who can see the real benefits may be more likely to pay the rates for insurance because they see it as a good way to protect their crops and income. Conversely, non-beneficiaries who don't benefit from crop insurance may not avail of it because they do not know about it or are skeptical about its benefits. The finding that most respondents, both beneficiaries and non-beneficiaries, said "no idea" or "no response" shows that most of the respondents may not fully understand the benefits of crop insurance (Table 51). This implies the need for educational programs and efforts to help farmers learn more about the benefits of crop insurance, which will help them make better decisions in the long run (Giné et al., 2008).

Table 50. Understanding about Crop Insurance

Item	**Frequency**	**Percentage**
Beneficiaries		

If crop is damaged or there is calamity, there can be financial assistance provided by PCIC or agriculture sector	25	65.79
Insurance of crops	9	23.68
Farmer's protection against calamities	5	13.16
help for farmers if they have gone to bankruptcy	2	5.26
No Answer	2	5.26
Non-Beneficiaries		
No answer/No idea	24	48.00
there can be help or financial assistance from the government in case of calamities/natural disasters that affects crops	17	34.00
Insurance of crops against calamities/natural disasters	9	18.00
if you are a member, maybe they can help when you go bankrupt	1	2.00
It's a good program of government	1	2.00

*multiple answers

Table 51. Perceived Benefits of Availing Crop Insurance

Item	Frequency	Percentage
Beneficiaries		
None	24	63.16
There is help/assistance given if crop is damaged/destroyed	7	18.42
Financial assistance that can be used as additional capital	2	5.26
Help augment financial loss due to crop damage	2	5.26
There are seeds given to be planted	2	5.26
Insurance of crops	1	2.63
Free to apply	1	2.63
Non-Beneficiaries		
No idea/No answer	38	76
There is help/financial assistance given if there is a calamity that destroys the crop	11	22
Assistance given are used as capital for next cropping season	1	2

The purpose of looking into these ideas is to find possible constraints that might influence farmers' decisions about crop insurance as one of their adaptations. Given that most beneficiaries stated they did not perceive any constraints as shown in Table 52, this means that they have a favorable attitude towards availing crop insurance. According to Mahul and Skees (2007), this positive attitude among tomato farmers makes them more likely to avail of crop insurance, which lowers their risk and makes them more financially stable. Finding out that most of the beneficiaries do not see any constraints is important for policymakers and agricultural extension services. This implies that the policies and support programs currently in effect may be effectively addressing possible obstacles to crop insurance adoption.

Table 52. Perceived Constraints of availing Crop Insurance (Beneficiaries)

Item	Frequency	Percentage
None	28	73.68
Delayed indemnity	3	7.89
There is no indemnity even if its reported	3	7.89
Unfair in giving indemnity	2	5.26
indemnity not enough to cover loss	2	5.26
Seed given is different from the ensured crop	1	2.63

Understanding the reasons why non-beneficiaries have not availed of crop insurance is crucial in assessing the barriers that may exist and in shaping strategies to increase awareness and adoption. The responses, as shown in Table 53, demonstrated a lack of awareness, indicating a critical knowledge gap for non-beneficiaries about crop insurance. This means that current methods of communication may not be reaching every segment of the farming community. Reconsidering and improving communication channels, modes, and content can help eliminate the knowledge gap and encourage greater participation in crop insurance programs.

The literature on how farmers make decisions about insurance is in line with how important it is to address knowledge gaps. According to Cole et al. (2013) and Karlan et al. (2014), information plays a big role in farmers' choices about which risk management tools to adopt. In addition, Cole et al. (2013) assert that it could have a positive impact on how farmers think about and decide on crop insurance.

Table 53. Reasons of non-beneficiaries why never availed crop insurance

Item	Frequency	Percentage
Not aware/No idea	40	75.47
Busy/No time to process papers	8	15.09
Forgot to enroll because of farm works	2	3.77
Area not being affected by disaster	2	3.77
Hassle going to OMAG	1	1.89

*multiple answers

Cost-Benefit Analysis. Tables 54a and 54b present the summary of the cost-benefit analysis of enrolling crop insurance considering the financial benefits to tomato farmers of enrolling considering the various potential scenarios regarding the occurrence of typhoons and drought. The typhoon damage years based on the data from PAG-ASA and the Department of the Interior and Local Government (DILG) office shows that there were 2 damaging typhoons and 3 damaging droughts from 2018-2022. Given these disaster years and using the average indemnity payment of PhP. 9,068.11 per hectare based on the secondary data from PCIC and an additional PhP. 300.00 estimated cost for processing (food, fare, etc.) given that the insurance that they are availing is free or fully subsidized by the government. The NPV for the 3 different scenarios for an insured farmer is positive both for typhoons and drought. Uninsured farmers also had a positive NPV but a bit lower compared to scenarios, under the scenario of actual damaging typhoon/drought and with yearly occurrence of typhoon/drought. These results imply that investing in crop insurance is beneficial to tomato farmers in Ifugao, where typhoons and drought occur causing damage to their crops. Pulhin et. al (2017), taking the case of Laguna, similarly concluded that investment in crop insurance is useful when catastrophic climate events are known with certainty. These benefit-cost estimates are limited to indemnity payments. They do not factor in other potential benefits such as reduced farms' reliance on short-term debt after a calamity and the production impacts of subsidized agricultural insurance in developing countries (Cai, 2016; Cole et. al 2017; Lumbres et. al)

Table 54a. Summary results of cost-benefit analysis of corn farmers enrolling crop insurance,, 5-yr period typhoon scenario, 10% discount rate

Typhoon	Crop Insured Farmer			Uninsured Farmer
Parameters	Actual Damaging typhoon occurrence	With Yearly Damage	Without typhoon Damage	
Net Present Value (NPV)	1,562,517.63	1,205,259.32	1,170,884.04	1,172,021.28
PV of Benefits	3,114,544.71	3,136,476.40	3,102,101.12	3,102,101.12
PV of Costs	1,931,217.08	1,931,217.08	1,931,217.08	2,545,751.00
Benefit-Cost Ratio	1.61	1.62	1.61	1.60

Table 54b. Summary results of cost-benefit analysis of corn farmers enrolling crop insurance, 5-yr period drought scenario, 10% discount rat

Drought	Crop Insured Farmer			Uninsured Farmer
Parameters	Actual Drought occurrence	With Yearly Damage	Without Drought Damage	
Net Present Value (NPV)	2,631,619.39	2,008,931.63	1,974,556.35	1,975,693.58

PV of Benefits	4,142,363.84	4,156,051.80	4,121,676.51	4,121,676.51
PV of Costs	2,147,120.16	2,147,120.16	2,147,120.16	2,830,524.45
Benefit-Cost Ratio	1.93	1.94	1.92	1.92

Rescheduling or Delaying the Planting as Adaptation

Many respondents answering "none," as shown in Table 55, indicates a potential lack of understanding or consideration for this specific component of farming. Understanding farmers' perceptions of delayed planting is critical in the context of climate change. Weather changes may cause changes to planting schedules. A study reveals that farmers who understand the advantages and disadvantages of delayed planting are better prepared to adapt their operations to changing climatic conditions, contributing to agricultural resilience (Lobell et al., 2011). In addition, the timing of planting has a considerable impact on crop productivity. While many respondents may believe that delayed planting has no specific advantages or disadvantages, it is vital to determine the potential effects on tomato harvest quantity and quality. According to research, planting timing has an impact on crop productivity, and understanding these effects is critical for making informed choices (Kadambot Siddique et al., 2018). Moreover, soil health and fertility can suffer because of delayed planting. Exploring the perceived advantages and disadvantages of delayed planting reveals whether farmers take these things into consideration. According to a study by Lal (2020), understanding the potential effects on soil conditions is critical for sustainable agricultural practice.

Table 55. Perceived Advantages and Disadvantages of Delayed Planting

ADVANTAGES	Frequency	Percentage
None	12	36.36
High price of crops because supply is low	6	18.18
Crops will thrive	6	18.18
Avoid calamity/flood	2	6.06
Prevents/lessen the occurrence of pests and diseases	2	6.06
the soil can rest	2	6.06
abundant rain to water the plant	2	6.06
Secured Capital	1	3.03
Total	33	
DISADVANTAGES		
None	18	54.55
Over mature seedlings	8	24.24
Sometimes low price	5	15.15
Added labor cost on cleaning since weeds will start to grow	3	9.09
Affected by typhoon	1	3.03
Decreased yield	1	3.03
Crop easily rot	1	3.03
Total	37	

*multiple answers

Using Irrigation Sprinkers as Drought Adaptation

The respondents' most perceived advantages of less labor, time savings, and energy correspond with the possible benefits of using sprinklers or rain bursts in irrigation. This information is important for the cost-benefit analysis since it directly affects the cost of operation. The farmers' recognition of these advantages indicates better efficiency, which could lead to higher output and lower labor costs (Perry et al., 2009). The reduced need for manual labor and the efficient use of time contribute to overall resource optimization, which positively influences the economic viability of tomato farming.

The perceived disadvantages of the greater number of respondents are technical problems or malfunctions, particularly those involving high water pressure, which highlight the possible challenges associated with the use of sprinklers or rain bursts (Table 56). These concerns might result in increased maintenance expenses and operating disruptions, affecting the overall cost-benefit ratio. Addressing these challenges is critical for increasing the economic efficiency of irrigation methods (Roth et al., 2017).

Table 56. Perceived Advantages and Disadvantages of using Sprinklers/Rain Burst

ADVANTAGES	Frequency	Percentage
Less labor and saves time and energy	26	29.89
Crops are well irrigated	19	21.84
Plants are guaranteed to thrive	16	18.39
Helps crop grow well	13	14.94
None	13	14.94
Easier type of irrigation	6	6.90
Good/Better harvest	3	3.45
Can still plant during dry season	2	2.30
Faster rooting of transplanted seedlings of tomato	1	1.15
Farmers can do other labor	1	1.15
DISADVANTAGES		
Technical problems/ Malfunction (especially if the pressure of water is high)	35	40.23
None	30	34.48
Labor in setting up and repair	15	17.24
Plants die from over-irrigation when the sprinkler is neglected and not shifted to the other portion of the field	7	8.05
It can't be used when the water flow is low especially during summer	1	1.15
Weeds easily grow	1	1.15

*multiple answers

Using Rainwater Harvesting as Drought Adaptation

Majority of the respondents' perception that rainwater collection provides a reliable source of irrigation, particularly during droughts, is highly significant for cost-benefit analysis. Droughts can have a severe impact on conventional water sources; hence, alternate water gathering systems are essential for ensuring regular crop irrigation. This advantage coincides with potential cost savings and increased resilience in tomato farming, which can have a favorable impact on overall economic dynamics (Nayak et al., 2009).

Another significant advantage, as perceived, is that rainwater collection provides a clean water source. Clean water is critical for crop health and can help eliminate the need for extra water treatment operations. According to Mishra et al. (2015), this advantage benefits both the economic and environmental elements of tomato production, possibly influencing overall operational costs and resource efficiency.

In addition, rainwater collection confirms sustainability goals by employing natural precipitation as a water source. The perceived advantages help to optimize resources by collecting and storing rainwater for later use. Assessing the economic implications of sustainable water management processes is important for the overall cost-benefit analysis (Peng et al., 2021).

Respondents answered none of the disadvantages of water harvesting, which implies a possible knowledge gap or a favorable impression of rainwater harvesting (Table 57). The cost-benefit analysis must consider possible disadvantages such as infrastructure expenses, maintenance issues, or fluctuations in rainfall patterns that may affect the reliability of rainwater collection systems (Rajsekhar et al., 2014).

Table 57. Perceived Advantages and Disadvantages of Rainwater Harvesting

ADVANTAGES	Frequency	Percentage
Secured source of irrigation/clean water (especially drought)	8	72.73
No Answer	2	18.18
You can use/spray on time (since there is source of water)	1	9.09

DISADVANTAGES		
None	4	36.36
Laborious	2	18.18
No or infrequent rainfall result in a small volume of rainwater being collected	2	18.18
May attract waterborne diseases for the plants	2	18.18
Produces algae	1	9.09

Early Harvesting

The perceived advantages and disadvantages of early harvesting in tomato farming in Ifugao are crucial in understanding the economic impact of this agricultural practice. Early harvesting as a risk-mitigation approach against adverse weather conditions, such as typhoons, is critical for reducing crop losses and maintaining economic stability. Typhoons and bad weather conditions can pose a serious threat to crops, perhaps resulting in considerable economic losses. Early harvesting as a risk mitigation measure improves crop resilience and has the potential to enhance tomato farming's overall economic viability (Kumar et al., 2017). Subsequently, understanding early harvesting as a tool for mitigating the economic risks associated with disastrous weather occurrences is critical. This perspective is consistent with methods for lowering agricultural systems' vulnerability to climate-related risks, which provide economic benefits in terms of crop preservation and total yield protection (Tack et al., 2015).

Table 58. Perceived Advantages and Disadvantages of Early Harvesting

ADVANTAGES	Frequency	Percentage
To avoid being destroyed by typhoon	8	28.57
None/No answer	7	25.00
Based on buyer's demand	6	21.43
When price is high	4	14.29
To avoid over ripening of tomato before going to NVAT and avoid low price	2	7.14
Early maturity/ripening	1	3.57
DISADVANTAGES		
None	9	32.14
Unripe tomatoes are not sold unless it is ordered by the buyer	7	25.00
Lower price	6	21.43
Decreased in weight	6	21.43

V. CONCLUSIONS

This project presented results of economic evaluation of selected climate resilient adaptation practices for major climate hazards in Ifugao. For rice production, evidence based on survey data showed that use of water pump and moreso, communal irrigation systems, resulted in better incomes for surface pump users with water source than pure rain-dependent rice farmers. It can be concluded that it is a profitable investment considering its yield and income effect. While it was beyond the scope of this project to determine and show the individual profitability of the alternative crops which can be rotated with rice as climate adaptation, qualitative narratives point to the usefulness of more diversified cropping when there are extreme weather events such as typhoons and drought. Further investigations are needed to quantify the identified costs and benefits of planting bamboo as climate adaptation for rice farming in the province.

For corn production, using hybrid and *labos* seeds are profitable as shown by the considerable positive values of the net profit-cost ratio. Also, the beneficiaries and non-beneficiaries of crop insurance have a positive understanding and perception of the benefits of crop insurance. Some of the farmers are constrained in terms of the lack of indemnity despite the crop damage during calamities while others mentioned that the indemnity is not enough or the processing of claims is time-consuming. The benefit of corn farmers availing crop insurance is shown in the higher NPV and BCR as compared to the corn farmers who did not avail of crop insurance. Crop insurance cannot eliminate the risks brought by climate change or fully compensate for their loss but it minimizes possible losses due to climate hazards..

For tomato, the CBA of tomato farming in Ifugao provides a thorough insight into the economic dynamics and sustainability of agricultural methods in the region. The data show that tomato production is profitable in Ifugao, with a positive return on investment for farmers. The study looked at a variety of factors, including irrigation systems, harvesting procedures, and timing of planting, to shed light on details that influence the overall economic viability of tomato farming. Despite knowledge gaps, especially in respondents' perceptions of specific agricultural practices, the findings highlight the resilience and adaptability of Ifugao farmers. The profitability of tomato farming at the average price in 2021 showed it benefited the local farmers financially, but it also stresses the significance of sustainable agricultural practices. The favorable cost-benefit analysis confirms tomato cultivation's importance as a sustainable and profitable farming endeavor in the area.

VI. RECOMMENDATIONS

The financial analysis of the selected adaptation practices, including the cost structure information from this project, can serve to inform decision-making, policy formulation, and the development of interventions and investment proposals to improve the economic sustainability of rice, corn, and tomato farming in Ifugao. The use of diesel-fueled surface water pumps is financially profitable in the rice areas in Ifugao with water sources, and is a worthwhile investment for farmers. Further study is needed considering whether the use of electric pumps is technically feasible and even more worthwhile for farmers in the various vulnerable locations in Ifugao. The use of communal irrigation systems results in higher net-profit cost ratio than pump-supported rice farms indicating that it confirms previous studies indicating its being a worthwhile investment for the government. Further study is recommended in improving association management of these irrigation systems for rice production. Crop insurance is beneficial to the corn farmers in the area, hence non-beneficiaries should consider availing of this program to ensure better income. The indemnity payments provided available cash to the affected farmers to recoup some of their losses due to the damage brought by calamities that affected the area. However, concerned government agencies should review their requirements, terms and conditions, and processes in providing crop insurance services to motivate more farmers to avail of the program. On tomato farming in Ifugao, the following are recommended to improve the economic sustainability and resilience of agricultural practices in the region: first, farmers may adopt a diverse approach that is tailored to their specific needs, taking into account the advantages and disadvantages of irrigation methods. Further, the revealed knowledge gaps from the respondents' perceptions of potential disadvantages emphasize the necessity of continuing education and extension activities. They need to continually gain more understanding of the advantages and disadvantages related to crop insurance and other farming practices through information drives. The integration of climate-resilient agricultural techniques into extension programs need to be sustained to further strengthen their adaptive strategies such as utilizing crop varieties and production techniques that are more resilient to changing weather conditions. Lastly, since the study emphasizes agriculture's vulnerability to climatic uncertainty, policymakers need to develop and implement climate-resilient agricultural policies that take into account the local context of Ifugao.

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