PHILIPPINES
CLIMATE RISK PROFILES

HIGHLIGHTS

- The Mindanao island group is considered the agricultural breadbasket of the Philippines, accounting for 40% of all agricultural production and 60% of agricultural exports. Important commodity value chains include yellow corn and coffee in Bukidnon, and cacao in Davao del Norte.
- The Philippines is one of the countries most vulnerable to climate change in the world, with climate impacts disproportionately affecting agricultural and rural communities.
- Droughts and heavy rains are the key climate-related hazards affecting Mindanao's agricultural sector. In recent years, farmers have observed longer periods of drought and heavier rains. In addition, the impacts of typhoons—which traditionally affect island groups further to the north—have been increasingly experienced by farmers in Mindanao.
- Agriculture in Mindanao is plagued by a variety of challenges that have prevented the sector from achieving its full potential in terms of economic growth and poverty alleviation. These issues include a non-diversified, export-oriented production model, pervasive poverty that traps smallholders in subsistence production, limited access to road and markets, a heavy reliance on rain-fed agriculture, and overlapping or insecure property rights.
- Adaptation practices adopted by farmers in the region include diversified farming systems, intercropping, crop rotation, deep hole planting, contour farming, terracing, water impounding, reforestation, and watershed management. Cacao farmers may also adopt sprinkler systems to combat the impacts of drought along with mulching, organic farming, and crop insurance.
- Common barriers to the adoption of these practices include poor information dissemination; resistance to new farming and management practices by more traditional, aging farmers; a lack financial capital, especially for larger-scale infrastructure investments; and uncoordinated or biased government service delivery.
- Government agencies like the Department of Agriculture, the Climate Change Commission, the Provincial Agricultural Office, and Local Government Units all support value chain actors in different ways, providing training, subsidized inputs, extension services, and agricultural research.

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FOREWORD

The Philippines is extremely vulnerable to climate change [1], with climate impacts disproportionately affecting agricultural and rural communities. Facing challenges such as low productivity, underinvestment, and extreme weather events, farmers in the Philippines are some of the poorest people in the country; the majority 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 Philippines faces severe challenges in meeting domestic food demand and relies heavily on imports, especially for wheat and rice.

The Philippines is vulnerable to a range of extreme weather events, particularly tropical cyclones ("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, ongoing 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. The Philippines boasts a Climate Change Council (CCC), a National Framework Strategy on Climate Change (NFSCC), and a National Climate Change Action Plan, each of which prioritizes agricultural adaptation to climate change.

Given agriculture'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 sector. To achieve this, three profiles have been created, one for each major island group in the Philippines, namely Mindanao, Luzon, and Visayas. Each profile examines the relationship between climate hazards, key commodities, and their value chains. In Mindanao, three major value chain commodities (VCC) were selected: coffee, cacao, and yellow corn. For each of these VCCs, a study area was selected through a consultative process supported by relevant literature about climate change impacts and Climate Resilient Agriculture (CRA) in the Philippines. Expert consultations were held with the Central Office and Regional Field Offices of the Department of Agriculture (DA) and the United Nations Food and Agriculture Organization (FAO) to define the scope of the Climate Risk Profiles. Considerations in selecting the representative study sites included prevalent climate risks, the vulnerability of commodity systems and their economic importance to the agricultural sector, and the historical cost of damages and production losses due to extreme climate events. The province of Bukidnon was chosen for both coffee and yellow corn due to high levels of production and recent losses from drought. For cacao, meanwhile, Davao del Norte was selected because it is one of the country's major cacao-growing regions.

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

MINDANAO

DEMOGRAPHICS

24% OF THE PHILIPPINES' POPULATION

24,000,000 INHABITANTS

49% **51%**

64% LIVE IN RURAL AREAS

FOOD SECURITY

47% OF THE POPULATION SUFFERS FROM **FOOD POVERTY**

46% OF HOUSEHOLD **INCOME SPENT ON FOOD**

23% CHILDREN **UNDERWEIGHT**

38% CHILDREN **STUNTED**

7% CHILDREN **WASTED**

3% CHILDREN **OVERWEIGHT**

FARMING

TOTAL LAND AREA (HA) **13.8 MILLION**

AGRICULTURE AREA (HA) **4.1 MILLION**

30% OF TOTAL LAND AREA

PEOPLE EMPLOYED IN AGRICULTURE PRODUCTION **4 MILLION**

8% OF

25% OF

ACCESS TO BASIC NEEDS

36% OF THE POPULATION LIVES IN **ABSOLUTE POVERTY**

WOOD FOR COOKING **3%**

ELECTRICITY FOR COOKING **69%**

ELECTRICITY FOR LIGHTING **71%**

SOURCE: PSA.GOV.PH

AGRICULTURAL CONTEXT

Mindanao is located in the southern region of the Philippine archipelago. It is the second largest island group of the Philippines with a land area of 10,202,192 ha [4]. Agricultural land comprises 29% of Mindanao's total land area, and the island group accounts for 40% of all agricultural production and 60% of agricultural exports in the country [5,6]. The island is divided into six administrative regions: Zamboanga Peninsula (Region 9), Northern Mindanao (Region 10), Davao Region (Region 11), SOCCSKSARGEN (Region 12), Caraga (Region 13), and the Autonomous Region of Muslim Mindanao. For the most part, Mindanao is located outside of the typhoon belt [7,8].

ECONOMIC RELEVANCE OF AGRI-FISHERIES

Mindanao is considered the agricultural breadbasket of the Philippines with a diverse set of crops—including high-value commodities and livestock—produced across its regions. In 2017, the agriculture, hunting, forestry, and fishing sector contributed 23% of total Gross Regional Domestic Production on the island [9]. Mindanao contributed 33% of the country's Gross Value Added (GVA) in the agriculture, hunting, forestry and fishing sector, with Luzon contributing 51% and Visayas the remaining 16% [9].

Mindanao is also a key contributor to the country's total world export volume. Its bananas, pineapples, and coconuts each account for approximately a third of the world's total export volume for these crops [6]. (The Philippines is the world's second largest producer of coconuts.) [6]. Coffee, aquatic products, seaweed, and coconuts have the potential to more effectively serve domestic and international markets. Despite this concentration of commodity crop production, the majority of farmers in Mindanao operate at subsistence or near-subsistence levels, with less than 16% producing a marketable surplus [6].

The agriculture sector in Mindanao employs over four million people; 76% are men and 24% women [10]. Children between five and 17 years old are also working in the sector, comprising 7.6% of the total workforce. There are over 1.6 million families currently active in agriculture in Mindanao [11]. Between a quarter and a third of the agricultural labor force—over a million people—are considered landless agricultural workers [6]. On-farm activities contribute approximately 60% of the income of farming households in Mindanao. The average daily nominal wage rate of an agricultural worker in Mindanao is around PHP 255 (USD 4.80), with the average man earning PHP 257 (USD 4.74) and the average woman earning PHP 246 (USD 4.53) [12]. These rates are lower than the country's nominal wage rate of around PHP 276 (USD 5.09). When compared with the wages of agricultural workers in the other island groups, Mindanao ranks lower than Luzon but higher than Visayas [13].

PEOPLE AND LIVELIHOODS

Based on the 2015 Census of Population and Housing, the Philippines hosts a population of over 100 million people. The Mindanao island group accounts for almost 24% of the country's total population, more than half of whom live in rural areas [14]. These rural populations are concentrated in the Autonomous Region of Muslim Mindanao (ARMM), which hosts 21% of the rural population; Northern Mindanao at 19%; Zamboanga Peninsula at 17%; and SOCCSKSARGEN at 16%. The more populous Caraga and Davao regions were more urban, with only around 13% and 14%, respectively, of residents living in rural areas [15].

Over 8.8 million people in Mindanao are considered to be poor, with 36% of the island group's population living below the poverty threshold [16]. This is the highest rate of poverty among the major island groups. Households from the Mindanao island group have uneven access to basic goods and services. In 2010, over 70% of households had access to electricity for lighting, while less than 3% of households reported using electricity for cooking, most choosing wood as a traditional alternative [17]. Access to a safe water supply varies among households in Mindanao, with between 20% and 30% of homes having access to water from a private or shared faucet [17]. Around 23% of children below five years old and 33% of children between five and 10 years old are underweight, while the prevalence of overweight or obese adults is 28%. Data from Food and Nutrition Research Institute also recorded a prevalence of chronic energy deficiency among adults at approximately 9% [18].

Of the population aged 15 to 24, fewer than 2% are considered illiterate [19]. According to the Mindanao Jobs Report, over 5.2 million people—or 57% of the population in 2012—were engaged in agricultural value chain activities. Around 47% were engaged in production, 4% each in agricultural manufacturing and agricultural logistics, while only 2% were involved in agricultural trade [6]. Based on the preliminary results of the 2015 Annual Survey of Philippine Business and Industry, Mindanao hosts 434 businesses employing more than 20 people that participate in agriculture, forestry, and fishing activities [20].

AGRICULTURAL ACTIVITIES

Agricultural land in Mindanao comprises 41% of the total agricultural area in the Philippines. This vast area of agricultural land is utilized for diverse purposes. Most of the country's high-value crops are produced on the island group [5], with Mindanao responsible for approximately 80% of banana and coffee production and over 60% of coconut production [6]. More than 48% of Mindanao's agricultural area is dedicated to such perennial crops. Major commodity crops produced in Mindanao include rubber, coffee, cacao, coconuts, oil palm, pineapples, and bananas—each at different scales. Commodities like rubber, coffee, cacao, and coconuts, for example, are commonly produced on small farms, oil palm on mid-sized farms, and pineapples on large farms [6].

The island group is also a major producer of corn, contributing 50% of the national production of this staple crop [6]. Other important crops for the Mindanao are rice, sugarcane, oil palm, and root crops such as cassava. The livestock sector is dominated by hog production, with an inventory of over 3.3 million hogs on Mindanao, followed by goats, with over 1.1 million head, the majority of which are raised in backyard farms [21]. The World Bank notes that smallholder farmers dominate the island's agricultural sector; about 60% of farms in Mindanao cover less than two hectares [6]. Mid-sized farms. Two to five hectares in size, account for 33% of landholdings. Thirty percent of the households in Mindanao own agricultural lands with 1.8% having acquired agricultural lands through the 1987 Comprehensive Agrarian Reform Program [22]. Mindanao (excluding the ARMM) has received over 18% of the public agricultural land patents that have been issued, with almost 46% going to women [23].

STUDY AREAS AND THEIR AGRICULTURAL VALUE CHAIN COMMODITIES

Agriculture is important to Mindanao, and climate variability and hazards may pose a serious threat to the sector. For this analysis, the corn, coffee, and cacao agricultural value chains were selected for detailed analysis. This selection was informed by the large contribution these crops make to total agricultural production and exports from the island group and the country more broadly, as well as by their vulnerability to the impacts of climate change. These three crops were identified as key to food security and livelihoods by the Philippines' Climate-Resilient Agriculture Profile [24]. To examine these VCCs in detail, two provinces were selected where these crops feature centrally in the local economy and where climate change is likely to affect production: Bukidnon (Region 10) for corn and coffee and Davao del Norte (Region 11) for cacao. Bukidnon is a highland province in Northern Mindanao characterized by rugged topography with rolling hills and flatlands. Davao del Norte, meanwhile, is located in the south-eastern part of the island of Mindanao, with terrain that is generally low-lying.

BUKIDNON

The province of Bukidnon is one of the top producers of corn and coffee in Mindanao. It has a land area of 1,049,859 has and a population of 1,415,226, representing almost 6% of Mindanao's total population [14]. More than half (58%) of Bukidnon's population lives in rural areas and over 52% are living in absolute poverty (around 700,000 people) [25]. The agricultural sector employs over 7,000 people and is the main contributor to the local economy [26]. Corn is the leading commodity grown by farmers, followed by rice and cassava. Other major agricultural crops include coconuts, pineapples, Cavendish bananas, and coffee [27]. Coffee, in particular, plays an important role in the overall economy of Bukidnon because of its contribution to poverty alleviation and income generation for communities faming on marginal lands. Coffee production is also important for the Indigenous Peoples (IP) community in Bukidnon. Some IP communities such as the Inhandig indigenous group are involved in Arabica production. Aside from these crops, livestock and poultry also thrive in the province, with backyard farms outnumbering commercial farms.

YELLOW CORN

Bukidnon is a major producer of corn, with 66,000 ha devoted to the production of yellow corn and a further 13,000 to white corn [28]. The majority of the yellow corn produced in Bukidnon is used in the production of livestock and poultry feeds and, to a lesser extent, starches for manufacturing. White corn, meanwhile, is favored for human consumption, as the secondary staple of the Philippines. Corn production in Bukidnon is focused in the rain-fed upland plains and rolling hills of Malaybalay, Cabanglasan, Kitaotao, Kadingilan, and Lantapan [28,29]. Bukidnon is home to a large livestock and poultry sector. Therefore, much of the corn produced in Bukidnon meets demand within the province, operating with a surplus of only 25% [30].

In Bukidnon, yellow corn is grown in three main production systems, namely monocropping, intercropping, and rotational cropping. Monocropping, in which one crop is cultivated in an area across all cropping seasons, is considered traditional. In an intercropping system, yellow corn is planted simultaneously with either coconuts, cassava, or peanuts. For example, farmers might plant yellow corn under coconut trees to maximize land use or intercrop cassava or peanuts with corn during long dry seasons. Farmers also apply rotational cropping, in which two different crops are cultivated in the same area in alternate seasons. Rotational cropping systems are prevalent in areas with insufficient rainfall, such as Rebona, Manolo Fortich, and Baungon.

Within the corn value chain in Bukidnon, input suppliers include seed companies and agri-vet stores supplying fertilizers, pesticides, herbicides, and other chemicals to farmers. In some places, Local Government Units (LGUs) also provide free and subsidized seeds and fertilizers to producers. In addition, traders and input suppliers play a role as informal money lenders, operating on the condition that inputs are bought—or produce is sold—exclusively through them, leaving farmers with limited bargaining power and fewer opportunities to explore alternative markets. In such arrangements, farmers are often "price-takers". The actors involved in the production of corn include farmers, producer organizations (POs), and cooperatives [31]. Various other service providers such as farm laborers and workers, farm equipment operators, and caretakers have a role to play. Meanwhile, government agencies such as the DA and the Agricultural Training Institute (ATI) provide technical support and training to yellow corn farmers. Some of these actors, particularly POs and cooperatives, also perform tasks related to postharvest processing and marketing, engaging in the shelling, drying, milling, and storage of corn. Some farmers sell directly through POs or cooperatives, while others opt to trade with individual traders, grain centers, and processors [31]. These actors are also engaged in primary processing activities of corn. Processors such as feed millers and food manufacturers are involved in both the primary and secondary processing of yellow corn. Corn classified as class A is sold to food manufacturers, while class B is often bought by feed millers. The end products are sold by wholesalers and retailers alike.

COFFEE

Bukidnon has the second largest coffee growing area in Mindanao and has been ranked as the fourth largest coffee-producing province in the Philippines [32]. Although Robusta is the most commonly grown variety, Arabica and Excelsa are also produced in the province. Areas in Bukidnon with over a thousand hectares of planted coffee include Maramag, Malaybalay, and Manolo Fortich. In 2014, the total harvested area for Robusta coffee was 9,000 ha. Coffee is most commonly intercropped with other crops or is grown in agroforestry systems, with relatively few farmers in the lowlands planting coffee

SA1

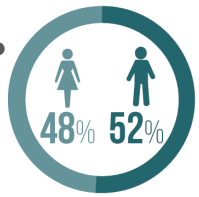
DEMOGRAPHICS

1,415,226
TOTAL POPULATION

6% OF TOTAL POPULATION IN **MINDANAO**

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

58% LIVE IN **RURAL AREAS**



PERCENTAGE OF **FEMALE AND MALE** POPULATION

ACCESS TO BASIC NEEDS

52% OF THE POPULATION LIVES IN **ABSOLUTE POVERTY**

97% ARE **LITERATE**

FARMING

AGRICULTURE AREA (HA) **322,804**

NUMBER OF FARMS **120,017**

SA2

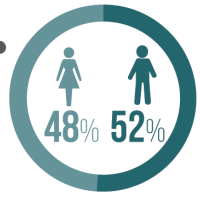
DEMOGRAPHICS

1,016,332
TOTAL POPULATION

4% OF TOTAL POPULATION IN **MINDANAO**

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

36% LIVE IN **RURAL AREAS**



PERCENTAGE OF **FEMALE AND MALE** POPULATION

ACCESS TO BASIC NEEDS

29% OF THE POPULATION LIVES IN **ABSOLUTE POVERTY**

98% ARE **LITERATE**

FARMING

AGRICULTURAL AREA (HA) **292,397**

NUMBER OF FARMS **120,014**

SOURCE: PSA.GOV.PH

as a monocrop. Commonly intercropped varieties include spring onions, broccoli, carrots, sweet potatoes, peanuts, flowers, abaca, and falcata. Some coffee farmers apply synthetic fertilizers, while others practice organic farming using chicken manure and other naturally grown fertilizers. In general, coffee farmers in Bukidnon utilize limited inputs.

Coffee seedlings are supplied by private nurseries, NGOs, and cooperatives, and they may be subsidized by LGUs. For farmers engaging in organic production, chicken farms provide important organic fertilizer, as long as they are located close enough to farms for the manure to be collected and transported cost-effectively. Coffee farmers, farmer organizations, small and medium-sized enterprises (SMEs), and cooperatives are among the actors involved in on-farm production. Indigenous people are also involved in on-farm production; some are members of cooperatives that produce coffee. Farmers have the option to sell coffee as fresh berries, green coffee beans (GCB), or roasted or ground coffee products to traders, cooperatives, farmers' organizations, and enterprises. Cooperatives, farmer organizations, and SMEs engaged in trading GCB accept fresh berries. There are two major and two minor processors located in Region 10. Nestle Philippines and Monk's Blend can process anywhere from 125-150 kg/day each, while smaller processors such as Balay Mindanao and LGU Maramag deal with lower quantities of 3-5 kg/day [33]. The big processors or traders may choose to purchase GCB directly from farmers who opt not to perform primary processing. However, the high standards required by big processors and companies prohibit some farmers from directly supplying to these institutions. As a result, many farmers sell to traders who only require acceptable quality, receiving lower prices. Actors involved in final processing include cooperatives, farmers' organizations, SMEs that ground and roast coffee, and coffee manufacturers such as Nestle. Specialty shops, exporters, grocery stores, and retail stores are involved in marketing coffee products. In addition, some traders also sell coffee beans directly to hotels.

DAVAO DEL NORTE

Relative to Bukidnon, the Davao del Norte province is characterized by generally low-lying terrain. The province's population of 1,016,332 represents 4.2% of the total population of the Mindanao island group [14]. Approximately 36% of the province's population lives in rural areas and almost 30% are living in absolute poverty (about 300,000 people). More than 63% of provincial income is sourced from agriculture [34]. Davao del Norte is becoming a lead player in the cacao industry, producing 81% of the country's total production [35]. Other major crops in the province include paddy rice, corn, bananas for export and local consumption, coconuts, fruits, and other high-valued commercial and industrial crops. Root crops, vegetables, and other temporary and perennial crops are also grown sporadically throughout the province.

CACAO

Cacao production in Davao del Norte is concentrated in the municipalities of San Isidro, Kapalong, and Asuncion [36]. Production is entirely market-oriented, generating an average annual production value of PHP 40 million (USD 700,000) and providing livelihoods to more than 4,000 cacao farmers [36]. Most of these are resource-poor smallholder farmers. Although Davao del Norte is still a small player in the international cacao trade, it has a competitive advantage due to the availability of land resources in the province as well as its favorable agronomic conditions. In upland areas, cacao is intercropped with coconuts, bananas, and other fruit trees such as durian, lanzones, rubber, and other shade trees. In the lowlands, cacao is often grown together with coconut, banana, and vegetables. Cacao is increasingly becoming a priority commodity in the Davao del Norte, although most areas still plant cacao as a secondary crop. Nurseries, NGOs, national and local government agencies, and agri-vet stores supply inputs to some farmers. Most commercial cacao farmers purchase planting materials from nurseries while smallholder farmers commonly produce their own seedlings. On-farm, smallholders tend to be solely dependent on cacao, while commercial farmers plant cacao between shade trees like bananas and coconuts.

Ultimately, there are different channels for farmers to sell their produce. Yet individuals and producer organizations differ in their access to certain markets. Since multinational companies and buyers, for example, have high specifications for beans, farmers—mostly individuals and smallholders—tend to sell their cacao to traders and consolidators who have less discerning quality requirements. Buying stations are also available for these farmers to sell their cacao. In contrast to individual farmers who tend to hold weak bargaining positions in the market, farmers who join cooperatives or farmer organizations are able to access better markets by collating production. Cooperative or farmer

organizations can then sell directly to processors at more favorable rates. Exporters involved in the value chain buy beans from collectors and traders, which they then sell primarily to regional buyers for processing. In terms of processing and postharvest activities, both the public and private sectors have established postharvest facilities in the Davao region. Some facilities are exclusive to members or suppliers of the facilities, while others serve as common service facilities open to all. There are four domestic processors in Davao del Norte and a number of informal enterprises engaged in the production of tablea (fermented cacao beans roasted, ground and molded into blocks with no additives) [37].

AGRICULTURAL SECTOR CHALLENGES

Agriculture in the Mindanao island group is plagued by a variety of challenges that have prevented the sector from achieving its full potential in terms of economic growth and poverty alleviation. These factors include an inequality-producing, export-oriented production model, pervasive poverty that traps smallholders in subsistence production, limited access to roads and markets, a reliance on rain-fed agriculture, and overlapping or insecure property rights.

Heavy reliance on high-value commodity or plantation crops has not only left the region vulnerable to volatile international markets, but this growth model has also led to considerable inequalities produced by preferential access by some groups to multinational organizations that buy and process their crops for international markets. The inequalities produced by this export-oriented model have led to limited investment in local processing and value-addition facilities and minimal local re-investment of profits. These growing inequalities have been linked to the rise of conflict in the Mindanao region [6].

Pervasive poverty more generally has trapped many smallholder farmers at subsistence levels of agricultural production in Mindanao. Of the roughly four million farmers in the region, only 700,000 are producing a marketable surplus. Farmers are limited in their growth by poor organization and a lack of access to markets. Given the disproportionate reliance on commodity and export-oriented crops, many farmers in Mindanao lack access to regional and national markets, which are expanding due to population growth [6].

Limited access to markets by many farmers in Mindanao is, in part, the product of a lack of access to market feeder roads and other critical rural infrastructure. Many roads in the region are in poor condition, and almost a quarter of all small villages in Mindanao lack connectivity to a national road. Similarly, many ports in the region for both domestic and international destinations are unavailable to smallholders or lack sufficient bay depth for modern transport ships. Farmers also suffer from limited access to critical inputs like improved seeds and fertilizers, causing the region to experience low agricultural productivity relative to neighboring island groups and international competitors with similar agroecological conditions. Road connectivity also limits the reach and impact of agricultural extension workers. At present, only 10% of corn farmers receive extension support in Mindanao [6].

Mindanao's high reliance on rain-fed agriculture places the sector at considerable risk especially from a rise in extreme weather events and the forecast long-term impacts of climate change. Less than half (43%) of Mindanao's irrigable land is currently under irrigation, a proportion well below the other island groups [6]. Land reform in the Philippines through the Comprehensive Agrarian Reform Program has been ongoing for several decades, yet the country remains plagued by overlapping or unclear property rights and land fragmentation that limits the size of agricultural operations. Mindanao is home to over a million landless farm laborers, a trend that drives rural unemployment due in part to limited year-on-year growth in the agricultural sector.

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 [38,39,40]. In both urban and rural areas, women are solely responsible for home-related tasks like caring for children, meeting household basic needs, and preparing food, whereas men engage primarily in production-related activities like agricultural labor or non-farm income generating activities [41]. Women customarily manage and allocate the household income and finances given

to them by their husbands [42]. Yet women's labor contributions are often overlooked or undervalued in both male- and female-headed households. [42]. Elderly women, women with children, pregnant women, and women with disabilities are the most vulnerable to production and value chain shocks [42,43].

In the yellow corn value chain, women are active at all stages, securing inputs for production, applying fertilizer, planting, furrowing, weeding, husking, drying, bagging, and, ultimately, marketing the corn. During periods of drought—across all commodity crops—women are also expected to secure a consistent supply of water. Women in the coffee industry are additionally involved across all stages of the supply chain including nursery operation, crop maintenance, and processing. Women are especially critical to harvesting, sorting, roasting, and marketing activities. While handpicking the beans, women are hired and paid on a per-kilo basis, often chosen over men for this work because of their perceived honesty and attention to detail. Children and youths perform tasks across the chain as well, including ploughing, planting, spraying, general crop maintenance, and harvesting. In the cacao industry, although women take part in activities across the supply chain, they contribute primarily during the harvest period, picking ripe cacao, bagging, washing pods, sorting, and processing cacao products. Children and youths primarily perform tasks such as bagging and pest control, for instance, plastic wrapping to control pod borers. Children as young as two years of age help in family-managed cacao farms.

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 children living in rural areas are disproportionately impacted; they are twice as likely to be involved than their female and urban counterparts. The most prominent form of labor is unpaid family work. Children's engagement in labor activities often hinders their education, causing them to be absent or too tired to actively participate in their schooling [44].

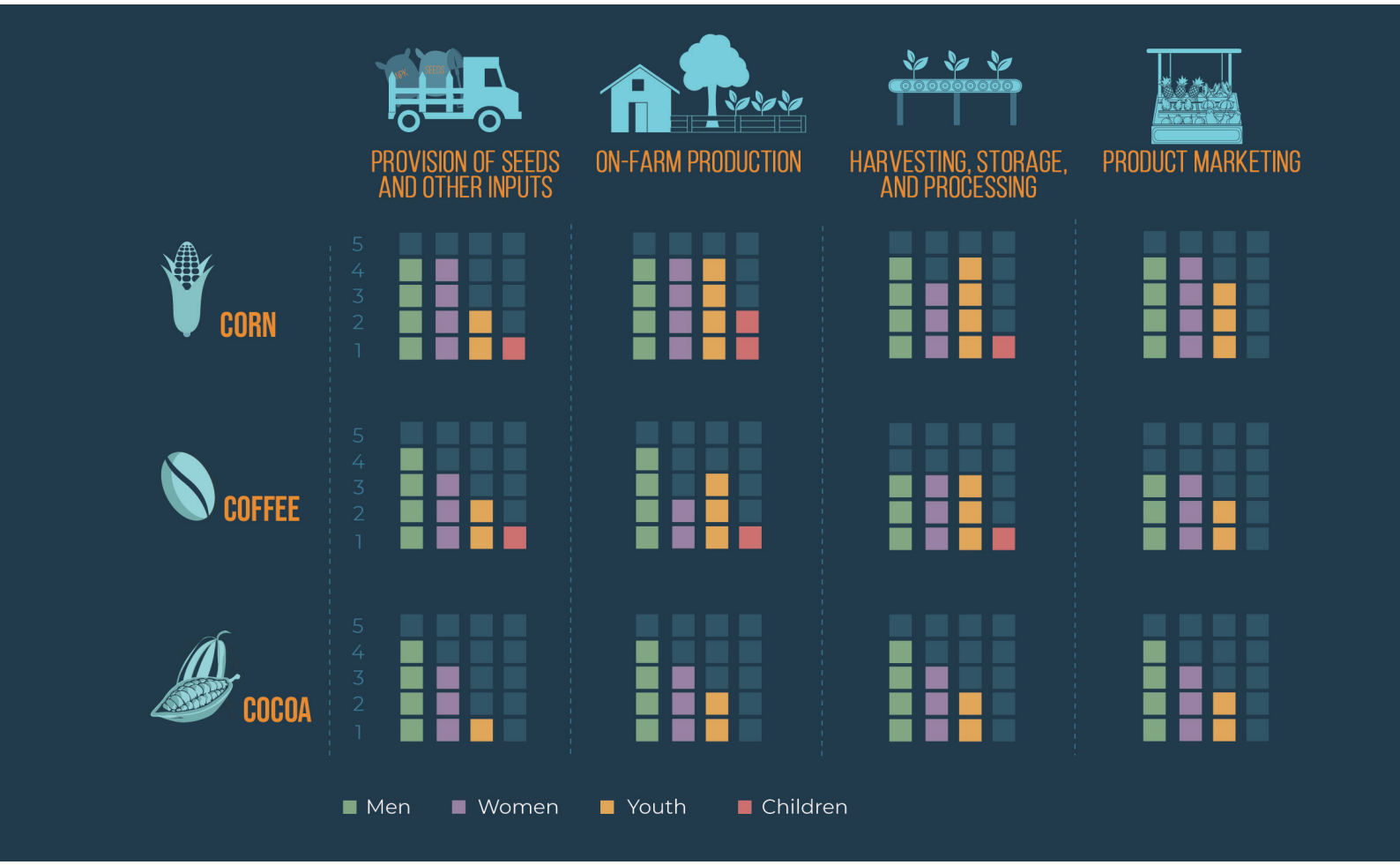


Figure 1: The roles of men, women, youths, and children across the different value chain stages. Results were collected through an expert workshop with key value chain actors in Mindanao.

CLIMATE CHANGE AND VARIABILITY: HISTORIC AND FUTURE TRENDS

CLIMATE CHANGE AND VARIABILITY: HISTORIC AND FUTURE TRENDS

The Philippines, by the nature of its geographical location and archipelagic formation comprised of over 7,000 islands, is highly vulnerable to the impacts of climate change. This vulnerability is the result of its severe exposure to multiple hazards, its sensitivity to these hazards in human and economic terms, and its limited adaptive capacity [2]. Globally, the Philippines is ranked 5th in terms of climate-related losses for the period of 1997-2016, with 289 events killing 85,955 people and costing 0.6% of the gross domestic product [1]. The impacts of climate change in the Philippines are felt most acutely by farmers and inhabitants of rural areas. Typhoons, flooding, and droughts damage crops and property. From 2000 to 2010, the total economic damage from typhoons, floods, and droughts was estimated to cost the Philippines USD 2.23 billion, including crop losses for rice (USD 1.2 billion), maize (USD 461.50 million), and high-value crops (USD 244.82 million) [45]. By 2050, this figure is projected to rise to USD 2.7 billion a year [3].

CLIMATE TYPE

Based on the Modified Coronas Classification System (MCCS) for climate typology, Mindanao is comprised of three of the four climate types in the Philippines. The eastern side of the island (Region 13) is classified as Type II, with no dry season and a pronounced period of heavy rain from December to February. The center of the island (Regions 10, 11, and 12) is classified as Type IV, with rain distributed evenly throughout the year. The western portion of the island (Region 9 and the ARMM), meanwhile, is classified as Type III, with a short dry period from December to February. Both the study areas of Bukidnon and Davao del Norte are classified as Type IV [46].

PROJECTED CHANGES IN PRECIPITATION AND TEMPERATURE BY 2050 [32]

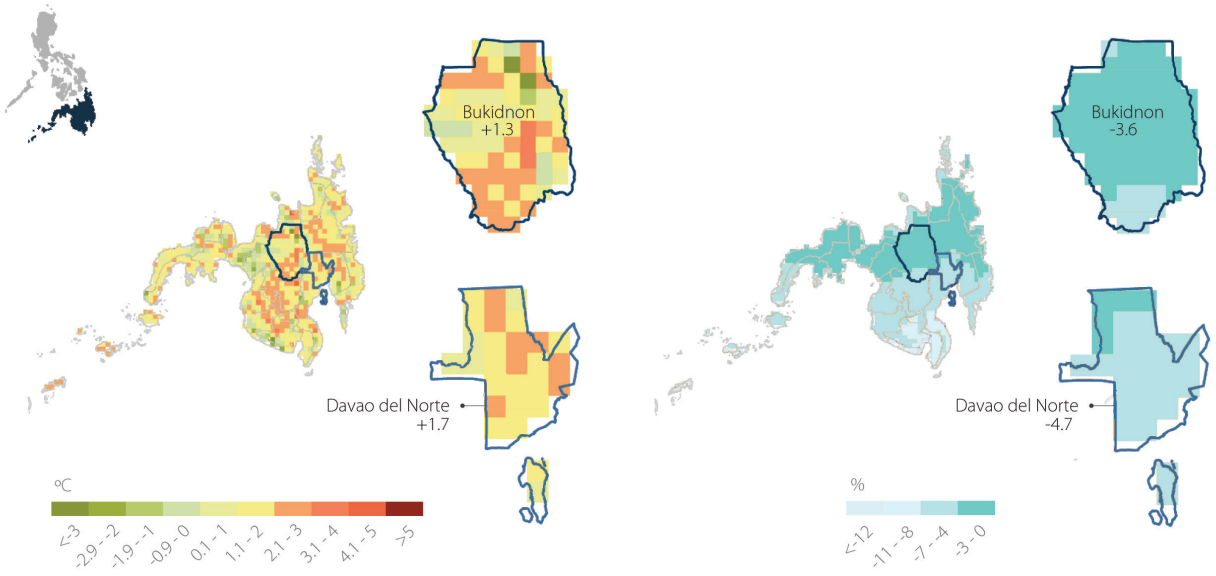


Figure 2: Modelled changes in temperature (left) and precipitation (right) under climate change by 2050, using Representative Concentration Pathway (RCP) 4.5.

THE STUDY AREAS

Bukidnon is forecast to experience an increase in the number of hot days (>35 °C) in 2050 relative to the 1972-2000 baseline. Over the same period the number of dry days will fall by almost a third, with the number of days experiencing excessive rains (>150mm) almost doubling from four to nine. The forecast changes in Davao del Norte mirror those of Bukidnon [46]. The sharp increase in the number of hot days, coupled with reduced rainfall, will negatively impact crop yields and further increase the risk of pest and disease outbreaks [47].

HAZARDS

Climate-induced variability in rainfall is likely to have a major impact on agriculture in the Philippines [46,47]. The increased frequency and intensity of extreme rainfall events damages crops directly by knocking over plants or dislodging grains, pods, or beans. This results in soil erosion and flooding that further reduce yields and increase post-production losses. In Mindanao these issues were exacerbated by widespread mining and deforestation, further increasing the risk of flash floods following periods of excessive rain. These activities were believed to be a factor in the flooding after Tropical Storm Sendong in 2011, which cost the lives of about 1,000 people [48]. A recent study using rainfall data from 2001 to 2010 suggested that a positive deviation of 8mm per month could result in a 35% increase in the frequency of rain-related disasters, leading to one more every three years [49]. This translates into an additional disaster every two years when a 12mm deviation is recorded. Mindanao has historically avoided the impacts of typhoons due to its geographic location south of the typhoon belt. However, a recent analysis of tropical cyclone trends in the Philippines observed a southward shift in the landfall of typhoons, reducing their incidence in Northern and Central Luzon and increasing their incidence in Visayas and Mindanao [50]. While the impacts and associated losses from these typhoons due to high winds and storm surges are less severe in Mindanao than the other island groups, the heavy rains associated with these events nonetheless have a considerable and worsening impact on agriculture in Mindanao.

Mindanao and Bukidnon provinces, in particular, have been identified as especially drought-prone areas [47]. This can be seen in figure 3, with large areas in Southern Bukidnon and Central Davao del Norte identified as at high risk of droughts. In 2016, Mindanao experienced a severe drought that directly impacted Bukidnon and Davao del Norte, with many provinces declaring a state of calamity. It is estimated that 181,687 farmers and 224,834 ha of agricultural land in the Philippines were affected, with an estimated USD 81 million of losses in agricultural production [51]. The severity of the droughts was strongly tied to the 2015-2016 El Niño event, one of the most powerful in modern times. The El Niño Southern Oscillation (ENSO) is a naturally-occurring climate phenomenon that has an impact throughout much of the tropics. It has two phases: El Niño, the warm phase, and La Niña, the cold phase. The ENSO has a modulating effect on rainfall patterns in the Philippines. A strong El Niño is associated with droughts and water stress, and a strong La Niña results in excessive rainfall [52]. Climate Type I experiences the largest positive rainfall anomaly in La Niña years, while climate Type III experiences the largest negative rainfall anomaly in El Niño years. The 1982-83 ENSO event impacted both Bukidnon and Davao del Norte [53]. One study of upland farmers in Lantapan, Bukidnon from this period showed farmers reporting crops drying up and delayed planting in El Niño years, and washouts due to heavy rains during a strong La Niña [54]. Similarly, an Oxfam assessment in Mindanao in April 2016 found that the impacts of drought resulting from the 2015 El Niño had devastated yields and forced families to reduce the quality and quantity of their meals [55].

Agriculture is also heavily dependent on the timing of rains, with certain stages in the crop cycle being more impacted by heavy or reduced rainfall than others. The 1997-1998 El Niño resulted in production losses of 100% during the dry season and greater than 33% during the wet season. This was repeated with the 2004 El Niño — but to a lesser extent— causing 18% losses during the dry season and 32% in the wet season [47]. Farmers in Bukidnon cited 'early onset of rains', 'late onset of rains' and 'prolonged rains' as negative consequences of the ENSO. Between 2005 and 2007, the ENSO became increasingly unpredictable, with Luzon experiencing dry conditions during usually wet La Niña events and Mindanao reporting excessive rains during usually dry El Niño events [56]. These conditions resulted in landslides and flooding in Mindanao and water and power shortages in Luzon. Droughts induced by El Niño have already been linked with falling cocoa yields in Brazil and will likely have similar impacts on production in the Philippines [57].

DROUGHT HAZARD MAP OF MINDANAO [58]

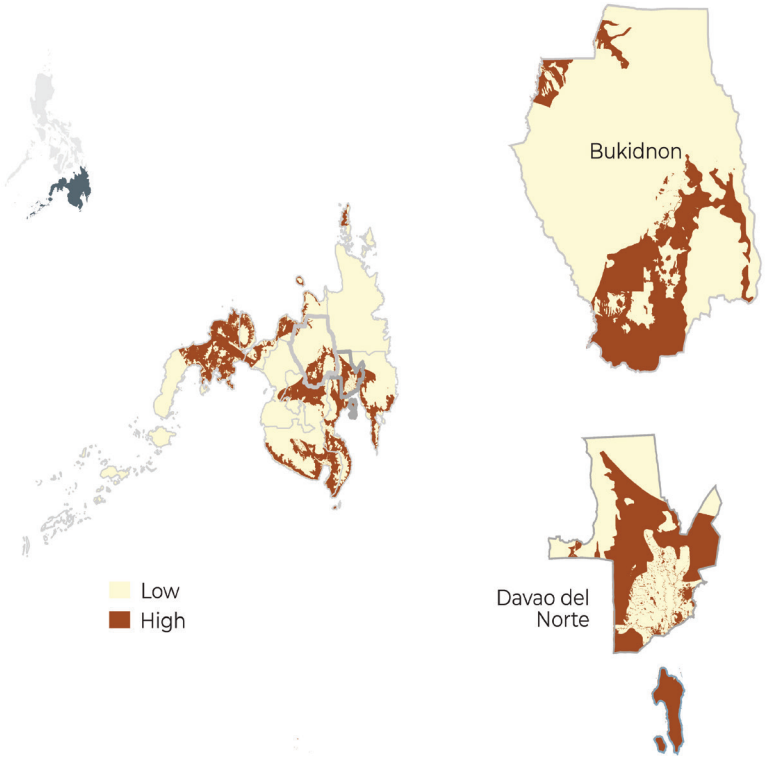


Figure 3: This drought map was acquired from the AMIA 1 dataset. It was produced using the integration of groundwater potential from the National Water Resources Board (NWRB) with topography and climate data from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA).

CROP SUITABILITY MAPPING

The climate change impacts and hazards outlined in the previous section—increased frequency and intensity of typhoons, higher temperatures, and an increased likelihood of prolonged droughts—acutely impact agricultural systems in Mindanao. By combining climate projections about temperatures and rainfall with specific parameters regarding a plant's basic physiology, modelling for suitability can provide useful projections as to where favorable growing conditions may exist for certain crops into the future. Suitability mapping for 2050 is provided here for cocoa, coffee, and corn in Mindanao relative to 1997-2000 baselines and ranges from 0 to 100%, with intervals classified as very high (81–100), high (61–80), moderate (41–60), marginal (21–40), and very marginal (<20). These measures of future suitability will support agricultural planning and investment in the selected regions, enabling long-term planning and transformation in response to climate change.

COCOA

Mindanao is highly suitable for cocoa production currently and under the projected impacts of climate change to the year 2050 (see figure 4). The suitability mapping approach used here does not account for the impact of extreme events on cocoa production in Davao del Norte.

CLIMATE SUITABILITY OF COCOA IN MINDANAO, CURRENT AND IN 2050 [46, 59]

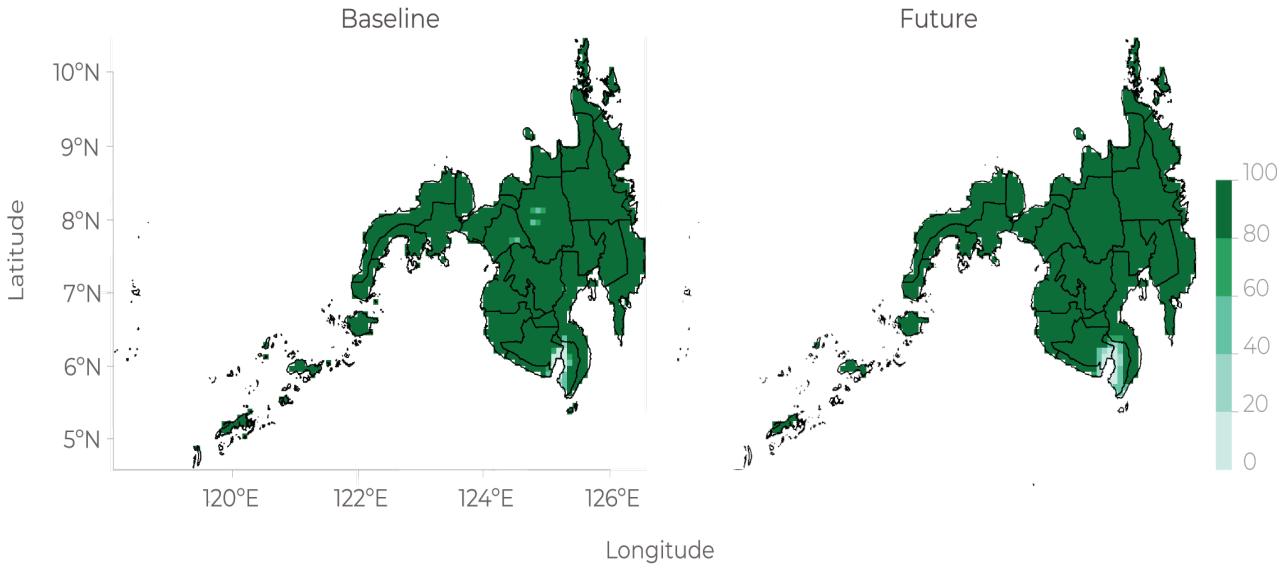


Figure 4: These climate suitability maps represent how well cocoa will thrive in Mindanao based on climatic factors such as temperature and rainfall. Cocoa's suitability ranges from 0 - 100% with an interval of 20: 81–100 (very high), 61–80 (high), 41–60 (moderate), 21–40 (marginal), and <20 (very marginal).

COFFEE ROBUSTA

Based on current suitability, Robusta coffee can be widely planted in Mindanao but with some limitations in high-elevation areas. This is consistent with the coffee production report in the Philippines where four out of the five highest producing coffee regions are in Mindanao: in order of greatest production to least, SOCCSKSARGEN at 31%, Davao at 21%, the ARMM at 12%, and Northern Mindanao at 6%.

Based on suitability projections for coffee to the year 2050, a large share of suitable areas are at risk in Mindanao—specifically, low lying areas of SOCCSKSARGEN, Caraga, Davao, and the Zamboanga Region. These areas are important for coffee production, with SOCCSKSARGEN and Davao representing >50% of the coffee production in the Philippines [33]. These projections are also consistent with recent research which found a pattern of altitudinal migration of coffee in the Philippines [60].

CORN

Corn is typically grown in the rain-fed areas of Mindanao, with sufficient rainfall for two to three crops per year. Farmers adjust their cropping calendars for sufficient rainfall to ensure crop water requirements are met. Corn is commonly grown in temperatures ranging from 18°C to 27°C and in areas with annual rainfall between 350 and 450mm. At present (1997-2000), corn has very high climate suitability in more than 60% of Mindanao. It is considered especially highly suitable in the regions of Zamboanga, the ARMM, SOCCSKSARGEN, and Northern Mindanao. By 2050, the crop's suitability is expected to decrease in the regions of Zamboanga, the ARMM, and SOCCSKSARGEN. In some areas in Davao and Caraga, however, corn suitability is projected to improve. This is also true of Bukidnon, especially in its central and northeastern areas.

CLIMATE SUITABILITY OF COFFEE IN MINDANAO, CURRENT AND IN 2050 [46, 59]

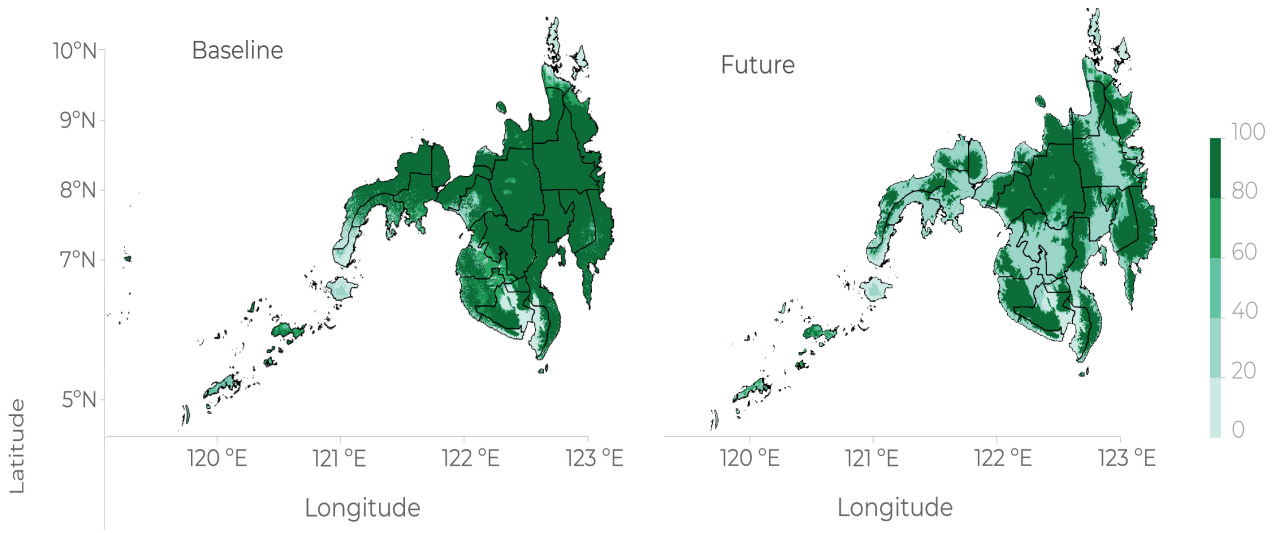


Figure 5: These climate suitability maps represent how well coffee will thrive in Mindanao based on climatic factors such as temperature and rainfall. Coffee's suitability ranges from 0 - 100% with an interval of 20: 81–100 (very high), 61–80 (high), 41–60 (moderate), 21–40 (marginal), and <20 (very marginal).

CLIMATE SUITABILITY OF CORN IN MINDANAO, CURRENT AND IN 2050 [46, 59]

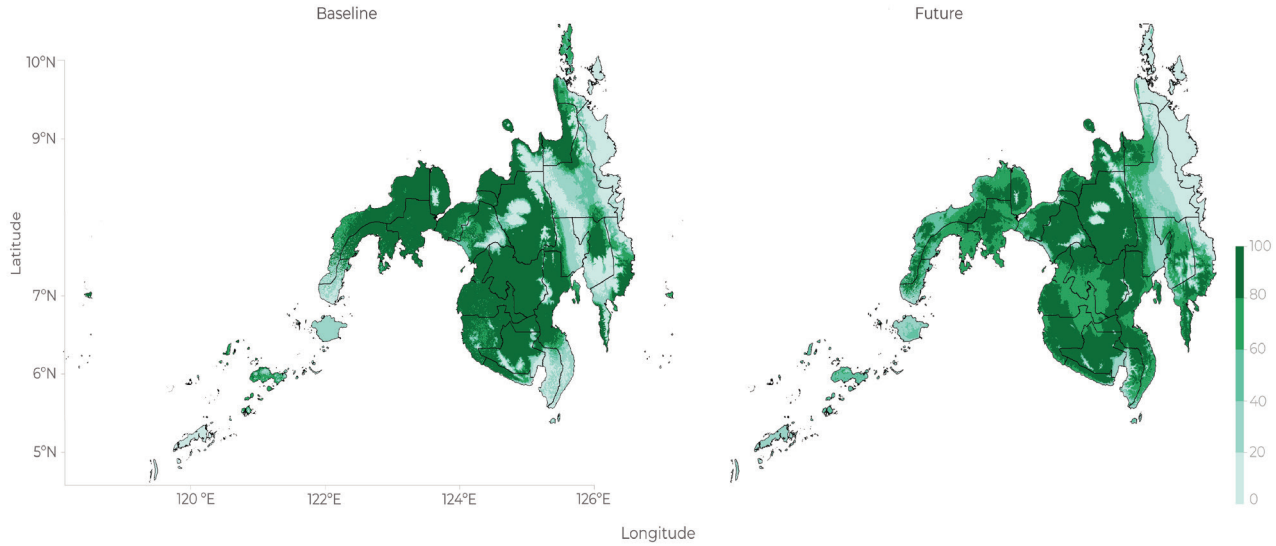


Figure 6: These climate suitability maps represent how well corn will thrive in Mindanao based on climatic factors such as temperature and rainfall. Corn's suitability ranges from 0 - 100% with an interval of 20: 81–100 (very high), 61–80 (high), 41–60 (moderate), 21–40 (marginal), and <20 (very marginal).

THE CLIMATE FROM FARMERS´ PERSPECTIVES

Coffee and yellow corn farmers in Bukidnon and cacao farmers in Davao del Norte have diverse perceptions regarding the manifestations of climate change and its impacts on their agricultural productivity. In general, farmers believe that longer dry periods, rising temperatures, changing weather patterns, and flooding are likely manifestations of climate change. Many observed that Mindanao—lying below the historical tropical cyclone belt—has been uncharacteristically experiencing typhoons in recent years. Heavy rains and flooding degrade soil quality, adversely affecting crop yields. Farmers have further noted that anthropogenic activities such as deforestation, slash and burn agriculture, soil depletion, and the conversion of grasslands to agricultural lands have intensified the impacts of climate change.

Bukidnon farmers, in particular, noted that heavy rains cause erosion and deforestation in their province. Over 52,000 has of corn farms and over 53,000 corn farmers in Bukidnon were affected by heavy rains [61]. Further, farmers indicate that the occurrence of droughts and heavy rains alter cropping seasons and may lower the volume of production. Most of these farmers rely on rain-fed agriculture, which makes them more sensitive to these impacts. Farmers reported that droughts during the planting stage may result in total crop loss, while growers affected by fifteen consecutive dry days saw damage to mature corn.

Cacao farmers from Davao del Norte asserted that both the long wet and dry seasons can reduce a harvest by up to half of its usual volume. Excessive rains can result in the rotting of cacao pods, while too much heat can wilt cacao pods even before they mature. One farmer explained that mature cacao trees will not die during long dry periods but will bear smaller pods. Seedlings, however, may die due to prolonged drought. Coffee farmers in Bukidnon, meanwhile, observed extreme heat and rainfall, longer dry periods, and sudden shifts in temperature, all of which have altered the production cycle and led to decreased yields. For some coffee farmers, however, warmer temperatures have resulted in larger beans and have assisted in the drying process.

CLIMATE VULNERABILITIES ACROSS AGRICULTURAL VALUE CHAIN COMMODITIES (VCCS)

CLIMATE CHANGE CONSEQUENCES AND ADAPTATION OPTIONS

The impacts of climate change and natural hazards are felt across the cocoa, corn, and coffee value chains, from the provision of seeds and inputs to product marketing. The consequences of these impacts vary across different VCC stages, variously affecting different actors and each requiring tailored adaptation options. In this section we look at the consequences of the hazards for the VCC, considering underlying vulnerability factors and the proposed options to either adapt to or mitigate the associated risks.

All three commodities are affected by droughts and heavy rains across their value chains.. Both droughts and heavy rains increase the mortality rate of coffee and cacao seedlings, impacting nursery owners and farmers looking to replenish old or dead stocks. For the suppliers of inputs for corn farmers, droughts could lead to periods of low demand, while heavy rains may increase demand, pushing up prices because farmers have to replant or reapply fertilizer and pesticides that were washed away. All three crops faced an increased incidence of pests and diseases following periods of heavy rains or drought [62]. Severe droughts can increase the mortality rate of coffee plants, resulting in costly replanting and diminished incomes while plants mature. With high temperatures and dry conditions, the mortality rate of newly planted cacao seedlings can reach as high as 50–70%. Farmers in sloping areas are particularly vulnerable to heavy rains because the resultant soil erosion and landslides destroy crops and cut farms off from markets and processing facilities. When rains arrive late in the cropping season, corn can be knocked over or kernels can rot, while droughts either delay planting or cause a whole cropping

season to be lost. The irregular supply of produce caused by both droughts and heavy rains can disrupt procurement schedules, leading to underutilization of machinery and facilities for processing and to potential layoffs. Processors and traders will receive reduced quality products or may suffer losses due to rot and fermentation (aflatoxin) during periods of excessive rain. This issue is felt more acutely by those who do not have access to proper storage facilities equipped with dryers and moisture meters. Those involved in product marketing can be left unable to fulfill orders on their books due to the low quality and quantity of produce, impacting future trading relations. Trading can also be delayed during heavy rains because transport to remote areas is delayed and becomes costlier.

YELLOW CORN

Diversified farming systems were identified as the priority adaptation strategy for yellow corn farmers and stakeholders in Bukidnon. This system involves production of various crops or animals—or both—simultaneously on a single farm in a way that maintains ecosystem services. Farmers intercrop corn with drought-tolerant crops such as cassava, taro, and bananas to mitigate the risks posed by droughts and to diversify their income sources. Some farmers also grow cash crops or organic vegetables, practice agroforestry, integrate poultry and livestock, and participate in on-farm value-addition activities. Diversified farming can therefore provide improved soil fertility, pest and disease control, water use efficiency, and pollination [63]. One study ascertained that increasing the diversity of cropping systems can lower synthetic input usage while maintaining the same crop yield, weed suppression, and economic performance of less diverse systems [64]. LGUs in Bukidnon, along with the ATI, have been running workshops to promote corn-based diversified farming systems. Still, only 30% of corn farmers in Bukidnon have adopted the practice, with traditional and plantation farmers least likely to do so. One of the practices used in Bukidnon is Sloping Agricultural Land Technology (SALT), which was developed by the Mindanao Baptist Rural Life Centre (MBRLC) in the 1970s. It involves the contour planting of leguminous shrubs or trees in double rows between which both perennial and seasonal crops are planted [65]. Corn can be grown in this system in rotation with other crops. SALT, and other contour farming techniques, delays and redirects water runoff, improves water infiltration, and reduces soil erosion. The reduction in water evaporation makes this practice suitable during both drought and heavy rain conditions. It also conserves soil fertility when leguminous plants are grown together [66]. Contour farming in some form has been adopted by 60% to 100% of farmers who live in hilly areas. There is, however, scope to better integrate diversified farming and identify the combinations best suited to protect farmers from the impacts of droughts and excessive rains.

Rainwater harvesting from rain shelters and rainwater impounding is also a viable adaptation option for farmers in both sloping and lowland areas. A study looking at the impacts of climate change on upland farmers in Lantapan, Bukidnon found that farmers were often impacted by the early onset of rains in La Niña years, while in El Niño years the late onset resulted in crop damages due to droughts [54]. In response to these impacts, farmers dug drainage channels to protect against heavy rains and deep wells for the dryer years, and also engaged in other practices such as intercropping and agroforestry.

YELLOW CORN

PROVISION OF SEEDS AND OTHER INPUTS

ON-FARM PRODUCTION

HARVESTING, STORAGE, AND PROCESSING

PRODUCT MARKETING

Hazard: DROUGHT

Consequences

- Decline in the demand for inputs due to failed crops
- Losses in crop production
- Attacks of pests like worms and rats following drought
- Corn of lower quality
- Low procurement for traders due to reduced production
- Production levels too low to supply POs

Underlying vulnerability factors and sensitive groups

Biophysical: elevation, soil profile type; **Socioeconomic:** low or unstable household income, youth or a relative dearth of farming experience, agricultural educational background; **Cultural:** a lack of traditional practices and participation or membership in organizations; **Policy:** a lack of common machinery and equipment distribution

Adaptation options proposed

- Reconstruction of accounts, additional interest
- Diversified farming (crops-livestock)
- Crop rotation involving corn and cassava ($)
- Rainwater harvesting
- Diversified sources and back up providers during scarcity scenarios

Hazard: EXCESSIVE OR HEAVY RAIN

Consequences

- Higher costs of inputs
- Low yield due to the incidence of pests, diseases, or fungi
- Delayed planting
- Rot due to the submergence of corn in water
- Loss of opportunity to sell quality corn
- Higher processing costs
- Excessive volume procured
- Higher costs for freight or hauling
- Difficult and more expensive transportation
- Less accessible roads and extra activities to prevent grains from getting wet

Underlying vulnerability factors and sensitive groups

Biophysical: difficult topography, soil profile or type, elevation; **Socioeconomic:** low or unstable household income, youth or a relative dearth of farming experience, agricultural educational background; **Infrastructure:** farm-to-market roads, difficult access or long distances to drying facilities; **Policy:** a lack of common machinery and equipment distribution

Adaptation options proposed

- Increased inventory levels
- Diversified farming (crops)
- Contour farming (SCoPSA, NVS, SALT)
- Alternative Post-Harvest Facilities (PHF)
- Mechanization
- Establishment of more PHF near production areas

Magnitude of impact: Minor | Moderate | Major | Severe

Score priority: High | Medium | Low

Cost-benefit analysis available in supplementary material: $ Available

COFFEE

For coffee farmers in mountainous and sloping areas, contour farming is proposed as an adaptation strategy for both droughts and heavy rains. Contour farming is the practice of growing crops in horizontal strips that follow the natural contours of the land. These strips act as a natural buffer, conserving soil and improving water retention on sloping lands. Contour farming is often used as part of an intercropping or agroforestry system, balancing the strengths of the different crops in terms of improved soil stability, reduced surface water runoff, reduced erosion and improved nutrient capture [67]. There are three main contour farming systems that have been used in Bukidnon since the 1980s [68]. SALT is an example of such a system, where crops are grown in contours with rows of nitrogen-fixing shrubs and trees planted between them. For coffee farmers in Bukidnon, *Arachis pintoi*, ipil-ipil and *Flemingia* were common examples of nitrogen-fixing crops that were grown alongside coffee. Another system used is Natural Vegetable Strips, growing assorted vegetables and root crops alongside coffee [67]. This could be taken one step further to become a Vegetable Agroforestry System with the inclusion of banana, abacas, and falcata trees. Of the farmers consulted in this study, 30% to 60% reported planting banana between rows of coffee, while between 60% and 100% intercrop coffee with abaca and falcata trees, vegetables, and root crops. For many of the farmers in Bukidnon who have adopted one of the above contour farming systems, coffee production is no longer their main income-generating crop. Furthermore, the diversity of their crops provides greater resilience to climate shocks.

Another adaptation strategy being employed by coffee farmers in Bukidnon is the use of deep hole planting. The practice of planting seedlings in deeper holes has been found to improve their survival rate if their planting is followed by a period of drought. Seedlings planted in this manner have improved access to water through a deeper root network. The practice is not found in the literature. It has, however, been promoted by the organization Coffee for Peace in Bukidnon, which saw improved drought resilience in crops planted using this practice. Another practice that was identified as a measure to combat the impacts of drought was watershed management. Agricultural expansion in Bukidnon has resulted in high levels of deforestation. Deforestation within the catchment exacerbates the impacts of droughts and heavy rains. A study in the Taguibo watershed in the Caraga region of Northern Mindanao found that historic logging and deforestation had resulted in much higher levels of surface water runoff, leading to flash floods during periods of heavy rain and drought due to the reduced water holding capacity of the watershed [69]. Recent government programs have recognized the importance of the watershed in building the resilience of farmers in Mindanao, such as the National Greening Program that aimed to increase forested area in the Philippines. Questions have been raised as to the effectiveness of deforestation programs in the Philippines; some participants have observed that areas that had been involved in tree planting programs were often cleared through slash and burn when the subsidies stopped.

CACAO

To adapt to the impacts of climate hazards such as droughts, cacao farmers in Davao del Norte identified the establishment of sprinkler systems as a priority on-farm adaptation option. These systems, which include micro-sprinklers and drip irrigation, improve both water and nutrient efficiency through the targeted application of water to a plant's roots. There are, however, very few farmers that have adopted this practice, with many unable to meet the high up-front costs, especially farmers without access to credit. Establishment of a water impounding (harvesting and storage) facility is another adaptation strategy currently being planned by the Provincial Agricultural Office (PAGRO) of Davao del Norte. At present, farms are predominantly rain-fed, and this facility will allow 60% to 100% of farmers in the area to access water during times of drought. In addition to these and other water saving interventions, mulching, organic farming, expansion of postharvest facilities, increased capacity to manage diseases, reforestation and watershed development, and crop insurance were also identified as adaptation options.

Farmers in drought-prone areas practice mulching using coconut husks that absorb water and retain moisture during periods of drought. The benefit of using coconut mulch is that it is a waste product from coconut production and therefore readily available in the Philippines. Organic farming, or the use organic fertilizers like vermiculture, is practiced by less than 30% of farmers. This adaptation option increases soil moisture retention and allows farmers to obtain higher prices for their produce. One of the obstacles to the adoption of mulching and organic agriculture is that they are labor- and time-intensive, a challenge

COFFEE

	PROVISION OF SEEDS AND OTHER INPUTS	ON-FARM PRODUCTION	HARVESTING, STORAGE, AND PROCESSING	PRODUCT MARKETING
Hazard	**DROUGHT**			
Consequences	▮ Higher mortality rate of seedlings in nurseries ▮ Delays in nursery production	▮ Increased mortality rate ▮ Lack of water supply ▮ Diminished productivity in the succeeding cropping year ▮ Limited income opportunities for farmers	▮ Lack of opportunities to earn other income	▮ Higher price of GCB and roasted beans ▮ Difficulty to meeting quality standards ▮ Problems to meeting contracts because of delayed harvests
Underlying vulnerability factors and sensitive groups	**Biophysical:** farm locations and distance to forest areas, **Socioeconomic:** level of access to education and information, farmers age, levels of partnership, **Infrastructure:** reduced efficient irrigation systems (e.g., drip irrigation), **Policy:** grants in farming equipment			
Adaptation options proposed	● Accreditation of nurseries ● Provision of nursery facilities ● Crop insurance	● Mulching ● Diversified farming and intercropping ● Rainforestation model ● Good Agricultural Practices (GAP) ● Information dissemination ● Deep hole planting ● Mini-forest and watershed development	● Provision of post-harvest and processing facilities and equipment ● Use of moisture meter for quality control ● Ventilation systems in warehouses ● Information dissemination	● Strengthened market linkages through agri-fairs and expos
Hazard	**HEAVY RAIN**			
Consequences	▮ Damage to nurseries and seedlings	▮ Increased soil erosion ▮ Potential low yield ▮ Farm flooding and waterlogging ▮ Increased occurrence of pests and diseases	▮ Over-fermentation	▮ Difficulty in transport
Underlying vulnerability factors and sensitive groups	**Biophysical:** farm location, **Socioeconomic:** household size, limited access to education and information, **Infrastructure:** Un passable or no roads and bridges, **Institutional:** government, NGO, and private-sector support and cooperation, insufficient extension workers, **Policy:** prioritization of LGUs, limited grants, training, and information, inadequate capacity building			
Adaptation options proposed	● Accreditation of nurseries ● Provision of organic fertilizer ● Training in organic fertilizer production	● Contour farming ($) ● Rainforestation model ● Mini-forest and watershed development	● Provision of post-harvest and processing facilities and equipment ● Ventilation systems in warehouses	● Road improvements ● Construction and improvement of storage and warehouse facilities

Magnitude of impact

▮ Minor ▮ Moderate ▮ Major ▮ Severe

Score priority

● High ● Medium ● Low

Cost-benefit analysis available in supplementary material

$ Available

COCOA

PROVISION OF SEEDS AND OTHER INPUTS

ON-FARM PRODUCTION

HARVESTING, STORAGE, AND PROCESSING

PRODUCT MARKETING

Hazard: DROUGHT

Consequences

- Increased mortality rate of seedlings
- Cocoa crop failure due to pest infestation
- Lower production quality
- Reduced pod size and total harvest
- Default volume such that agreements with exporters or buyers are not met

Underlying vulnerability factors and sensitive groups

Biophysical: scarcity of water sources,
Socioeconomic: reduced or unstable household income, household size,
Infrastructure: difficult road access

Adaptation options proposed

- Water drilling using solar energy and water reservoirs
- Crop insurance
- Establishment of technological agriculture facilities and learning resource center
- Water pumps in nurseries
- Shading in nurseries
- Establishment of irrigation systems
- Rainwater harvesting
- Improved services and access to water services
- Rainwater harvesting
- Reforestation and watershed development
- Mulching
- Organic fertilizer (**$**)
- Good Agricultural Practices (GAP)
- Improved storage facilities

Hazard: HEAVY RAIN, TYPHOON

Consequences

- Increased mortality rate of seedlings
- Increased risk of crop failure
- Cocoa disease outbreaks
- Increased moisture in cocoa beans and growth of mold
- Increased drying time and cost
- Damaged farm-to-market roads

Underlying vulnerability factors and sensitive groups

Biophysical: difficult topography, **Socioeconomic:** reduced or unstable household income, access to services and climate information, educational level, **Institutional:** a lack of government support, poor dissemination and inadequate discussion of climate change impacts, **Infrastructure:** deteriorated road conditions, **Policy:** lack of awareness and knowledge about crop insurance

Adaptation options proposed

- Establishment of technological agriculture facilities and learning resource centers
- Crop insurance
- Capacity building in integrated pest and disease management
- Rainwater harvesting
- Improved drying facilities and methods, such as mechanical and solar dryers
- Improved fermentation facilities and methods
- Formation of"small group organizations" at barangay level
- Improved storage facilities
- Strengthened agricultural infrastructure such as bridges and trading centers
- Increased access to transportation, such as through motorcycles
- Sensory facilities and instruments (cut tester, moisture meters, oven, grinder, willower)

Magnitude of impact: Minor, Moderate, Major, Severe

Score priority: High, Medium, Low

Cost-benefit analysis available in supplementary material: $ Available

for farmers that are increasingly looking to off-farm income sources who are already demanding more of their time. In addition to the above practices, crop insurance is proposed as a last resort for farmers that have been impacted by droughts. The Philippine Crop Insurance Company (PCIC) offers insurance to farmers, but uptake remains very low (<30%) due to a lack of understanding of the insurance products.

BARRIERS

There are considerable barriers to both on- and off-farm adaptation strategies utilized by farmers and other value chain actors in Mindanao. This section examines common barriers to adaptation as they exist across the yellow corn, coffee, and cacao value chains. These include informational, technical, behavioral, financial, and institutional barriers.

The lack of access to reliable and timely information to inform adaptation decision making is a central challenge across supply chains. Input suppliers often do not have access to data-based planning tools like weather forecasts that would allow them to prepare for demand spikes following extreme weather events or pest and disease outbreaks. This situation leaves them unable to meet the demand of farmers, reducing agricultural productivity and input supplier incomes. A lack of information sharing is also a major barrier to the adoption of adaptation strategies by farmers in Mindanao. Some farmers are simply unaware of climate-resilient agricultural practices and do not have access to climate information services of any kind—nor are they aware of support options provided by the DA or the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), for example.

Many farmers also refuse to adopt practices such as integrated or diversified farming, crop rotation, and water impounding strategies. They perceive that these interventions require high capital investments and have unproven returns; that they themselves lack possess the technical capacity to implement such interventions; or that these interventions conflict with the longstanding traditional practices to which many farmers are accustomed. This is true of mechanization technologies for harvesting, storage, and processing; many farmers are simply more comfortable with traditional methods.

While high capital requirements are misperceived in some instances, in other cases farmers and other actors do lack financial capital for implementing certain adaptation strategies. Construction of postharvest storage and processing facilities, for example, involves large-scale infrastructure investments that are out of reach for many. Coffee farmers, meanwhile, have further identified limited access to credit and a lack of available collateral, together with long payback periods, as affecting their adoption of certain adaptation practices. High financial barriers were also cited by cacao farmers seeking to install water systems, drilling facilities, and postharvest structures.

Ineffective government support was also a common issue recognized by stakeholders as discouraging farmers from implementing some adaptation practices. Government intervention programs are sometimes considered inappropriate to farmers' needs. Several coffee growers, for example, reported that some government projects are politically driven and may be biased in providing services. Other institutional barriers include the need for coffee and cocoa nursery accreditation. Finally, on occasion, the DA directly taps sub-provincial LGUs to implement projects rather than going through provincial authorities like the PAGRO, sometimes resulting in poor coordination and fragmented service delivery to farmers.

POLICIES AND PROGRAMS

The Philippines has long-established laws aimed at promoting adaptation to climate change. The Climate Change Act of 2009 (Republic Act No. 9729) mainstreams climate change into government policy formulations. Through this act, the Climate Change Commission (CCC) was created to serve as the sole policy-making body responsible for coordinating, monitoring, and evaluating climate change programs and action plans in the country. In order to ground this national-level policy, LGUs subsequently crafted Local Climate Change Action Plans (LCCAPs) for their respective communities, directly engaging barangays.

Amending the Climate Change Act, R.A. No. 10174 established the People's Survival Fund in 2012 to provide long-term financing to projects that address climate change. Its PHP 1 billion (USD 18.5 million) appropriation from the General Appropriations

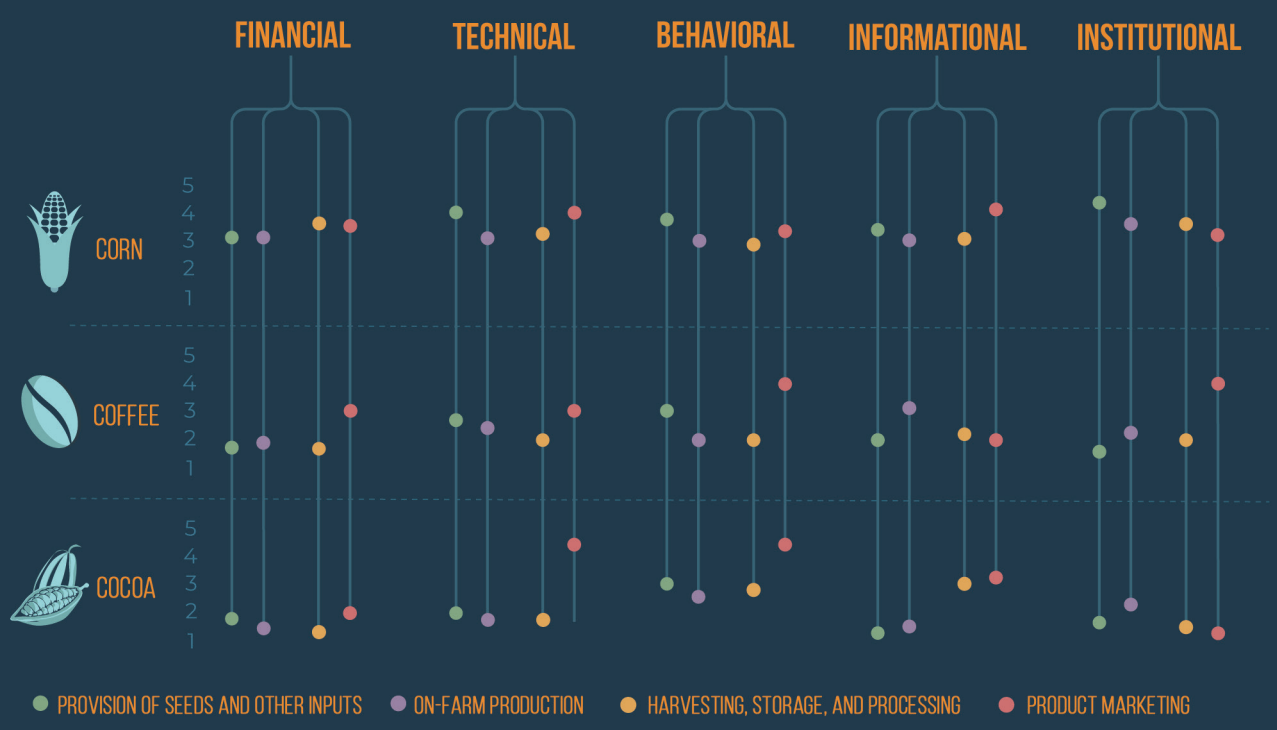


Figure 7: This is a map of the severity of different barriers across the value chains for key commodities. The height of the barrier corresponds to the severity on the left-hand scale with 1 = no barrier and 5 = severe barrier.

Act is supplementary to any annual appropriations allocated by LGUs for Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA). Recognizing the close interrelation between DRR and CCA activities, R.A. No. 10174 mandated the integration of DRR activities into climate change programs and initiatives. The National Framework Strategy on Climate Change for 2010-2022 was introduced by the CCC with an emphasis on adaptation, while mitigation was included as a function of adaptation.

The Philippines Intended Nationally Determined Contribution (INDC), submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in accordance with the Paris Agreement, targets a 70% reduction in greenhouse gas (GHG) emissions by 2030 compared to the business-as-usual scenario of 2000-2030. While adaptation is the focus of many policies due to the Philippines' high exposure to the impacts of climate change, there are also a number of policies and initiatives that emphasize mitigation. In 2014, President Benigno Aquino III signed Executive Order No. 174 to institutionalize the Philippine GHG inventory management and reporting system in order to enable the country's transition to a climate-resilient path towards sustainable development.

In 2013, the DA Secretary, Proceso Alcala, issued the memorandum "Mainstreaming Climate Change in DA Programs, Plans and Budget" to further strengthen the implementation of R.A. 9729, particularly within the agriculture and fisheries sectors. The Secretary likewise approved the Department's Seven-Wide Programs on Climate Change (DA-SWPCC), with the following seven focus areas: "(1) Mainstream Climate Change Adaptation and Mitigation Initiatives in Agriculture (AMIA); (2) Climate Information Systems; (3) Philippine Adaptation and Mitigation in Agriculture Knowledge Toolbox; (4) Climate-Smart Agriculture Infrastructure; (5) Financing and Risk Transfer Instruments on Climate Change; (6) Climate-Smart Agriculture and Fisheries Regulation; and (7) Climate-Smart Agriculture Extension Systems." In 2016, the program fund was pegged to the Climate Change Program of the Bureau of Agricultural Research to be used for research and development activities that are aligned with the AMIA framework, with an emphasis on increasing the adaptive capacity and productivity of agriculture and fisheries livelihoods.

The Agriculture and Fisheries Modernization Act (AFMA) aims to modernize the agriculture and fisheries sectors of the Philippines and to enhance these sectors' profitability and preparedness related to the challenges of globalization. The AFMA has also led to the formulation of Strategic Agricultural and Fisheries Development Zones and the Agricultural

and Fisheries Modernization Plan. Across these policies, the government prioritized irrigation and increased access to credit for farmers. However, because of underinvestment in the sector, progress in these areas has been slower than expected [70,71].

The Adaptation and Mitigation Initiative in Agriculture, meanwhile, is the flagship program for climate change and mitigation within the DA. The Department of Agriculture Systems-wide Climate Change Office (DA-SWCCO) oversees AMIA. Central to the AMIA initiative is the establishment of "AMIA villages," where climate-smart best practices are showcased [72]. Currently, AMIA villages have been established in Bukidnon Province, specifically in the communities of Libona and Manolo Fortich. In Davao del Norte, however, only Davao City hosts an AMIA village.

Climate change is also captured in the country's overarching framework for the DA, the Agri-Pinoy strategy (2011-2016). This strategy was built on four central themes: food security and self-sufficiency, sustainable agriculture and fisheries, natural resource management, and local development. It calls for coordinating regionally-based spatial planning, providing infrastructure critical to priority value chains, and building a more resilient production base to accommodate the variations in the global markets and the effects of climate change [37]. The framework itself has various sub-programs, most notably rice and corn programs.

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 sectors. The PRDP is a scaled-up version of the Mindanao Rural Development Program and is aligned with the Agri-Pinoy strategy. Through this project, value chains—including high-value crops such as coffee and cacao—are prioritized for investment and development. The "I-PLAN" component of the PRDP assists LGUs in the development of Provincial Commodity Investment Plans (PCIP) that serve as blueprints for investment in priority commodities. In Davao del Norte, for example, the PCIP aims to improve the market competitiveness of the cocoa bean industry. The "I-BUILD" component of PRDP then puts in place strategic and climate-resilient infrastructure along these value chains, including farm-to-market roads, communal irrigation systems, potable water supplies, and postharvest and other rural infrastructure.

GOVERNANCE AND INSTITUTIONAL RESOURCES AND CAPACITY

Government institutions active on climate change issues in the Philippines include the Climate Change Commission, DA, and other related agencies such as the PAGASA 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 on the regional, provincial, and city levels, the DA is pivotal in implementing new technologies, practices, and other services that may impact farmers or agricultural value chain actors in the Philippines. The DA has attached bureaus and agencies—like the ATI or the Bureau of Agricultural Research—tasked with implementing climate change-related programs, conducting research, providing trainings, and offering extension services. The Systems-wide Climate Change Office, meanwhile, coordinates and manages AMIA, the flagship program for climate adaptation and mitigation of the DA.

LGUs also play a central role in mainstreaming climate change adaptation in the Philippines, as evidenced by their development and implementation of LCCAPs. LGUs consist of various sub-national administrative units including the region, province, city, municipality, and barangay. 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 within its territorial jurisdiction. The PAGRO is mandated to promote sustainable agriculture and enhance the growth of fisheries through increased productivity and profitability, coordinating DA projects and programs. The office employs coordinators for every crop grown in the province, reaching specific farmers with specially tailored services.

EXTENSION

The DA, through the ATI, is the agency charged with the delivery of extension services for the agriculture and fisheries sectors, providing training to agricultural extension workers. Apart from the ATI, DA offices in LGUs also conduct ad-hoc trainings for farmers. The Municipal Agriculture Office, for example, conducts trainings on nursery establishment, crop production, and postharvest practices. NGOs and private entities or companies like CIDAMI often have more resources to provide extension services to farmers and often do so through seminars.

RESEARCH AND DEVELOPMENT

The Department of Science and Technology (DOST), the Department of Environment and Natural Resources (DENR), and the DA through the BAR are among the 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. Under DOST, the Philippine Council for Agricultural Resources, Research, and Development has a number of researchers working on these topics. Through the BAR, meanwhile, spending on agricultural research for national programs on rice, corn, and high-value crops has grown substantially in recent years. Still, the research system of the Philippines remains fragmented and lacks synergy among institutions in terms of identifying shared research priorities [6].

FINANCING

There are also various financial institutions in the Philippines that provide support for climate change adaptation. The Philippine Crop Insurance Corporation (PCIC), for example, is a DA-affiliated agency that provides insurance protection for corn, rice, and other crops against losses resulting from natural disasters, pest infestations, or plant diseases. Coverage typically protects farmers for up to 120% of the cost of production inputs. Not all farmers can access insurance, however. Some are not properly enrolled in the Registry System for Basic Sectors in Agriculture, while others are entirely unaware of its existence.

The Land Bank of the Philippines is also a formal provider of financial services for the agricultural sector. Through its Agricultural Credit Support Project and Agrarian Production Credit Program (APCP), the bank provides loans and financing to farmers. The APCP is a joint credit program with the Department of Agrarian Reform to provide financing to newly-organized Agrarian Reform Beneficiary Organizations and to farmer organizations that would traditionally be ineligible to access loans from commercial banks. 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 Program with an interest rate of 10-12%, but accessing it requires Securities and Exchange Commission/Cooperative Development Authority SEC/CDA registration with a land title and other business documents. Other banks in Mindanao accessed by farmers include Peoples of CARAGA, Cantilan, and First Valley Bank, although these institutions are characterized by stricter loan applications compared to government-owned or associated banks. Private banks often have a number of other conditions, including higher collateral requirements, with which farmers struggle to comply.

The Agricultural Credit Policy Council (ACPC) assists the DA in synchronizing all credit policies and programs in support of the DA's priorities. Under ACPC and closely related to the Agricultural and Fisheries Financing Program of the Land Bank of the Philippines, the Climate Change Adaptation Financing Program (CCAFP) aims to encourage the adoption of climate change adaptation practices and technologies. It aims to help agricultural households cope and adapt to the adverse effects of climate change through the provision of loans for climate change-resilient practices and technologies.

Another program under the ACPC is the Production Loan Easy Access, a special credit facility of the program for Unified Lending to Agriculture. Eligible borrowers include farmers or fishers engaged in agri-fishery production. Loan limits are typically PHP 50,000 (USD 923), but vary depending on the project requirements and the repayment capacity of borrowers as evaluated by the lending conduit.

Finally, the Survival & Recovery (Sure) Assistance Program serves as a quick-response, post-disaster support facility of the ACPC. It offers interest-free loan assistance of up to PHP 25,000 (USD 461) for calamity-affected small farmers and fishers and their households. The program's service area is limited to places "under a state of calamity" as determined by the DA and/or LGUs. It has initial funding of PHP 100 million (USD 1.8 million) with an additional PHP 1 billion (USD 18.5 million) commitment from the president.

SYNTHESIS AND OUTLOOK

Agriculture in Mindanao faces a considerable threat from the impacts of climate change. Droughts and heavy rains are the most significant hazards experienced by farmers, affecting actors across the yellow corn, coffee, and cacao value chains, three major sources of income and livelihoods for farmers in the Mindanao region. Cacao and coffee nurseries face mortality of seedlings and fertilizer non-absorption during droughts and heavy rains. Pests and diseases also proliferate during drought and rains. These key hazards also have an impact on processing, affecting the quality and prices of the three commodities along their value chains. Higher transportation and postharvest costs are often experienced by farmers during heavy rains due to poor road conditions and the need for additional drying and storage equipment.

To address these and other impacts, various adaptation options are available to stakeholders across these priority value chains. For yellow corn farmers, the key on-farm adaptation practices are diversified farming systems, crop rotation, and contour farming. Other adaptation options include water impounding, rain gathering, and seeking alternative livelihoods. Coffee farmers may adopt contouring and terracing as on-farm adaptation strategies, especially in high-elevation areas. These strategies help hold water, prevent or reduce erosion, and preserve soil fertility. Intercropping and diversified farming, deep hole planting, reforestation, and watershed management are additional adaptation options for coffee farmers. Cacao farmers may adopt sprinkler systems to combat the impacts of drought, along with mulching, water impounding, crop insurance, and reforestation.

Certain factors, however, hinder farmers and stakeholders from adopting these adaptation strategies, including informational, behavioral, financial, and institutional barriers. Low awareness of climate-smart techniques and a lack of climate information services remain a key challenge in the region. There is also considerable resistance to the adoption of new farming and management practices by more traditional, aging farmers who are sometimes unconvinced about the benefits of climate-smart interventions. A lack of financial capital is also a major challenge given that adaptation for some elements of these commodity value chains—like postharvest storage and processing facilities—will involve large-scale infrastructure investments that are out of reach for actors unable to access sufficient financing. Finally, while government agencies like the DA, the Climate Change Commission, the Provincial Agricultural Office, and Local Government Units all support these value chain actors in different ways, their interventions can be uncoordinated and, at times, biased towards certain communities.

With proper planning and implementation of adaptation options. Value chain actors in Mindanao can greatly improve their resilience to the impacts of climate change, especially droughts and heavy rains. Beyond expanding financial support to farmers and other actors in these critical supply chains, improved information dissemination can better inform and sensitize farmers and stakeholders about likely climate impacts, potential adaptation options, and government support options. Coordination among key actors in the value chain, government agencies, NGOs, and the private sector will be necessary for adaption success.

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