PHILIPPINES
CLIMATE RISK PROFILES

HIGHLIGHTS

- Luzon concentrates half of the total agricultural production in the Philippines, producing 44% of the crops, 57% of the livestock, 66% of the poultry, and 52% of the fishery for the entire country. While Central Luzon remains the rice granary of the Philippines, the Cordillera Administrative Region (CAR) is the key source of cabbage, potato, and other highland vegetables.

- Tropical cyclones (typhoons) and droughts are the key climate-related hazards affecting Luzon. Heavy rains and floods associated with strong typhoons disrupt the activities of most lowland rice farmers, while highland vegetable and upland corn growers are vulnerable to soil erosion, landslides, and strong winds. Drought has detrimental effects on upland corn and rainfed production.

- Low productivity associated with floods and/or droughts occurring during the crops' vegetative stages results in significantly lower farm incomes and reduced capacity to invest in household and farm resilience building.

- Common adaptation practices adopted by farmers in Luzon include: maintenance of existing drainage canals; re-adjustment of the cropping calendar (delayed planting); use of rain-water harvesting tanks and/or of water pumps; building of crop shelters (greenhouses) to protect crops from strong winds and heavy rains; use of traditional pest control methods integrated crop and livestock farming and organic farming, among others.

- To promote climate-resilient agriculture, the government, through its regional offices and institutional partnerships has actively supported the development and dissemination of new crop varieties, of Alternative Wetting and Drying (AWD) technology and the Rice Crop Manager (RCM) tool. In addition, climate information service systems, farmer field schools (FFS), and radio programs have been set up to increase farmers' capacity to reduce climate risks.

- Across the value chains, actors remain confronted with a series of barriers that prevent uptake of climate-smart practices, such as: low awareness of adaptation opportunities and limited technical skills to implement them; low financial capacity to make long-term investments in technology and equipment; limited access to insurance schemes; unfavorable market prices, among others.

- Partnerships between private, research and non-governmental agriculture stakeholders can help enhance effectiveness of public efforts to increase resilience of the sector; leveraging funds and knowledge from different sources would help address financing gaps and scale-out successful interventions, thus enlarging the pool of beneficiaries.

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FOREWORD

The Philippines is one of the most vulnerable countries to climate change [1], with climate impacts disproportionately affecting agricultural and rural communities. Low productivity, underinvestment and extreme weather events, mean farmers in the Philippines are some of the poorest people in the country, the majority of which manage small farms of less than 1 hectare (ha). The agricultural sector employs some 32% of the Philippines' working population and occupies almost 41% of the country's land area. Comprised of over 7,600 islands—with 11 providing the bulk of the country's landmass—the country faces severe challenges in meeting domestic food demands and relies heavily on imports, especially for wheat and rice.

The Philippines is affected by a range of extreme weather events, particularly tropical cyclones (or "typhoons") [2]. In this humid, tropical environment, climate change is expected to produce even higher temperatures and increasingly unpredictable rainfall by 2050, negatively affecting yields for most crops. In this same period, it is estimated that climate change impacts of all kinds could cost the Philippines' economy over USD 2.7 billion a year [3]. These climate impacts will be exacerbated by rapid population growth, on-going conflict, and severe land degradation. Still, the Government of the Philippines has taken policy and institutional steps to combat the impacts of climate change and adapt the country's agricultural sector to likely impacts.

Given the agricultural sector's importance for poverty reduction and economic growth in the Philippines, it is important to understand the impacts of climate change and extreme weather events across the entire agricultural value chain. To achieve this, three profiles have been created, one for each major island group in the Philippines (Mindanao, Luzon and Visayas), examining the relationship between climate hazards, key commodities and their value chains. In Luzon, four major value chain commodities were selected: rice, yellow corn, cabbage and potato. For each of these commodities, a study area was selected through a consultative process supported by relevant literature and expert consultations. The study areas selected, are located in the Cordillera Administrative Region, covering rice and corn in Abra, Ifugao, Kalinga, Mountain Province and Apayao, and the province of Benguet for cabbage and potato. These areas are characterized as key producers of the selected crops and are highly vulnerable to typhoons and drought.

The profile is organized into six sections, each reflecting an essential analytical step in understanding current and potential adaptation options in key local agricultural value chain commodities. The document first offers an overview of the county's main agricultural commodities key for food security and livelihoods as well as major challenges to agricultural sector development in the island group. This is followed by identification of the main climatic hazards based on the analysis of historical climate data and climate projections including typhoons and drought. The document continues with an analysis of vulnerabilities and risks posed by the hazards on key commodities through crop suitability mapping and their respective value chains. Based on these vulnerabilities, current and potential on-farm adaptation options and off-farm services are discussed. The text also provides snapshots of the enabling policy, institutional and governance context for adoption of resilience-building strategies. Finally, pathways for strengthening institutional capacity to address climate risks are presented.

AGRICULTURAL CONTEXT

Luzon is the country's economic and political center, located in the northern region of the Philippine archipelago and bounded by the Philippine Sea (east), Sibuyan Sea (south), and the South China Sea (west). It is the largest among the three island groups in the Philippines and is comprised of eight regions, namely: The National Capital Region (NCR); the Cordillera Administrative Region (CAR); Ilocos (Region I); Cagayan Valley (Region II); Central Luzon (Region III); CALABARZON (Region IVA); MIMAROPA (Region IV-B); and Bicol (Region V).

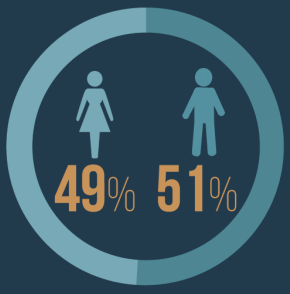
ECONOMIC RELEVANCE OF FARMING

Agriculture, hunting, forestry, and fishing activities on the island contributed 16% of the Gross Regional Domestic Product (GRDP) and 51% of the country's Gross Value Added (GVA) in 2017. Luzon contributed

DEMOGRAPHICS

57% OF THE PHILIPPINES' POPULATION

57,000,000 INHABITANTS



52% LIVE IN RURAL AREAS

FOOD SECURITY

24% OF THE POPULATION SUFFERS FROM **FOOD POYERTY**

42% OF HOUSEHOLD **INCOME SPENT ON FOOD**

21% CHILDREN **UNDERWEIGHT**

32% CHILDREN **STUNTED**

7% CHILDREN **WASTED**

3% CHILDREN **OVERWEIGHT**

LUZON

FARMING

TOTAL LAND AREA (HA) **14,882,279**

AGRICULTURE AREA (HA) **3,635,740**

24% OF TOTAL LAND AREA

PEOPLE EMPLOYED IN AGRICULTURE PRODUCTION **4.3 MILLION**

4% OF

11% OF

ACCESS TO BASIC NEEDS

13% OF THE POPULATION LIVES IN **ABSOLUTE POVERTY**

WOOD FOR COOKING **35%**

ELECTRICITY FOR COOKING **2%**

ELECTRICITY FOR LIGHTING **88%**

SOURCE: PSA.GOV.PH

the largest to the country's 2017 gross GVA, followed by Mindanao and Visayas [4]. Agriculture employs more than 4.3 million people, equivalent to 7% of the island's population [5]. Roughly 18% of the men and 5% of the island's women are employed as skilled workers in agriculture, forestry and fishing activities [6]. Men usually engage in agricultural operations, while women mostly help with on-farm activities or work on neighboring farms [7]. Agricultural child labor (children aged 5-17 years) is at roughly 8% [8]. The average daily income for agricultural workers is PHP 209 (less than USD 4), with fishing activities being slightly better rewarded (PHP 226) compared to agriculture, hunting and forestry (PHP 208) [9].

PEOPLE AND LIVELIHOODS

Luzon hosts roughly 57% (over 57 million) of the population in the Philippines [9]. The rural population is concentrated in CALABARZON (accounting for 23% of the island's total rural population), followed by Central Luzon (22%), Bicol (21%), Cagayan Valley (13%), and MIMAROPA (9%). CAR, Ilocos and NCR account for only 5, 2 and less than 1 % of the island's rural population, respectively [10].

Poverty on the island affects approximately seven million people and is characterized by low incomes[1] and limited access to basic needs (food, water, electricity, education, among others). Families spend almost half (42%) of their incomes on food [11] and more than 14 million island inhabitants suffer from food poverty. In 2015, the per capita income in Luzon was PHP 15,189, which is above that of the per capita food threshold (PHP 8,858) [12,13]. Approximately 87% of the families have access to safe water supply [14]. In 2015, almost a third of the households sourced their drinking water from a community water system using their own faucet, while 9% used a shared faucet and only 3% used water from protected springs. Over 93% of the island's households are electrified [15]; however, only 2% use electricity for cooking, while 35% use wood [16].

Among the three island groups, Luzon has recorded the lowest rates of undernourishment over the past years. Incidence of underweight children (aged 10 and below) was 21% in 2015, while the youth stunting rate (age 19 and below) was 32%, about 6-8% lower than the other island groups. The overweight population reaches 4%. Literacy rates vary across age groups. In 2018, 97% of the people aged 10 years or older were literate [10].

AGRICULTURAL ACTIVITIES

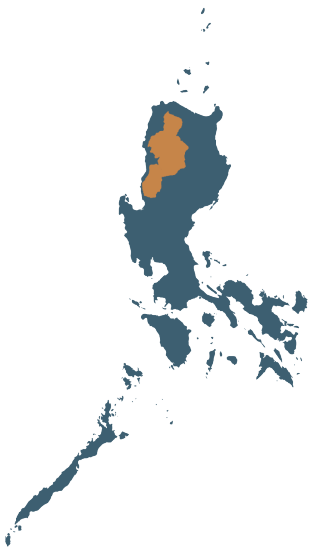
Farms in Luzon occupy roughly 3.6 million hectares (ha) and employ 4.6 million if the inhabitants [9]. Average farm size is below 1ha [17]. Of all island groups in the Philippines, Luzon had the highest contribution (51%) to the country's total and sub-sectoral agricultural production in 2017. Poultry, livestock, fisheries, and crops accounted for 66%, 57%, 52%, and 44%, of total national production, respectively [4].

Temporary crops grown on the island include rice, corn, tubers, roots and bulbs, fruit bearing trees, sugarcane, tobacco (particularly in Ilocos), legumes (in Cagayan Valley) and vegetables (in CAR), while dominant permanent crops include coconut, banana, mango, pineapple, abaca, coffee robusta, abaca, kalamansi, and cashew nut (MIMAROPA). In 2016, 60% of the total rice and 43% of the corn in the Philippines were cultivated in Luzon [18]. Roughly seven million metric tons of rice were produced between October and December 2017; over the same period, key rice-producing regions registered increases in yields of 3% in Central Luzon, 2% in the Cagayan Valley and less than 1% in Bicol [19]. In 2016, CAR produced 89%, 85% and 77% of the country's carrot, white potato, and cabbage, respectively [18].

Livestock reared on the island includes hogs, cattle, goats, carabaos, horses, and poultry. Chicken and duck production account for 67% and 60% of total national production, respectively. Luzon is also a key producer of chicken and duck eggs, contributing 61% of total national production [18]. Other common agricultural activities include production of ornamentals, flower gardening, bee culture/honey production, silkworm production, and orchid growing.

[1] Annual per capita poverty threshold is valued at roughly PHP 21,000.

STUDY AREAS AND THEIR AGRICULTURAL VALUE CHAIN COMMODITIES



Considering the importance of agriculture to Luzon, climate variability and hazards may pose a serious threat to the sector. For this analysis the cabbage, potato, rice and yellow corn supply chains were selected for detailed analysis. This selection was informed by the large contribution that these crops make to total agricultural production and exports from the island group (and the country more broadly), as well as their vulnerability to the impacts of climate change. Rice and corn were previously identified as key to national food security and livelihoods [20].

To examine these VCCs in detail, two study areas in CAR were selected based on two pre-established criteria: importance of agriculture to national economy and vulnerability to climate change. CAR is the country's only land-locked region. With a mountainous topography, it is also known as the "Watershed Cradle of North Luzon", as it hosts major rivers that provide continuous water for irrigation and energy for northern Luzon. In 2016, the region contributed close to 2% of the country's GDP. In the same year, the agriculture, hunting, forestry and fishing sector accounted for almost 9% of the total output of the region. Agriculture absorbed roughly 44% of the total employees in CAR, 36% of whom where women and 64% men [21]. Rice, corn, fruit trees, as well as industrial and plantation crops cover approximately 247,000 ha of land, while lowland and upland vegetables extend over almost 5,000 ha. The region's provinces maintain communal and national irrigation systems, such as the Upper Chico River Irrigation System (UCRIS), West Apayao Abulug Irrigation System (WAAIS) and Hapid Irrigation System [22].

Area 1 of this study is composed of the provinces Abra, Ifugao, Kalinga, Mountain Province and Apayao. These provinces are predominantly rice and corn producing, and highly susceptible to the impacts of climate change. Area 2 covers Benguet, a key producer of cabbage and potato, which like the other provinces of CAR is highly susceptible to the impacts of typhoons and droughts [23].

STUDY AREA 1: THE PROVINCES OF ABRA, IFUGAO, KALINGA, MOUNTAIN PROVINCE AND APAYAO

Roughly 2% (968,000 people) of Luzon's population lives in the provinces of Abra, Ifugao, Kalinga, Mountain Province and Apayao in CAR. Most people (93%) live in rural areas where incidence of absolute poverty is at 33% [13,21].

RICE

Rice is the country's most important staple crop, contributing roughly 20% of the country's agricultural GVA. Approximately 2.5 million households practice rice farming; most of them engage in production activities (2.1 million), 4% in post-production and 13% work on ancillary activities [24]. Roughly 30% of the poorest people spend a quarter of their food money on rice.

In 2016, the total rice harvested area in these five provinces was over 104,000 ha, with an average yield close to four metric tons per hectare [25][2]. Rice is mostly grown as a monocrop, two-three times a year. Rice production as part of an integrated system remains uncommon, with relatively few examples of farmers supplementing farm income by harvesting other cash crops or by breeding poultry [26]. Lowland rice depends on irrigation and its cultivation is done manually or mechanically. Most farmers practice conventional farming using available synthetic chemicals (fertilizers, pesticides, fungicides) to fertilize and control pests and diseases. These are usually available in stores3 or provided by government programs through the Provincial and

[2] This is above the average rice yields registered between 2007 and 2016, estimated at approximately three metric tons per hectare

[3] Established farm stores in Abra include Superbreed farm supply, Formoso farm and poultry supply, Khaleet farm supply, and Banez commercial. The known farm stores in Kalinga are JAC farms and Oplay Tay-og farm supply..

Municipal Agricultural Office. Farmers' associations, cooperatives, non-government organizations (NGOs), and the Rural Improvement Council (RIC) provide technical, financial, and/or livelihood assistance to their members. Financial and credit services are available through government line agencies at national and municipal level.

Land preparation, seed broadcasting (on beds), spraying and irrigation are mostly men-led activities; women help in planting and manual weeding. Large-scale farmers hire laborers and machinery (rotavators for ploughing and harrowing), especially for land preparation and crop harvesting. Fresh and dry rice paddy is sold to traders or middlemen who offer prices that vary depending on crop quality. Part of the rice paddy is milled and packaged by established traders, while the rest is sold on the market by local and national retailers. The National Food Authority (NFA) is a major buyer of rice in CAR [26].

YELLOW CORN

Corn is the second most important crop in the Philippines and serves as the main source of livelihood for 600,000 households. While white corn is the main staple food of 14 million Filipinos, yellow corn accounts for half (50%) of the livestock mixed feeds produced in the country, covering more than 53,000 hectares in CAR, and yielding three metric tons per hectare [25][4]. Corn is also processed into high-value products, such as corn-starch, corn syrups, corn oil, gluten, and snack foods.

Upland yellow corn is grown in monocrop systems, intercropping systems, rotational cropping and multiple cropping systems (corn, vegetables and/or papaya). To supplement cash resources and provide for the household, some farmers intercrop yellow corn and banana, betel nut and taro. Sweet potato and peanut are common substitutes when corn is affected by flooding [26]. Yellow corn production is rainfed (farmers rely on the onset of the rainy season to start the field operations) and is carried out both manually and mechanically. Most corn farmers practice conventional farming and depend on the use of synthetic chemicals to enhance yields and control pests and diseases.

Hybrid seeds, fertilizers, pesticides and fungicides are available in agricultural farm stores located in the central towns. The Provincial and Municipal Agricultural Offices also offer and/or sell seeds and other inputs to farmers. Loans are mostly accessed by women and are largely provided by private companies and cooperatives such as St. William's Multipurpose Cooperative in Paracelis (Mt. Province) and Lamut Grassroots Development Cooperative (LAGSADECO) in Ifugao. However, many farmers prefer to obtain their supplies from private individuals (trade financiers), through a financing system that discounts the price of the purchase from the gross sale. Agricultural line agencies at national and municipal level also offer financial and credit services to farmers, yet the process is believed to be lengthy and cumbersome [26].

Men usually engage in land preparation and crop spraying, while women help in topdressing[5] and manual weeding. When family labor is insufficient, off-farm men and women are employed during planting, fertilizer application, weeding, harvesting, threshing, and bagging. Harvesting is carried out manually or with hired agricultural machinery. The crop is then sold mainly to poultry and piggery farmers who own feed mills, but also to backyard swine and poultry raisers. Others purchase dried corn in bulk and sell them to retailers [26].

STUDY AREA 2: BENGUET PROVINCE

Benguet's population represents less than 1% of the total population in Luzon. Nearly half of the people in the province (226,000) live in rural areas [21] and 6% (28,000) are considered poor [27]. Agriculture has traditionally been the main income source of the region, employing roughly 101,000 people in the province [28].

With a sub-tropical climate and a total land area of 277,000 ha, Benguet abounds in fertile soils, timberland, and mineral deposits. The main agroecological zone (AEZ), the rainfed upland area, is aimed for high-value crop production and trade. Farm activities are carried out on approximately 27,000 farming households and extend over 30,000 ha. Approximately 21,000 ha are dedicated to lowland and upland vegetables[6], while the remaining area of 11,000 ha are dedicated to rice, corn, fruit trees (oranges, pears and other temperate fruits), as well as industrial crops [29].

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[4] This is close to the average yellow corn yields registered between 2007 and 2016, estimated at three to four metric tons per hectare.

[5] Topdressing refers to the application of fertilizers into the soil during the growing season in order to improve plant nutrition and boost yield.

[6] Benguet is also known as the "salad bowl" of the Philippines, given the large diversity of salad vegetables (Baguio vegetables) produced in the area.

SA1

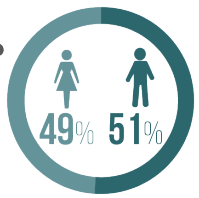
DEMOGRAPHICS

968,774
TOTAL POPULATION

2% OF TOTAL POPULATION IN **LUZON**

<1% OF TOTAL POPULATION IN **THE PHILIPPINES**

93% LIVE IN **RURAL AREAS**



PERCENTAGE OF **FEMALE AND MALE** POPULATION

ACCESS TO BASIC NEEDS

33% OF THE POPULATION LIVES IN **ABSOLUTE POVERTY**

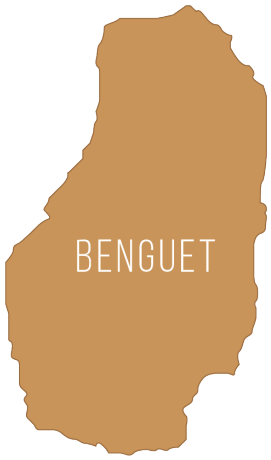
97% ARE **LITERATE**

FARMING

AGRICULTURE
AREA (HA) **197,278**

NUMBER OF FARMS
131,305

SA2



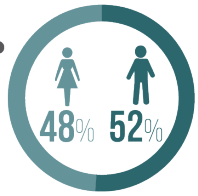
DEMOGRAPHICS

446,224
TOTAL POPULATION

1% OF TOTAL POPULATION IN **LUZON**

<1% OF TOTAL POPULATION IN **THE PHILIPPINES**

56% LIVE IN **RURAL AREAS**



PERCENTAGE OF **FEMALE AND MALE** POPULATION

ACCESS TO BASIC NEEDS

6% OF THE POPULATION LIVES IN **ABSOLUTE POVERTY**

98% ARE **LITERATE**

FARMING

AGRICULTURE
AREA (HA) **29,983**

NUMBER OF FARMS
27,491

SOURCE: PSA.GOV.PH

CABBAGE AND POTATO

Due to favorable agro-climatic conditions, the area is the largest potato and cabbage producing region in the country (approximately 11,000 ha of land) [28]. The crops are typically cultivated under a monocrop system with sprinkler irrigation[7]. Farmers often grow crops in sequence on the same plot area, potatoes are planted from January to February and harvested by June, cabbage is planted in July and harvested from October to November, and carrot/ radish is planted as third crop and harvested between December and January. Cabbage farmers usually plant companion crops (leeks or radish) on the plot borders, to supplement farm income and household diet. Production records for 2008-2017 show an average yield of 19 to 23 metric tons per hectare for cabbage and 17 to 20 metric tons per hectare for potato.

Farmers use synthetic chemicals for improving soil fertility and for managing pests and diseases. Chicken dung—sold mainly along the Halsema highway in Caponga (Tublay)—and lime—sold in Buguias—are also used for increasing soil fertility. In general, agricultural inputs are purchased in advance for the next cropping season, after selling the harvest [26]. Agricultural farm stores in central towns (e.g., Sayangan, Atok, Abatan, Buguias, La Trinidad, Benguet, in Baguio City) sell imported hybrid cabbage seeds and fertilizers. The popular and common cabbage varieties preferred by farmers are Scorpio, Lucky Ball, Ace Green, Gladiator, and Rare Ball, among others.

There are a few organizations that offer or sell potato plant materials, including the Northern Philippine Root crops Training Center of the Benguet State University (BSU-NPRCRTC) in La Trinidad, the Bureau of Plant Industry of the Baguio National Crop Research and Development Center (BPI-BNCRDC) in Guisad, as well as other private producers of stem cuttings in the province. Some farmers produce their own seeds by separating the medium-sized potatoes from their harvest and storing them for use in the next cropping season.

A relatively common practice in the province is the "Pa-supply system", whereby the supplier provides all the farm inputs (land, seeds, fertilizer and pesticide) to a farmer who agrees to provide labor during the entire cropping season. After the crop is harvested and sold, the total expenditures will be deducted from the gross income and the remaining proceeds will be divided equally between the supplier and the farmer, as their net income [26].

La Trinidad Vegetable Trading Post (LTVTP) is the center of marketing activities in the province, where sorters, packers and haulers can be hired on the spot, in the trading post area. Cabbage and potato marketing is oftentimes carried out through middlemen (predominantly women, also called "disposers") who sell the produce to retailers in the LTVTP and/or to wholesalers from Metro Manila (Balinatawak and Divisoria markets), Pangasinan (Urdaneta market), and other provinces. Unlike the LTVTP, where most of the profit goes to the disposer, the recently established Benguet AgriPinoy Trading Center (BAPTC) in La Trinidad helps create direct links between farmers and buyers, cutting off the middlemen and thus ensuring better prices for farmers and protection from price fluctuation [26].

While the study did not identify any cabbage processing technology in Benguet, stakeholder discussions revealed that there are small-scale local processors of potato, such as the Rural Improvement Council (RIC) and Taynan Livelihood Farmer's Association (TLFA), both located in Atok (Benguet). TLFA has a processing capacity of a maximum volume of 30 kilograms (kg) a day and mainly produces potato chips. Their products are available at the Benguet State University Marketing Center in La Trinidad and occasionally during agri-trade fairs.

For both value chain commodities, men are mostly responsible for seed and other input acquisition, land preparation, crop spraying, hauling and transporting, while women work mainly during planting, weeding, sorting, packaging, and crop processing (especially potato). Both women and men are engaged in crop harvesting.

[7] This type of irrigation involves the use of a suspended and/or embedded High-density polyethylene pipe (HDPE) that transports water from the source to a reservoir tank. Famers connect their individual pipelines to the reservoir's distribution pipe, adding a sprinkler head with small orifices or nozzles to the pipeline; this allows producing water under pressure in the form of spray, which simulates rain water [22].

IMPACTS ON WOMEN AND YOUTH

Gender roles and relations in the Philippines are strongly influenced by cultural, social, and economic factors and substantial gaps remain between men and women with respect to access to resources, economic opportunities, and influence in decision making. In CAR as in the rest of the country, women are primarily responsible for household activities (i.e. child care, basic needs, food preparation, etc.) but also actively participate in productive tasks (i.e. repetitive, less strenuous agricultural activities, such as watering and sewing or non-farm income-generating activities). Men engage almost exclusively in productive activities, especially those that are physically demanding (e.g., application of pesticides or fertilizers).

In the Filipino society, women's labor contributions—both productive and reproductive—are often overlooked, undervalued, or invisible in both men and women-headed households. 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 agricultural households in CAR noted that women often controlled the family finances, making decisions on the purchase of seeds and other inputs and on marketing of farm produce.

In addition, women and men experience climate hazards differently, as they experience different vulnerabilities. In general, men are more exposed to climate risks and hazards, primarily because they are responsible for carrying out physically-intense labor during harsh conditions, such as restoring eroded farms during and after a typhoon (e.g., carrying stones to riprap the affected area/s), exposing themselves to strong winds and heavy rains [26].

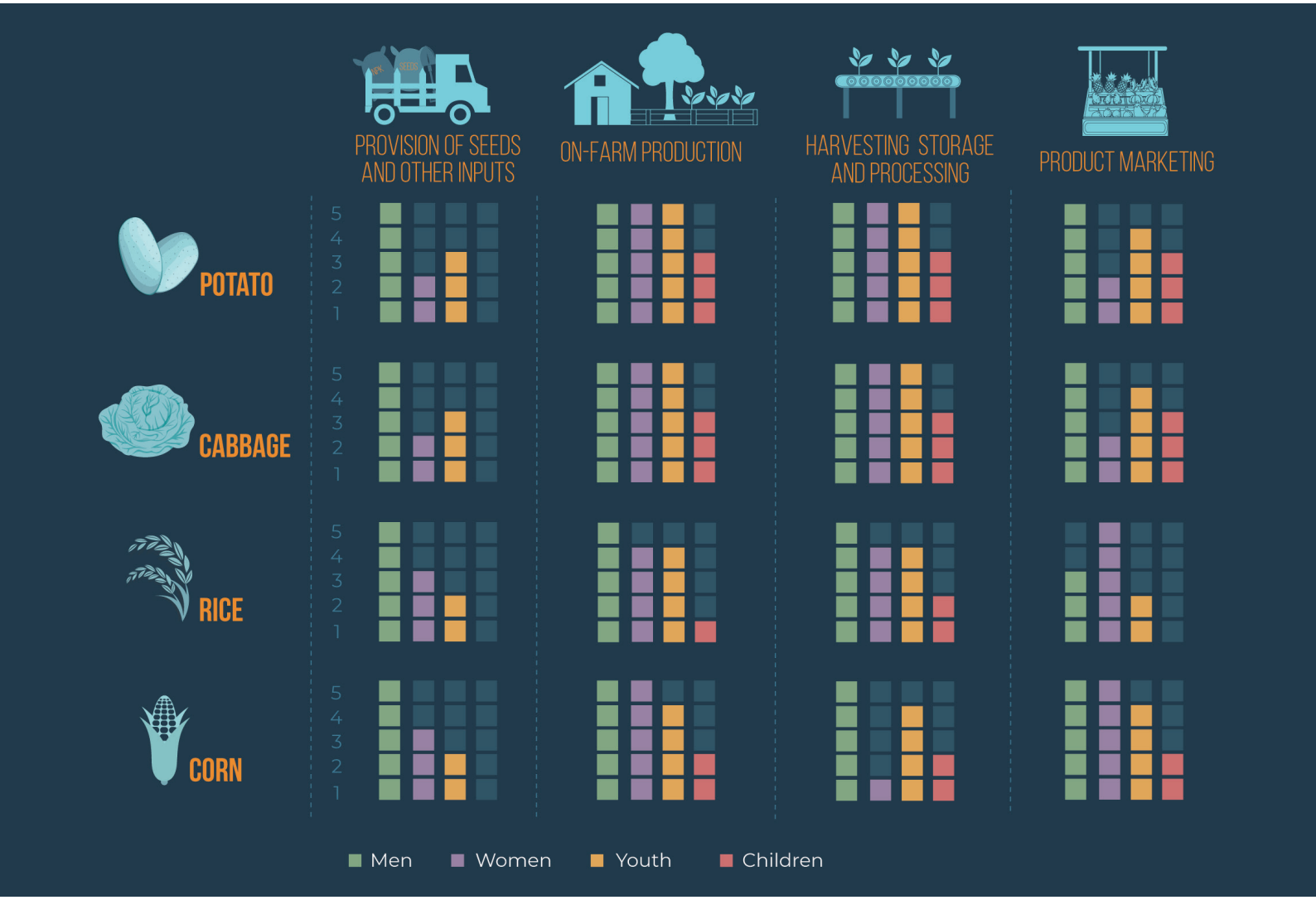


Figure 1: The role of men, women, youth and children across the different Value Chain stages. Results collected through expert workshop with key Value Chain actors in CAR.

It is estimated that up to 2.1 million Filipino children remain trapped in child labor, with agriculture responsible for a large proportion (62%). Boys and those living in rural areas are disproportionately impacted, being twice as likely to be involved than their female and urban counterparts. The most prominent form of labor is that of an unpaid family work. The impact of children's engagement in labor activities is often to the detriment of their education, with children absent or too tired to actively participate in their schooling [8].

AGRICULTURAL SECTOR CHALLENGES

Crop farming in Luzon is challenged by a variety of inter-twined factors that have prevented the sector from achieving its full economic potential. These factors include: high costs of production, volatile prices, diminishing soil fertility, limited road and market access, and limited irrigation and post-harvest facilities, among others.

High cost of production causes a heavy strain on the limited capital of farmers. Farmers' heavy dependence on synthetic chemicals to fertilize and protect their crops from pests and diseases incurs a major cost to production, while diminishing soil fertility and contributing to environmental pollution. Without proper soil nutrient analysis, farmers may use inadequate types and amounts of chemicals, further reducing the quality of already-degraded soils. To modernize their farming practices and purchase essential inputs farmers require credit. The government has introduced an agricultural loan program, yet this has been deemed ineffective as farmers often fail to have the required documentation. This leaves farmers dependent on exploitative trade financiers and Pa-supply systems.

Fluctuating commodity prices reflect unstable quality and seasonality of supply, absence of adequate postharvest technologies, a highly layered marketing system, and a lack of adequate policies to ensure farmers fair prices. Limited market outlets are believed to encourage fluctuating, low prices and over-supply, affecting farmers' bargaining power.
Unstable crop supply is also linked to high post-harvest losses due to inadequate infrastructure and processing facilities. Publicly-funded irrigation projects do not reach all farmers in the region, highly exposing production in times of drought. The rugged terrain of Benguet and Mountain Province, the poor road infrastructure, long farm-to-market distances and high costs of fuel and vehicle maintenance affect commercialization activities, especially during the wet season. Many roads, particularly at the municipal and barangay levels, have yet to be cemented, making farmer's access to markets difficult. Additionally, post-harvest facilities (pre-coolers, pre-packing facilities and grading materials) and processing machinery are insufficient and barely maintained due to limited funding.

CLIMATE CHANGE AND VARIABILITY: HISTORIC AND FUTURE TRENDS

All four climate types present in the Philippines can be found in Luzon[8]. The eastern side of the island has no dry season but a pronounced period of heavy rain from December to February (type II climate). The center of the island has a short dry period from December to February (type III), while the eastern side has a pronounced dry season from November to April and a wet season for the rest of the year (type I). There is a small area in Region 5 with rain distributed evenly throughout the year (type IV climate). Study area 2 (Benguet) is classified as type I, while study area 1 is a mix of type I and type III, with the western side experiencing a more pronounced wet season from November to [35].

[7] Assessment base on the modified coronas classification system (MCCS).

[8] Assessment base on the modified coronas classification system (MCCS).

PROJECTED CHANGE IN PRECIPITATION AND TEMPERATURE BY 2050 [38, 39]

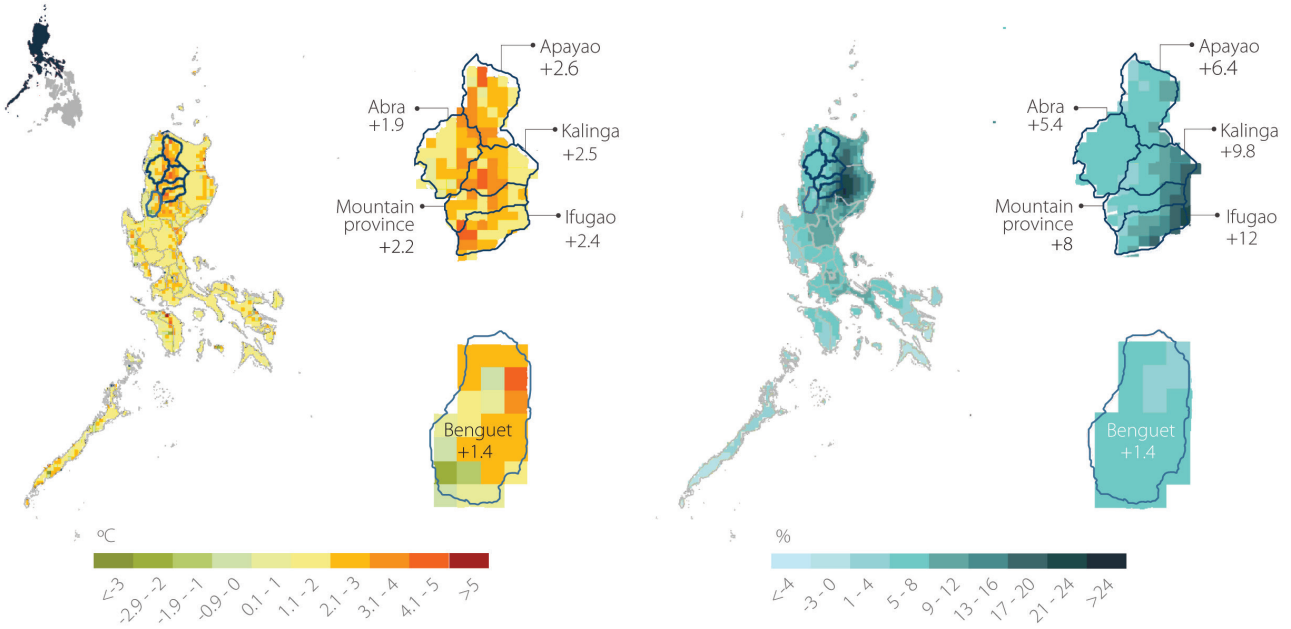


Figure 2: Modeled changes in temperature (left) and precipitation (right) under climate change by 2050, using RCP 4.5.

By 2050[9], both study areas are expected to experience decreases in rainfall by 20-30% during the months of March to May and increases during the other parts of the year. This increase is greatest in Benguet, with 63% increases in June, July and August and a further 21% increase in September, October and November. Overall, dry days in Benguet are projected to fall by 26% and extreme rainfall events (>300mm) to increase from 29 to 30 in a year. Study area 1 will likely experience an increase in the number of hot days (>35° C), fewer dry days and an increase in extreme rainfall events (>300 mm) [35].

Due to its geographical location and archipelagic formation of over 7000 islands, The Philippines is highly vulnerable to climate change impacts, particularly typhoons[10], flooding and droughts. Heavy rains brought by typhoons often result in landslides, destroying areas of agricultural land, blocking roads, causing death and destruction of homes. Globally, the Philippines ranks fifth when it comes to climate-related losses, with 289 events registered between 1997 and 2016, causing the death of 85,955 people and costing the country 0.6% of its GDP [1]. Between 2000 and 2010, the total economic damage from typhoons, floods, and droughts was estimated at USD 2.2 billion, with rice crop losses amounting to USD 1.2 billion, corn losses USD 461.5 million, and high value crop losses worth USD 245.8 million. By 2050, total economic losses from climate hazards are expected to increase to USD 2.7 billion a year [3].

Northern Luzon, Southeastern Luzon and Eastern Visayas are the geographical regions with the highest incidence of typhoons and tropical storms in the country. Studies have found that up to 54% of rainfall in Luzon can be attributed to tropical cyclones, an increase of 19% from 15 years ago [37]. A southward shift in the typhoon belt has been observed; the frequency of landfall has been decreasing in Northern and Central Luzon and increasing in areas in Visayas and Mindanao [36].

9 Using 1971-2000 baseline.

10 The Philippines is the second most exposed country to typhoons after China, receiving at least 15 typhoons (aggregate of tropical storms and typhoons) a year.

LANDSLIDE AND TYPHOON HAZARD MAPS OF LUZON [38, 39]

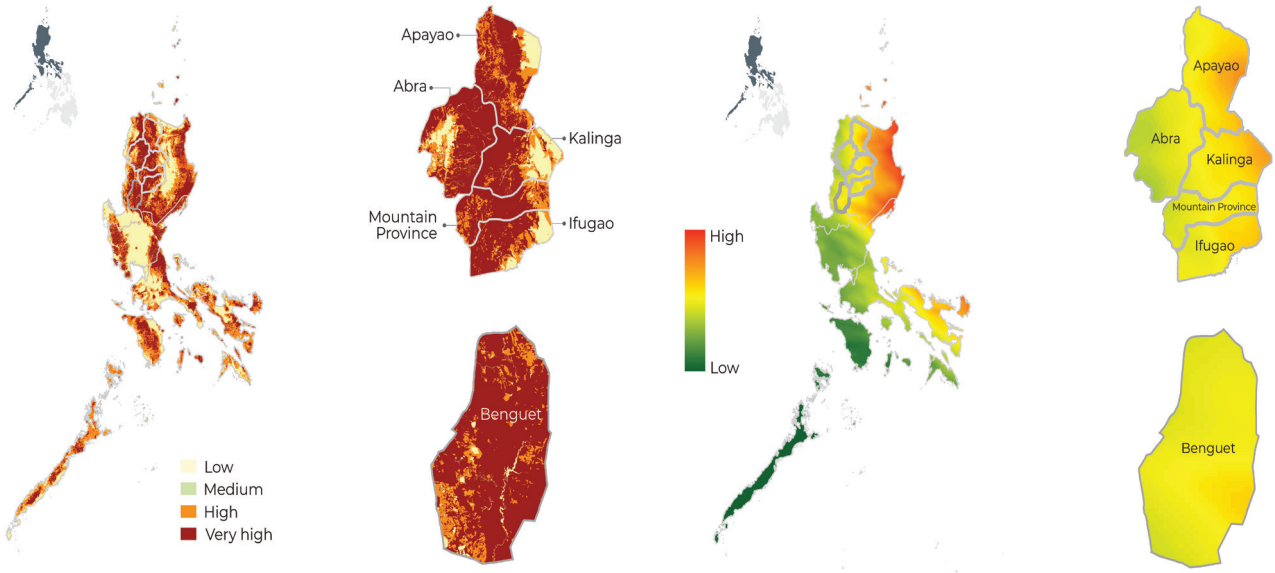


Figure 3: Landslide (left) and typhoon (right) maps for Luzon, study areas 1 and 2. The landslide maps was acquired from the AMIA multi-hazard map. The original data source came from the Department of Environment and Natural Resources, Mines and Geosciences Bureau. The typhoon map was acquired from the UNEP/UNISDR dataset using a 1 kilometer pixel resolution. Estimate of tropical cyclone frequency based on Saffir-Simpson scale category 5 (> 252 km/hr) from year 1970 to 2013.

DROUGHT HAZARD MAP OF LUZON [38]

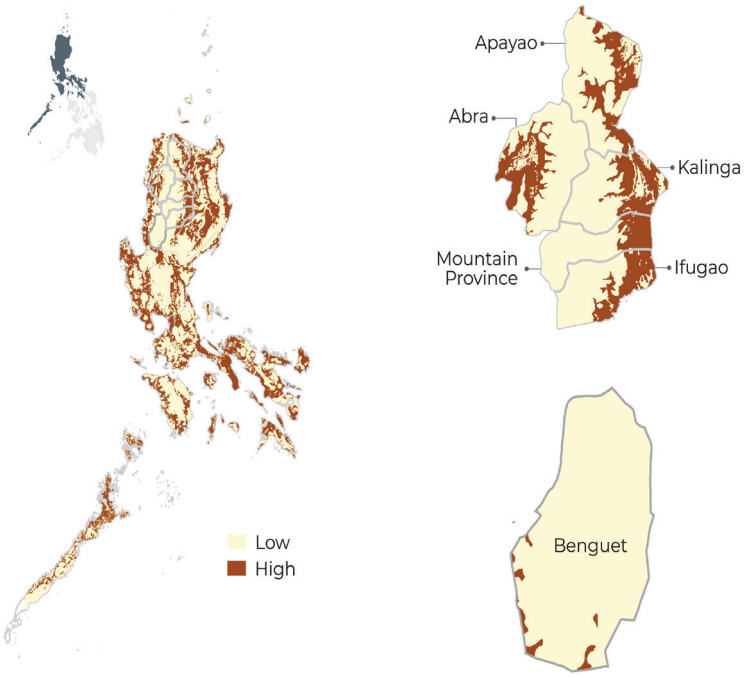


Figure 4: Drought maps for Luzon, study areas 1 and 2. The drought map was acquired from the AMIA 1 dataset. It is produced using the integration of groundwater potential from National Water Resources Board (NWRB), topography, and climate data from PAGASA.

Climate-induced rainfall variability is likely to have a major impact on agriculture throughout the entire country [35, 40] as farming heavily depends on the timing of rains, with certain stages in the crop cycle being more impacted by heavy/reduced rainfall than others. 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. Study area 1 (climate type I) experiences the largest positive rainfall anomaly in La Niña years (the cold phase of an ENSO, which results in excessive rainfall), whilst Study area 2 (climate type III) experiences the largest negative rainfall anomaly in El Niño years (the warm phase, which is associated with droughts and water stress) [41]. Evidence shows that the ENSO has become increasingly unpredictable, with Luzon experiencing dry conditions during usually wet La Niña events and Mindanao reporting excessive rains during usually dry El Niño events [42].

El Niño events that caused significant losses to agriculture occurred in 1997-1998 (which resulted in production losses of 100% during the dry season and greater than 33% during the wet season), in 2004 (18% losses during the dry season and 32% in the wet season) [40] and 2015-2016 (causing dry spells in the west of Luzon, including Benguet [43]).

CROP SUITABILITY

As discussed in the previous section, agriculture in the Philippines is already impacted by changes in temperature and precipitation. The combination of these factors will over time alter the agro-ecological conditions, making certain region more or less conducive to the production key commodities. The following climate suitability maps show the expected performance of cabbage, white potato, corn and rice considering climatic factors (temperature, rainfall). Climate suitability is estimated using bioclimatic factors derived from temperature and rainfall baseline climate data from WorldClim (1970-2000), and future climate data from PAGASA ensemble GCMs for the year 2050 time period under RCP 8.5. To simplify the interpretation, the values can be translated into the following suitability classes: 0-20 (very marginal); 20-40 (marginal); 40-60 (suitable); 60-80 (very suitable); and 80-100 (excellent). These measures for future suitability will assist agricultural planning and investment in the selected regions, supporting long term planning and transformative change in response to climate change.

CLIMATE SUITABILITY OF RICE IN LUZON, CURRENT AND 2050 [35, 44]

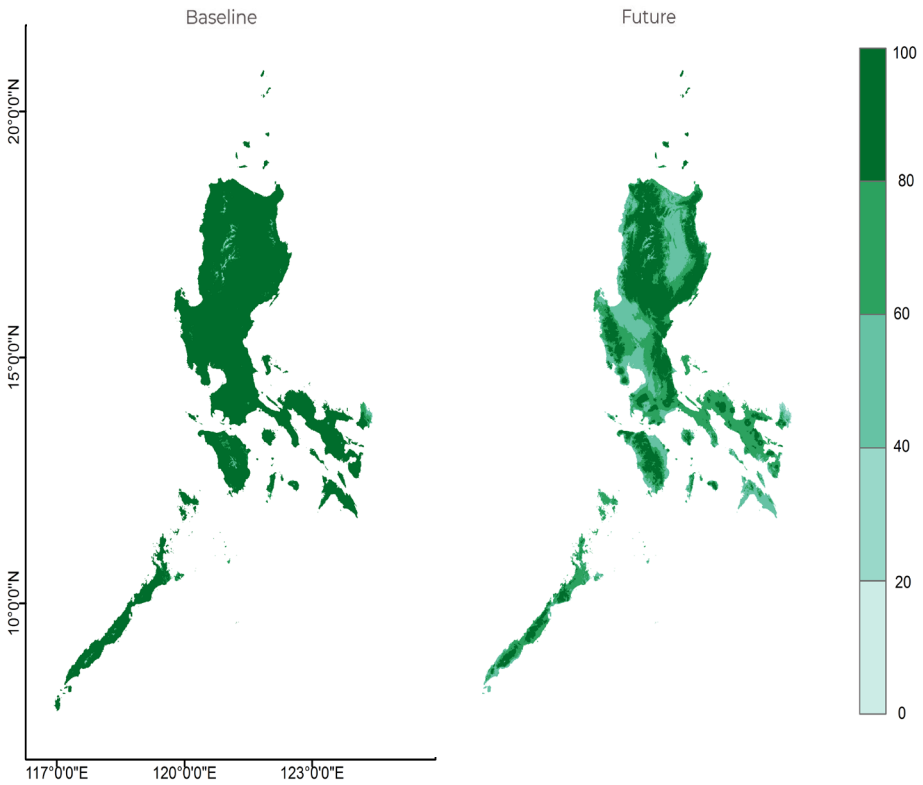


Figure 5: Climate suitability of rice. The crop is typically suitable in almost all of Luzon. By 2050, large areas of Luzon will experience a loss in suitability of as much as 40-60%. Such a fall in suitability will have wide reaching impacts across Luzon, which is currently the largest producer of rice across the three island groups. Unlike other more lowland regions CAR is projected to remain highly suitable for rice production.

CLIMATE SUITABILITY OF CORN IN LUZON, CURRENT AND 2050 [35, 44]

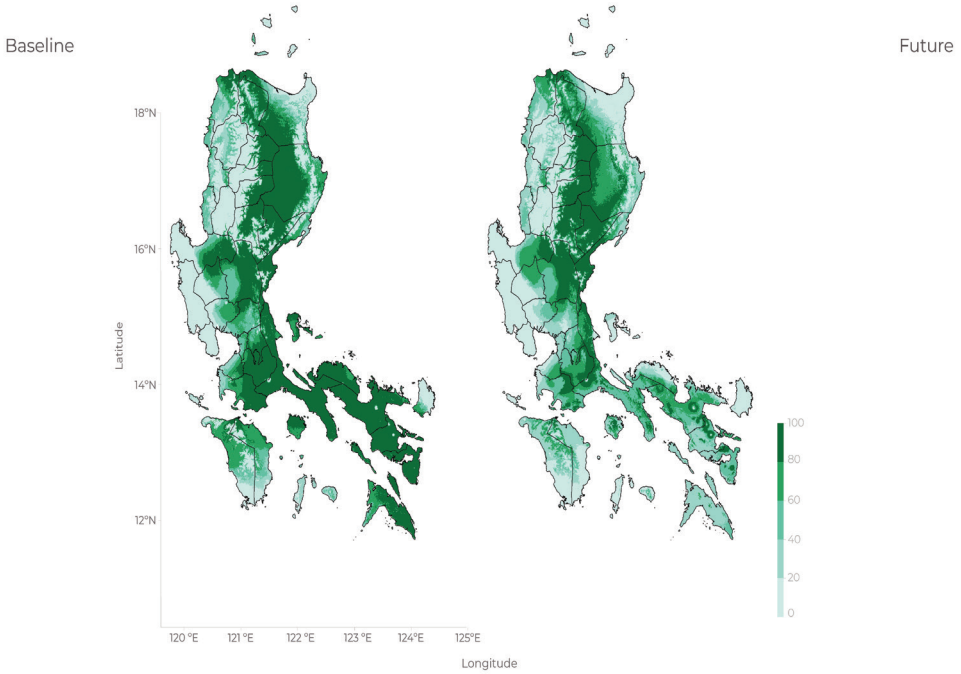


Figure 6: Climate suitability of corn. The crop has a high to very high climate suitability in eastern Luzon (specifically in Region 2, Cagayan Valley), east of Region 3 (Central Luzon), Region 4A (CALABARZON), Region 5 (Bicol), and majority of Region 4B (Mindoro, Marinduque, and Romblon). By 2050, the crop's climate suitability is expected to decrease by roughly 60% from very high to marginally suitable in the northern part of Luzon and all over Region 4.

CLIMATE SUITABILITY OF CABBAGE IN LUZON, CURRENT AND 2050 [35, 44]

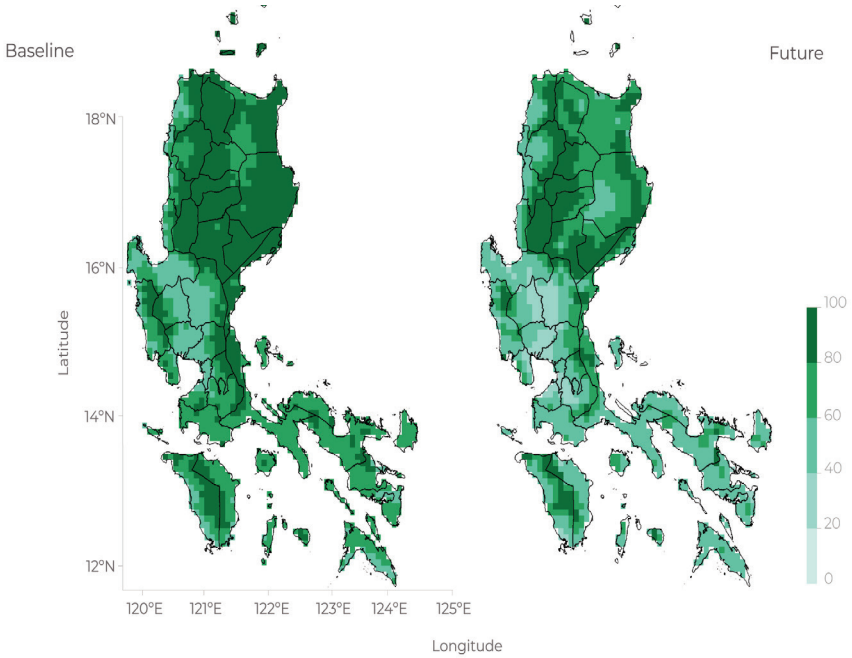


Figure 7: Climate suitability of cabbage (Brassica oleracea var. Capitata Linn.). Cabbage grows best on sandy loamy soil, in cool and moist climate, with temperature ranging from 15o C to 20o C but can successfully thrive in the lowlands during cooler months of the year. In general, cabbage has a moderate to very high climate suitability in Luzon, particularly in CAR (the provinces Apayao, Abra, Kalinga, Mountain Province, Ifugao, Benguet, and Nueva Vizcaya). By 2050, suitability of cabbage is expected to decrease slightly (from very high to high) in the provinces of Apayao, Abra, Kalinga, Mountain Province, and Nueva Vizcaya.

CLIMATE SUITABILITY OF POTATO IN LUZON, CURRENT AND 2050 [[35, 44]]

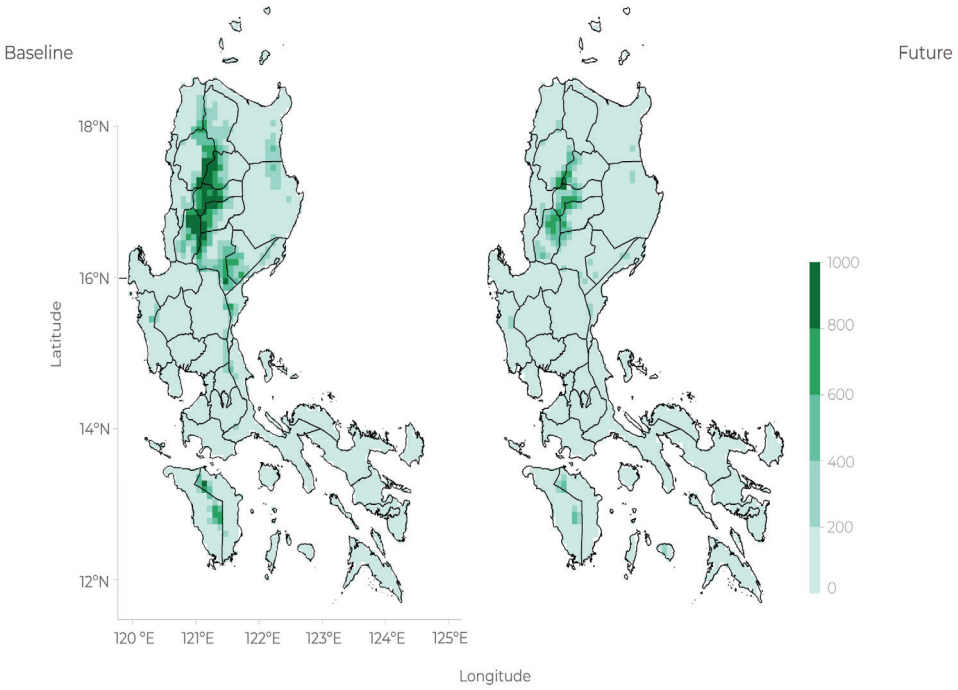


Figure 8: Climate suitability of white potato. White potato (Solanum tuberosum L.) grows best in moderately cool temperatures (20-24º C), on loose soils (e.g., loamy and sandy loam). In the Philippines, the crop is only suitable in selected hilly areas of the provinces in CAR, especially in the east of Abra, west of Kalinga and Ifugao, almost half of Mountain Province in the western side, and on the northern part of Benguet. By 2050, the crop's climate suitability is expected to decrease from very high to marginally suitable in the provinces of Apayao, Abra, Kalinga, and Ifugao, and will remain highly suitable in Benguet and Mountain Province.

THE CLIMATE FROM FARMERS' PERSPECTIVES

Farmers in the study areas believe that erratic weather, intensifying and irregular rainfall, more frequent and stronger typhoons, and prolonged droughts are clear manifestations of a changing, more variable climate. Indigenous people of Benguet used to predict the end of the typhoon by observing the arrival of a migratory bird known as "Kiling" in local dialect and design the cropping calendar based on these observations. Traditional knowledge used to play a major role in planning agricultural activities and in strengthening community ties and household food security [45]. However, according to farmers, such weather forecasting methods have lost effectiveness nowadays, as the weather has become more unpredictable. With distorted wet and dry seasons, estimating the right planting time or selecting the right crop type has become increasingly difficult. Highland farmers have a hard time knowing when to activate anti-frost sprinklers, as frosting no longer occurs between 1am and 2am, but rather at unexpected times in the morning or evening.

Some farmers have also witnessed increases in summer temperatures and prolonged droughts, which have led to crop wilting and drying and/or to an increases in on-farm water consumption (given faster evaporation rates). Due to high temperatures, farm working hours have to be changed (with a break between 11am and 1pm), so as to avoid intense, unhealthy exposure to sunrays. As one farmer said, "It is very difficult to find on-farm workers who will really work for exactly 8 hours due to the extreme temperature" [26]. Additionally, prolonged droughts have caused drying up of creeks and springs and low water level in rivers, affecting upstream and downstream farms alike.

According to farmers, erratic weather conditions and intensifying and irregular rainfall have increased crop vulnerability to stress, wilting, blight, leaf rusting, clubroot, leaf miner and other plant pests and diseases. If grains get wet due to abrupt rains, farmers

experience high post-harvest losses in manual drying of corn and rice. Crop losses from typhoons – which nowadays are stronger than before, leading to the loss of human life and damages to infrastructure – resulting in significantly lower household incomes [26].

VALUE CHAINS, VULNERABILITIES AND PROPOSED ADAPTATION OPTIONS

The impacts of climate change and natural hazards are felt across all stages of the value chain, from provision of seeds and inputs to product marketing. Climate impacts are felt differently in each value chain activity and by each actor group, which suggests the need to provide context-specific adaptation options. In this section we look at the consequences of climate hazards across the value chains of rice, yellow corn, cabbage and potato, considering the underlying vulnerability factors and recommended adaptation options to adapt to or mitigate associated risks.

All four commodities are highly exposed to typhoons and droughts. These hazards limit the supply of important inputs such as nursery plants, which are particularly vulnerable under drought or heavy rain conditions. Droughts reduce yields and crop quality and, in extreme cases, lead to crop failure. Landslides caused by typhoons reduce market accessibility, limiting the ability of input suppliers to reach remote areas. Heavy rains brought on by typhoons also increase the incidence of pest and diseases and advance soil erosion, causing significant nutrient losses. Additionally, typhoons were found to increase costs for harvesting storage and processing . Unpredictable and excessive rains have detrimental effects on rice and corn farmers and processors who depend on sunlight for drying their grains; they have to wait for the weather to improve or opt for the costlier mechanical drying. Lastly, product marketers see their incomes and local reputation affected by disrupted and low-quality supply.

RICE

Rice suitability in CAR is projected to remain stable under climate change (see figure 5), it will however remain vulnerable to yearly swings in production bought about by extreme weather events and natural hazards. Multiple adaptation options have been suggested for managing risks in the rice value chain. One of these is the provision and use of improved varieties, which not only enhances productivity but also allows fetching higher margins. Additionally, diversification (e.g., integrated crop-livestock systems) can help spread climate risks, ensuring farmers a "second option" to rely on when the primary crop fails. In areas with unpredictable rains, the use of tarpaulin and a hole could facilitate cost-effective water storage for use in times of drought. Climate resilience could also be achieved through access to climate advisory and planting calendars, according to focus group discussions with farmers. Other promising and already-practiced adaptation options noted include: integrated pest management (IPM) with the use of botanical attractants[11] or of papaya leaves, sweet potato vines or banana leaves to attract golden snails[12], and adoption of early-maturing varieties to ensure harvested before the onset of rains.

To mitigate the negative impacts of typhoon and droughts on rice processing, value chain actors could benefit from training on risk management strategies, as well as early warning systems, which would help farmers to decide when to switch between lower cost sun drying and mechanical drying. A growing market for low-cost flatbed dryers/mechanical dryers was noted, allowing farmers to dry their grains during periods of heavy rain. The need for pricing regulations to ensure firer incomes for farmers and local traders were also mentioned by study participants. Moreover, improved, timely access to credit following a disaster would allow value chain actors to quickly rebuild their business and recover from losses.

[11] Botanical attractants refer to plants grown in strips along the border of a field, which have the function of attracting potential pests and thus reducing their impact on the rice crop.

[12] This indigenous method is particularly important following typhoons, when wet conditions lead to an abundance of golden snails.

RICE

PROVISION OF SEEDS AND OTHER INPUTS

ON-FARM PRODUCTION

HARVESTING STORAGE AND PROCESSING

PRODUCT MARKETING

Hazard: TYPHOON

Consequences

- Poor quality seeds
- Increases in prices of seeds and farm inputs
- Reduces access to seeds and inputs
- Damage to crop resulting in lower yields
- Damage to irrigation system
- Kills carabao
- High incidence of plant pests and diseases
- Delayed planting
- Reduced sunlight for grain drying
- Negatively affects the quality of rice
- Reduces final price
- Generates problems in the market dynamics of local and outside buyers

Underlying vulnerability factors/ sensitive groups

Biophysical: lowland areas are prone to flooding; Socio-economic: high interest on lending companies; **Institutional:** reduced government support, price volatility, insufficient training/knowledge on pest and disease management; **Infrastructure:** poor farm-to-market-road conditions, insufficient/poor irrigation systems

Adaptation options proposed

- Provision of flat-bed dryer/mechanical dryers
- Development of typhoon/drought resistant rice variety
- Development of improved varieties (early-maturing)
- Facilitate access to credit after disasters
- Diversified farming (crops-livestock)
- Climate advisory
- Planting calendar (Synchronized planting)
- Integrated pest management (e.g. botanical attractants)
- Use of early maturing varieties
- Early warning system for each community/rain or typhoon detector
- Use mechanical dryers
- Attend rice processing trainings and seminars by government line agencies
- Establish pricing regulation for rice

Hazard: DROUGHT

Consequences

- Higher incidence of pests and diseases
- Delays in planting time
- Reduces the water availability for crop production
- Generates problems in the market dynamics of local and outside buyers

Underlying vulnerability factors/ sensitive groups

Institutional: Insufficient knowledge on pest and disease management, inappropriate soil fertility management; **Infrastructure:** insufficient/poor irrigation systems

Adaptation options proposed

- Provision of flat bed dryer/mechanical dryers
- Development of drought-resistant rice varieties
- Facilitate access to credit after disasters
- Use of early maturing varieties
- Diversified farming (crops-livestock)
- Rainwater harvesting
- Planting calendar (Synchronized planting)
- Improvement to irrigation systems
- Integrated pest management (e.g. botanical attractants)
- Attend rice processing trainings and seminars by government line agencies
- Establish pricing regulation for rice

Magnitude of impact: Minor | Moderate | Major | Severe

Score priority: High | Medium | Low

YELLOW CORN

PROVISION OF SEEDS AND OTHER INPUTS | ON-FARM PRODUCTION | HARVESTING STORAGE AND PROCESSING | PRODUCT MARKETING

Hazard: TYPHOON

Consequences

- Difficult accessing seeds and inputs
- Increase in the price of seeds and farm inputs
- Increased soil erosion
- Increased crop damage/broken stem
- Higher incidence of plant pests and diseases
- Limited labor
- Increase in postharvest losses
- Poor quality product
- Farm to market roads damaged
- Reduced income across VC

Underlying vulnerability factors/ sensitive groups

Biophysical: lowland areas more prone to flooding; **Socio-economic:** high interest from lending companies; **Institutional:** no stablished price regulation; **Infrastructure:** poor farm-to-market-road conditions, lack of processing facilities

Adaptation options proposed

- Provision of corn transplanter
- Facilitate access to credit after disasters
- Planting calendar
- Diversified farming (crops-livestock)
- Contour farming (SCoPSA, NVS, SALT)
- GAP (Good Agricultural Practices)
- Delaying harvest
- Establishment of processing facilities
- Corn-by products utilization and processing
- Early warning system for each community/rain or typhoon detector
- Price monitoring after harvest
- Establishment of markets for corn (especially within Paracelis, Mt. Province)
- Facilitate access to credit after disaster
- Establish pricing regulation policies

Hazard: DROUGHT

Consequences

- More expenses for farm equipment
- Stunted and weak plants
- Difficulties in land preparation
- Low productivity due to production loss
- Poor quality product
- High price in the market
- Reduced income across VC

Underlying vulnerability factors/ sensitive groups

Institutional: high interest from lending companies; Infrastructure: precarious road conditions and poor irrigation systems

Adaptation options proposed

- Provision of water pump
- Provision of corn transplanter
- Facilitate access to credit after disasters
- Deep well digging
- Planting calendar
- Diversified farming (crop-livestock)
- Rainwater harvesting
- GAP (Good Agricultural Practices)
- Manual weeding
- Establishment of processing facilities
- Corn-by products utilization and processing
- Facilitate access to credit after disaster
- Price monitoring after harvest
- Establishment of markets for corn (especially within Paracelis, Mt. Province)
- Establish pricing regulation policies

Magnitude of impact: Minor | Moderate | Major | Severe

Score priority: High | Medium | Low

YELLOW CORN

Luzon is projected to see a fall in corn suitability by 2050, with the largest losses seen in the south and the west of the island. CAR region fairs better with only a small reduction in suitability see figure 6). Production will however continue to be impacted by typhoons and droughts requiring improved management practices. Due to the slow and labor-intensive nature of corn transplanting—particularly in times of drought— farmers often miss the optimum planting window, affecting productivity. Mechanized transplanters would improve the efficiency of the planting process, allowing farmers to adapt the planting time to unpredictable weather. Additionally, the provision of an accurate corn cropping calendar and early warning systems would help complement indigenous farm planning and harvesting methods, which are becoming increasingly ineffective due to changes and variations in climate. In sloping areas, where heavy rains cause soil erosion, nutrient leaching and landslides, some corn farmers already practice contour farming[13], thus being able to maintain top soils and the nutrients contained within them. In times of drought, rainwater harvesting and impounding is an important lifeline for many farmers. The impacts of both drought and typhoon are less acute for farmers who follow good agriculture practices and diversify[14] their farming systems.

The processing capacity for corn in the region—and especially in marginalized areas—is insufficient. Study participants noted the need for government support to improve processing capacity, which would allow farmers to add value to their products and ensure better incomes. Other areas of intervention noted by study participants as measures to de-risk the corn value chain included improved market access for farmers located in remote and hard to reach areas in CAR, as well as access to affordable credit and insurance products for all.

CABBAGE AND POTATO

The suitability of cabbage in Benguet continues to be classified as very high in 2050, while other areas particularly in the south and east of Luzon are projected to experience falling suitability (see figure 7). Potato is currently only suitable in the upland areas of central CAR, this already small area of suitability is projected to fall further by 2050, Benguet will experience decreasing suitability from very high to marginal suitability (see figure 8). Falling suitability coupled with the effects of drought and typhoon will increase the vulnerability of potato and cabbage farmers in the region, requiring a robust response.

In the aftermath of a typhoon or drought, cabbage and potato seeds and seedlings are very difficult to acquire, as the nurseries will have been damaged and the demand for seeds will be high. Capacity building on practices for raising seedling, establishment of seed banks with local varieties/certified seeds and the modernization of commercial nurseries would be key measures to mitigate the impacts of climate hazards on cabbage and potato farmers. Additionally, accurate planting calendars and information on product zoning would help farmers better plan their activities. Study participants also noted the need for using improved varieties (blight-resistant potatoes[15], drought-resistant cabbage varieties such as Lucky Ball and Ace Green) to help adapt the system to changing climate conditions, but also the possibility to switch to organic farming[16], which would open up doors to new markets and bring important benefits to soils.

Reforestation projects on the hilltops in Benguet would reduce the exposure of farmers to both typhoon and drought, as trees would act as a wind breaks and reduce the likelihood of landslides, while also increasing soil health and water holding capacity. On a smaller scale, the addition of cut flower strips as windbreaks would also reduce the impacts of typhoon, while diversifying the farmers income sources. Additionally, rain burst sprinklers could help reduce the impact of frost on the plants, which have grown in frequency and unpredictability over the years.

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[13] The Agricultural Training Institute (ATI) in CAR promotes two forms of contour farming: the Sloping Agricultural Land Technology (SALT) and Sustainable Corn Production in Sloping Areas (SCoPSA). SALT is a method of growing field and permanent crops in 3- to 5-meter-wide bands between contoured rows of nitrogen-fixing trees. The nitrogen-fixing trees are thickly planted in double rows to make hedgerows. When a hedge is 1.5 to 2 meters tall, it is cut down to about 75 centimeters; the cuttings (tops) are placed in alley-ways to serve as organic fertilizers . SCoPSA is a key measure for soil conservation and climate change adaptation promoted by the government in corn areas vulnerable to soil erosion [46].

[14] One common diversification method practiced by corn farmers is intercropping of corn and squash, with the broad squash leaves shading the ground, reducing evapotranspiration, increasing soil moisture in times of drought.

[15] Such varieties are particularly important in typhoon-prone areas, as heavy rains cause water logging, increasing the threat of potato blight which significantly reduces yields and incomes.

[16] Roughly 50 farmers' organizations devoted to organic agriculture exist in Benguet province alone.

CABBAGE

	PROVISION OF SEEDS AND OTHER INPUTS	ON-FARM PRODUCTION	HARVESTING STORAGE AND PROCESSING	PRODUCT MARKETING
Hazard	**TYPHOON**			
Consequences	Delays purchase of seeds and farm inputs	Causes farm soil erosion Higher occurrence of pests and diseases Reduces size and quality of the produce Low productivity/yield and low income	Increases the risk of crop loss during harvesting and transporting	Increases the market prices of food High demand but low supply
Underlying vulnerability factors/ sensitive groups	**Socio-economic:** reduced farm capital, behavioral attitude of the farmers, limited funding for government programs; **Institutional:** issues on credit, limited access to lending institutions, NGO agencies and government support; **Infrastructure:** precarious farm location and conditions of farm-to-market-roads, lack of alternate routes (roads and bridges)			
Adaptation options proposed	Establishment of seed banks Extension services, trainings, and seminars on seed production Facilitate access to credit after disasters	Establishment of crop Shelter (e.g. greenhouse) Planting calendar/product zoning Organic farming ($) Reforestation program (local trees, bamboo) Planting cutflowers as windbreakers	Pre-cooler storage and refrigerated van Construction of Tramline	Establish pricing regulation for vegetables at the trading center Food grade packaging materials Construction of product storage system or cold chain storage in the strategic areas near production and market More cold and dry storage facilities per municipality
Hazard	**DROUGHT**			
Consequences	Nurserys fail	Reduces size and quality of produce Higher occurrence of pests and diseases	Reduced quantity of crop for processing	Increases the market prices of food Lower quality produce
Underlying vulnerability factors/ sensitive groups	**Socio-economic:** farm capital problem; **Institutional:** unestablished trading regulations (e.g. pricing), poor policy programs on product marketing, limited funding for government programs, limited access to credit/lending institutions, NGO agencies and government support; **Infrastructure:** lack of irrigation and potable water, scarce and expensive irrigation facilities, limited/non-functioning product storage and processing/packaging facilities			
Adaptation options proposed	Establishment of seed banks Extension services, trainings, and seminars on seed production Facilitate access to credit after disasters Acquisition of certified/quality seeds or seedlings Development of cabbage drought resistant variety	Establishment of crop Shelter (e.g. greenhouse) Rainwater harvesting ($) Planting calendar/product zoning Organic farming Reforestation program (local trees, bamboo) Facilitate access to credit after disasters	Pre-cooler storage and refrigerated van Construction of Tramline	Establish pricing regulation/ monitoring for agricultural products at the trading center Food grade packaging materials (eco-friendly) Construction of product storage system or cold chain storage in the strategic areas near production and market

Magnitude of impact: Minor | Moderate | Major | Severe

Score priority: High | Medium | Low

Cost-Benefit Analysis: $ Available

POTATO

PROVISION OF SEEDS AND OTHER INPUTS

ON-FARM PRODUCTION

HARVESTING STORAGE AND PROCESSING

PRODUCT MARKETING

Hazard: TYPHOON

Consequences

- Delays purchase of stem cuttings/tubers and other inputs
- Crop failure
- Reduces yield hence lower income
- Increased occurrence of pest and diseases (e.g. potato blight)
- Causes soil erosion
- Increases the risk of crop loss during harvesting and transporting
- Affects processing activities
- Delays in produce delivery to the market
- Increases the market prices of food
- High demand but low supply

Underlying vulnerability factors/ sensitive groups

Socio-economic: mining and deforestation activities; Institutional: issues on credit or lending institutions; Infrastructure: precarious farm location and conditions of farm-to-market-roads, lack of alternate routes (roads and bridges)

Adaptation options proposed

- Establishment of seed banks
- Create nurseries for potato tubers
- Adequate storage facilities in diffuse light conditions
- Strengthen extension services, trainings, and seminars on seed/tuber/ seedling production
- Facilitate access to credit after disasters
- Establishment of crop Shelter (e.g. greenhouse)
- Planting of blight resistant varieties (Igorota variety) ($)
- Planting calendar/product zoning
- Organic farming
- Reforestation program (local trees, bamboo)
- Planting cutflowers as windbreakers
- Facilitate access to credit after disasters
- Pre-cooler storage and refrigerated van
- Establishment of processing center
- Construction of Tramline as an alternative transportation system
- Establish pricing regulation/monitoring for agricultural products at the trading center
- Trading facility regulations
- Food grade packaging materials (eco-friendly)
- Construction of product storage system or cold chain storage in the strategic areas near production and market
- More cold and dry storage facilities per municipality

Hazard: DROUGHT

Consequences

- Low productivity/yield/ low income
- Limited supply of potato for processing
- Increases the market prices of food

Underlying vulnerability factors/ sensitive groups

Socio-economic: farm capital problem; **Institutional:** unestablished trading regulations (e.g. pricing of vegetables), poor policy programs on product marketing, limited funding for government programs; **Infrastructure:** lack of irrigation and potable water, scarce and expensive irrigation facilities, limited/non-functioning product storage and processing/packaging facilities

Adaptation options proposed

- Establishment of seed banks
- Extension services, trainings, and seminars on seed/tuber/ seedling production
- Facilitate access to credit after disasters
- Establishment of crop Shelter (e.g. greenhouse)
- Rainwater harvesting
- Organic farming
- Reforestation program (local trees, bamboo)
- Facilitate access to credit after disasters
- Pre-cooler storage and refrigerated van
- Establishment of processing center
- Construction of Tramline
- Establish pricing regulation/ monitoring for agricultural products at the trading center
- Trading facility regulations
- Food grade packaging materials (eco-friendly)

Magnitude of impact: Minor | Moderate | Major | Severe

Score priority: High | Medium | Low

Cost-Benefit Analysis: $ Available

Investments in small, local cold storage facilities, processing and packaging plants would help reduce post-harvest losses (particularly in times of drought and heavy rains), improve the quality and value of the product that reaches the market and hence increase farmers' income. Study participants also highlighted the need for price regulations to ensure fairer prices and affordable credit products to support value chain activities and help actors respond quickly to climate hazards.

OFF-FARM SERVICES

RICE

Through its Flagship Agri-Pinoy Rice Program, the regional office of the Department of Agriculture (DA-CAR) takes the lead in providing support and services to rice farming communities across the region. Activities include: distribution of seeds to boost production, soil analyses to increase soil fertility, distribution of Zinc sulphates (which serve as compost soil activators and soil ameliorants), farmer trainings, outreach campaigns (through printed material and radio), among others. For instance, in 2017, roughly 30 rice seed growers in the region participated in refresher courses on rice production and other 50 farmers benefited from good agricultural practices (GAP) trainings, through Farmer Field Schools (FFS). To mitigate the effects of drought, DA-CAR promotes Small Water Impounding Projects (SWIP), diversion dams and distributes pumps. Additionally, tractors, walk-behind planters, seed cleaners and dryers are distributed to farmer groups and cooperatives.

The development, maintenance, and deployment of the Rice Crop Manager (RCM) Advisory Service is supported by the DA [47]. RCM is a web-based platform that provides rice farmers across the Philippines with personalized recommendations for crop and nutrient management. The advice comes in the form of a one-page printout and text messages sent to farmer's phone. The service combines different tools aimed to reduce production costs, increase yields, increase net income, and facilitate the delivery of appropriate, timely advisory through information and communications technology.

CORN

DA-CAR, through its Flagship Corn Program, provides support and services to corn farming communities across CAR, including: soil analyses, provision of earwigs (as biological control agents against cutworm, corn earworm, armyworm, grasshoppers, and semi-looper), establishment of trial sites to test for fungus, provision of hauling trucks, construction of grain mills and seed storage facilities. Additionally, the farmer education program aims to build farmers' capacity to analyze their production systems, identify problems, test possible solutions, and encourage adoption of site-specific practices. To this end, DA-CAR facilitated the establishment of four corn demonstration sites through the Sustainable Corn Production in Sloping Areas (SCoPSA) Project, which served as interactive learning platforms for farmers. Corn growers are also offered opportunities to take part in FFS, GAP trainings, and entrepreneurship trainings, among others.

To help mitigate the impacts of drought felt by corn farmers, DA-CAR distributes pumps and engine sets for shallow tube wells. The agency also facilitates access to hauling trucks, two-row corn planters, combine harvesters, and establishes post-harvest facilities such as corn mills, hammer mills, mobile flash dryers, moisture meters, hermetic storage bags, vacuum pack scalers, and mechanical shellers, amongst others.

CABBAGE AND POTATO

With support from DA-CAR, Local Government Units (LGUs) and other line agencies, BSU conducts hands-on training on the rapid multiplication of quality planting materials of potato varieties, including the blight-resistant potato. Following the training, technical assistance is being continuously provided to trainees to ensure success in use of planting materials. Moreover, though the Climate-Smart Agriculture Center (CSAC), the BSU promotes various climate adaptation technologies, including water harvesting tanks, structural windbreak, rain shelters, resilient varieties, and pest and disease management. The "BSU-on-air" radio program also delivers information on farming technologies and climate risk management techniques to farmers in Benguet and neighboring areas.

Between 2011 and 2015, DA-CAR implemented several projects aimed at the development of the vegetable industry in the region, helping farmers to adapt to the adverse effects of climate change. One such example was the "Benguet Cold Chain" Project implemented by the Bureau of Postharvest Research and Extension (BPRE), an agency adjacent to the DA, together with the Province of Benguet, which facilitated the commercialization of fresh vegetables on high-end markets. In addition, the

agency conducted trainings on farming techniques, distributed vegetable seeds, and established greenhouses and rain shelters. To mitigate drought impacts, the agency distributed shallow tube wells, rolls of irrigation hose, pumps on highly affected areas and built small farm reservoirs. To support product marketing, the DA-CAR established packaging house units and trading centers.

BARRIERS

A series of factors hinder the uptake of on- and off-farm adaptation strategies by value chain actors in Luzon. This section examines common barriers to adaptation as they exist across the rice, yellow corn, potato and cabbage value chains. These include informational, behavioral, financial, and institutional barriers, amongst others.

Farming investments in Luzon are generally guided by a short-sighted vision; risk-coping models promoted on most potato and cabbage farms reflect a reactive, rather than an adaptive approach to climate risks. Farmers are caught in-between the short-term food security needs of the family and the continuously growing concern for the farm's productivity and even survival in 10-20 years. With limited resources (knowledge, information, finances), they are unable to conceive of and prepare for the medium- and long-term risk associated with climate change and variability.

Limited awareness on risk-management practices and lack of access to reliable and timely information (especially climate) to support adaptation decision-making represent the central challenges across supply chains. As a result, many corn and rice farmers are unprepared when typhoons and droughts hit, suffering from significant production and livelihoods losses.

Many farmers also lack the technical capacity to take up knowledge-intensive adaptation measures. Rice farmers claim that dependency on synthetic pesticides is related to insufficient knowledge on alternative, sustainable plant pests and diseases management, which should normally be provided through extension services and farmer trainings. Moreover, adaptation costs can be high, hindering the uptake of capital-intensive agricultural practices. Many cabbage and potato farmers cannot afford to establish greenhouses or to adopt costly water harvesting techniques. Rice farmers hardly have the financial capital to purchase water pumps and other production and processing machinery that would yield higher incomes. For corn farmers, the poorly maintained irrigation systems and road network increase product and transportation costs, while limited access to quality seeds translates into lower incomes; all these prevent farmers from making additional investments to increase farm and household resilience.

Delivery of governmental subsidies and other services is usually granted upon membership in an association, while credit access is a heavily bureaucratic and lengthy process. Many farmers still fail to see the advantages of joining a group while others are discouraged by the amount of paperwork required to access funds. In addition, there are major concerns that benefits provided by various actors, such as input and service provision, are reaped by a select few individuals and farmer associations. Some farmers believe that beneficiaries of the equipment distributed through DA programs are selected based on political affinity and not on socioeconomic condition of the producer. Government providers, on the other hand, complain that the equipment distributed is poorly maintained or goes missing [26].

The absence of market regulations in favor of small-scale producers is felt by all value chain actors, particularly vegetable and rice growers, as there is no price guarantee for their harvest. In a context where prices offered by the NFA[17] to national producers are low, competing with imported products becomes difficult for many farmers (particularly for rice farmers).

[17] NFA is the main rice importer in the country.

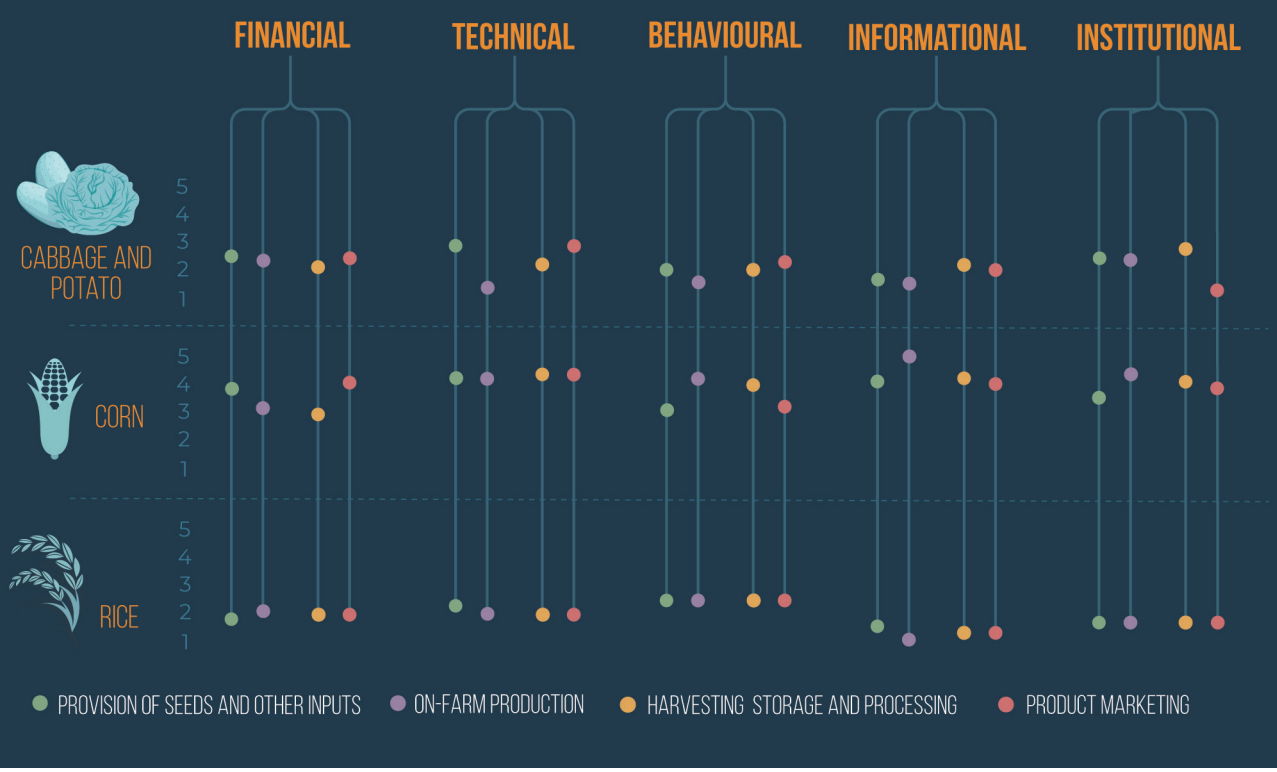

Figure 9: Severity of different barriers across the Value Chain of the key commodities. The height of the barrier corresponds to the severity on the left hand scale with 1 = no barrier and 5 = severe barrier.

POLICIES AND PROGRAMS

Given the region's agricultural sector vulnerability to the impacts of climate change, several policies and programs—both national and local in scope—have been implemented to support farmers directly or indirectly to adapt to climate change. These measures are discussed in this section.

The Philippines has long-established laws aimed at promoting climate action in the country. These include Republic Acts (RA) such as the Climate Change Act of 2009 (RA 9729), the Disaster Risk Reduction Act of 2010 (RA 10121), and the Agriculture and Fisheries Modernization Act of 1997 (RA 8435), among others. The Climate Change Act (CCA) created the legal framework for mainstreaming climate change into policy formulation processes and established the Climate Change Commission (CCC), the body responsible for coordinating, monitoring, and evaluating climate change programs and action plans in the country. Republic Act No. 10174 amended the CCA and established the People's Survival Fund in 2012 to provide long-term financing to climate change projects. It also mandates the integration of disaster risk reduction (DDR) activities into climate change programs and initiatives. The National Framework Strategy on Climate Change for 2010-2022, led by the CCC, puts particular emphasis on adaptation action, regarding mitigation as a co-benefit.

The Philippines Nationally Determined Contribution (NDC) targets a 70% reduction in GHG emissions by 2030 compared to the BAU scenario of 2000-2030. While adaptation is the focus of many policies given the country's high exposure to climate change impacts, there are a number of mitigation policies. In 2014, the President institutionalized the Philippine GHG inventory management and reporting system (Executive Order No. 174), created to enable the country's transition to a climate-resilient, sustainable economy.

To further strengthen the implementation of the CCA in the agriculture and fishery sector, the DA Secretary issued the memorandum "Mainstreaming Climate Change in DA Programs, Plans and Budget" in 2013 and approved the Department's Seven-Wide Programs on Climate Change (DA-SWPCC), namely: 1) Mainstream Climate Change Adaptation and Mitigation Initiatives in Agriculture (AMIA); 2) Climate Information System (CIS); 3) Philippine

Adaptation and Mitigation in Agriculture Knowledge Toolbox (PAMAKT)[18]; 4) Climate-Smart Agriculture Infrastructure (CSAI); 5) Financing and Risk Transfer Instruments on Climate Change (FRTICC); 6) Climate-Smart Agriculture and Fisheries Regulation (CSAFR); and 7) Climate-Smart Agriculture Extension System (CSAES).

The Agriculture and Fisheries Modernization Act (AFMA) aims to modernize the agriculture and fisheries sectors of the country and to enhance the sectors' profitability and competitiveness. The AFMA also established the formulation of Strategic Agricultural and Fisheries Development Zones (SAFDZ) and the Agricultural and Fisheries Modernization Plan (AFMP). Across these policies, the government prioritized access to credit to farmers and irrigation. However, given underinvestment in the sector, progress in these areas has been slow [48, 49].

The Adaptation and Mitigation Initiative in Agriculture (AMIA) is the flagship program for climate change and mitigation within the DA. The Department of Agriculture System-wide Climate Change Office (DA-SWCCO) oversees AMIA. Central to the AMIA initiative is the establishment of "AMIA Villages," where climate-smart practices are piloted.

The climate change agenda is also reflected in the country's overarching strategic framework for the DA, Agri-pinoy (2011-2016). The strategy was built on four central themes: food security and self-sufficiency, sustainable agriculture and fisheries, natural resource management, and local development. The strategy calls for the coordination of regionally-based spatial planning, the provision of critical infrastructure needed by priority value chains, and the building of a more resilient production base to accommodate the variations in the global markets and the effects of climate change.

The Philippine Rural Development Project (PRDP) is a six-year national project under the DA that aims to establish a modern, value-chain oriented, and climate-resilient agriculture and fisheries sector. The PRDP is a scaled-up version of the Mindanao Rural Development Program (MRDP) and is aligned with the Agri-Pinoy strategy. Through this project, value chains are prioritized for investment and development. The "I-PLAN" component of PRDP assists LGUs in the development of Provincial Commodity Investment Plans that serve as blueprints for investment in priority commodities. The "I-BUILD" component of PRDP established strategic climate-resilient rural infrastructure facilities along these value chains, including farm-to-market roads, communal irrigation systems, potable water supplies, and postharvest and other rural infrastructure.

Mainstreaming climate change in agriculture policy does not come without challenges. From an institutional and operational point of view, climate change is missing from the agenda of many agencies. The capacity (knowledge, skills, financial) to operationalize complex interventions that address climate change threats across sectors and sub-sectors is often missing.

GOVERNANCE AND INSTITUTIONAL RESOURCES AND CAPACITY

The policy environment in Luzon is supported and complemented by a host of actors at both the national and local level—government, NGOs and the private sector alike—that are actively involved in the implementation of climate change adaptation action. This institutional landscape in support of supply chains is discussed in this section.

POLICY SUPPORT

The government institutions active on climate change issues include the CCC, the DA and related agencies, such as the Philippine Atmospheric, Geophysical and Astronomical Services Administration and LGUs. The CCC is responsible for coordinating, monitoring, and evaluating programs and actions on climate change by the government. The DA is mandated to promote agricultural development by providing public investments, policy frameworks, and services needed for domestic and export-oriented agricultural business enterprises. Through its offices in the regional, provincial, and city level, the DA's role is pivotal in the promotion of technologies, practices, and other services that impact farmers

[18] PAMAKT and CC RDEAP have been aligned to target the same objectives.

and agricultural value chain actors in the country. The DA has attached bureaus and agencies (e.g., ATI) tasked with implementing climate change-related programs, conducting research, providing trainings and offering extension services. The SWCCO coordinates and manages AMIA, the flagship program for climate adaptation and mitigation of the DA.

LGUs[19] also play a central role in mainstreaming climate change adaptation throughout the country. They consist of various sub-national administrative units including the region, province, city, municipality, and the barangay[20] and are responsible for crafting Local Climate Change Action Plans (LCCAP) for their respective communities. Finances for LCCAP implementation can be sourced from the People's Survival Fund[21], which was created to provide long-term climate change finance. The Provincial Agriculturist's Office (PAGRO) is mandated to coordinate DA projects and programs that promote sustainable agriculture and enhance the growth of fisheries through increased productivity and profitability. The office employs coordinators for every crop grown in the province, reaching farmers with tailored services.

EXTENSION

The DA, through ATI, delivers extension services for the agriculture and fisheries sectors, providing training to agricultural extension workers. ATI also supports the establishment of learning sites in indigenous peoples' communities and conducts Farm Business School to help build entrepreneurship skills among small-scale farmers. DA offices in LGUs also conduct ad-hoc trainings to farmers. The Municipal Agriculture Office, for example, conducts trainings on nursery establishment, crop production, and post-harvest practices. NGOs and private entities or companies like CIDAMI often have more resources to provide extension services to farmers.

RESEARCH AND DEVELOPMENT

The Department of Science and Technology (DOST), Department of Environment and Natural Resources (DENR), and the DA through the Bureau of Agricultural Research (BAR) are the main institutions that provide research and development support to the agricultural sector in the Philippines. In addition, individual academics also play a key role in research and development related to climate change and climate-smart agriculture. However, the research system of the country remains fragmented, with institutions struggling to identify synergies and shared research priorities [51].

Led by the DOST regional office (DOST-CAR), the Program on Science and Technology Action Frontline for Emergencies and Hazards (SAFE) implements science-based solutions to address the negative impact of climate change. SAFE is spearheaded by the DOST and implemented by the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), in partnership with the Highland Agriculture, Aquatic and Resources Research and Development Consortium (HAARRDC) and six participating state colleges and universities. The Program focuses on six different provinces and farm types, namely Abra (vegetable farms), Benguet (terrace farms), Ifugao (rice farms), Kalinga (coffee farms), Apayo and Mountain Province (farms in general) [45]. Under this framework, in Benguet, the Climate Smart Agriculture Center of the BSU (BSU-CSAC) has developed and packaged cost-effective agricultural technologies for terraced vegetable farms. These include: water harvesting tanks, structural windbreaks, reinforced vegetable terraces, rain shelters, improved crop varieties, and the promotion of GAPs (soil management, crop production and pest/disease management), among others.

[19] According to the Climate Change Act (Section 14), LGUs are the frontline agencies in the formulation, planning and implementation of climate change action plans in their respective areas, consistent with the provisions of the Local Government Code, the Framework, and the National Climate Change Action Plan.

[20] According to the Local Government Code of the Philippines, the barangay acts as the primary implementing unit of government policies, plans, programs, projects and activities. Municipalities also coordinate and deliver primary. services within their territorial jurisdictions. The province serves as a dynamic mechanism for developmental processes and effective governance of other LGUs with its territorial jurisdiction.

[21] The Fund has been allocated PHP 1 billion from the General Appropriations Act (GAA) to augment financial support for climate change adaptation and disaster risk reduction projects and programs. To be eligible for funding, LGUs need to submit updated LCCAPs to the CCC [50]; local communities (including NGOs) can also apply for finance to the PSF.

In addition to their work under the SAFE project, BSU researchers have led various R&D activities on crop improvement, including the development of potato varieties resistant to late blight (e.g., Igorota), promotion of drought-tolerant varieties of cabbage (Lucky Ball and Ace Green), and the design and implementation of improved crop shelters for the production of high-value crops in the highlands [46].

The Philippine Rice Research Institute (PhilRice) and the International Rice Research Institute (IRRI) have bred several rice varieties that can survive extreme climatic conditions such as droughts, floods, heat, cold, and adapt to soils with high salt and iron content. Drought-tolerant rice varieties available in rainfed lowland farms include Rio Grande, Sacobia, and 12 varieties of Sahod Ulan, while upland farmers can use Pasig, Apo, and Katihan 1 varieties [44]. In addition to these efforts, the regional office of the National Irrigation Administration (NIA-CAR) has set up demonstration farms on water-saving technologies, including Alternate Wetting and Drying (AWD) systems [22].

FINANCE

There are various financial institutions in the Philippines that provide support for climate change adaptation. For instance, the Philippine Crop Insurance Corporation (PCIC), a government-owned institution attached to the DA, provides insurance protection for corn, rice and other crops against losses resulting from natural disasters, pest infestations, or plant diseases. The scheme typically protects farmers for up to 120% of the cost of production inputs. However, not all farmers are able to access the insurance schemes. Some are not enrolled in the Registry System for Basic Sectors in Agriculture, while others are unaware of the existence of the scheme.
The Land Bank of the Philippines (LANDBANK), through its Agricultural Credit Support Project (ACSP) and Agrarian Production Credit Program (APCP), provides loans and financing to farmers. APCP provides financing to newly-organized Agrarian Reform Beneficiary Organizations and to farmer organizations who would traditionally be ineligible to access loans from commercial banks. The Agricultural Credit Policy Council (ACPC) assists the DA in synchronizing all credit policies and programs in support of the DA's priority programs. Other financing schemes under the ACPC include the Climate Change Adaptation Financing Program (CCAFP), which is aimed to encourage adoption of climate change adaptation practices and technologies through loans, and the Production Loan Easy Access (PLEA), a special credit facility for marginal farmers or fishers. ACPC's Survival and Recovery Assistance Program (SURE) serves as a quick response, post-disaster support facility. It facilitates access to grants and loans to small-scale farmers and fishers whose farms and households have been affected by natural disasters.

Another government-owned bank that provides financial support to farmers is the Development Bank of the Philippines (DBP). The bank has a Seed High Value Crops Financing Programs with an interest rate of 10-12% and requires farmers to have a land title and be registered with the Securities and Exchange Commission/ Cooperative Development Authority SEC/CDA. Private banks often have a number of additional requirements that are difficult for farmers to comply with, including high collateral requirements.

SYNTHESIS AND OUTLOOK

The agricultural sector in Luzon is highly exposed to climate risks, particularly to typhoons and droughts. Of all agricultural value chain stages, on-farm production is usually the most affected. Accompanied by heavy rains and strong winds, typhoons cause landslides and soil erosion, affecting highland vegetable farming, upland corn and lowland rice yields. Landslides also cause delays in input delivery and application, reductions in commodity supply and quality for processing and marketing. To cope with the impacts of heavy rains and strong winds, highland farmers require assistance building crop shelters and adjusting their cropping calendars to the new climate conditions.

Prolonged droughts have detrimental effects on crop production in Luzon, reducing the production quantity and quality of rice, corn, cabbage and potato. The increased frequency and unpredictability of drought events has intensified the vulnerability of farmers in CAR. In response, farmers build rain harvesting and water impounding facilities, use drought-resistant crop varieties and practice integrated farming to minimize economic loss. Corn farmers also dig deep wells and use water pumps to source out water for their crops.

From an institutional standpoint, efforts to increase farm resilience and productivity have intensified over the past years. Through its regional office and in partnership with research institutions and NGOs, the DA has carried out several flagship programs targeting the provision of inputs (seeds, equipment, etc.), development of improved crop varieties, establishment of processing facilities and trading centers, provision of financial services, and delivery of trainings, FFS, and other educational programs aimed at building farmers' technical and entrepreneurship skills relevant to the crops they grow. While these programs have achieved localized successes, work remains scaling these initiatives to reach farmers in remote, often indigenous, communities.

However, a series of informational, financial, and institutional factors continue to hinder adoption of climate-risk strategies by value chain stakeholders in Luzon. These include, among others: low awareness of climate-risk management techniques and limited access to climate information services among farmers; lack of finances to invest in capital-intensive on-farm resilience-building activities (e.g., adoption of improved varieties, building of complex water-saving structures, etc.) and/or infrastructure for value-addition (post-harvest, storage, and/or processing facilities) and commercialization; limited awareness, mandates and budgets for climate change action across key governmental institutions working on agriculture.

Effective management of risks to the agricultural sector requires systematic, concerted action assumed by various stakeholder groups, at all stages of the value chain; farmers, private sector individuals, government agencies, NGOs and development partners have a key role to play in the planning and implementation of interventions to build resilience and increase agricultural productivity and incomes. By engaging in collaborative efforts (e.g., membership in associations), farmers are more likely to increase the production volume and thus meet the demands of the market, to boost their power to negotiate fairer prices, and to be eligible for financial and educational services that usually target groups rather than individuals. In this sense, an essential incentive to increase cooperation in the early stages of the value chain is to provide farmers with opportunities to gain insights into the benefits of collective action, by increasing institutional and financial support to farm associations and showcasing successful models.

Moreover, leveraging resources (financial, informational) from private sector, NGOs, academia and other actors would help government institutions to close investment gaps, increasing capacity to support short-, medium-, and long-term climate adaptation efforts in the agricultural sector. Numerous opportunities presented themselves across the value chains to establish public-private partnerships that promoted the uptake of adaptation practices, promising examples include; the development of a timely distribution network for seeds, equipment and other inputs, the provision of weather-based insurance schemes blending private and public sector insurance through opening up the market, and the development and maintenance of irrigation and road infrastructure projects to enable production and market access. Policies that facilitate the establishment of public-private partnerships in the Philippines will better enable agricultural value chain actors to implement the range of adaptation options prioritized.

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