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Culprit and Victim: Scenarios for Philippine Agriculture amidst Climate Change

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Abstract

The study explores the complex role of Philippine agriculture, both as a contributor to and a victim of climate change. The agriculture sector, responsible for 23 percent of the country′s greenhouse gas (GHG) emissions, simultaneously faces severe losses from extreme climate events, accounting for 60 percent of disaster-related damages. This study aims to assess the impact of climate change on Philippine agriculture, evaluate mitigation and adaptation options, and formulate effective policy recommendations to foster resilience and sustainability. Scenarios are analyzed using a computable general equilibrium model to examine different pathways for adapting to and mitigating climate change impacts on agriculture, framed as a) baseline; b) intensified adaptation; and c) combined adaptation and mitigation scenarios.

The findings reveal that without enhanced interventions, Philippine agriculture is at risk of long term supply and consumption reductions, and therefore greater vulnerability. Meanwhile, adoption of intensified adaptive and mitigation measures shows potential for improved resilience, increased productivity, and contributions to national climate commitments, at fairly modest intervention costs.

The policy recommendations emphasize proactive climate action in agriculture that aims to enhance adaptation while contributing to mitigation efforts. Accurate GHG emissions estimates across sectors, especially agriculture, are crucial for targeted policies. Climate adaptation measures must be prioritized to ensure sustainable production amid growing climate risks, despite potential uneven outcomes across sub-sectors. Introducing cost-effective mitigation technologies, such as Alternate Wetting and Drying for rice and improved manure management, can reduce emissions without compromising productivity. The Philippines should integrate agriculture into its unconditional Nationally Determined Contributions (NDC), focusing on technologies that offer sustainability while maintaining sectoral competitiveness and food security.

Keywords: climate change, Philippine agriculture, mitigation, adaptation, greenhouse gas emissions, GHG, nationally determined contributions, sustainable farming, resilience, climate-smart agriculture, food security, emission reduction, alternate wetting and drying, manure management, climate adaptation policy, agricultural sustainability, Department of Agriculture, climate change expenditure tagging, Climate Change Commission, Paris Agreement

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1. Introduction

Agriculture, bearing significant losses worth PHP 44 billion annually from 2012-2022 due to adverse weather and climate impacts, accounts for 60 percent of the Philippines' total disaster-related property damages (PSA 2023). Despite the Philippines contributing only 0.49 percent to global greenhouse gas (GHG) emissions, the agriculture sector's 23 percent share of the country's emissions highlights its dual role as both victim and contributor to climate change. This is in the context where energy and transport sectors contribute 30 percent and 13 percent, respectively, to the national GHG emissions (Crippa et al 2023). Even as agriculture seeks exemption from cost-inducing limits to GHG emissions, it is difficult to see how the country's overall Nationally Determined Commitments (NDCs) under the Paris Agreement can be achieved without bringing agriculture into the equation for unconditional commitments.

The Philippine Development Plan (PDP) Chapter 15 proposes a transition to a green economy, emphasizing innovative low-carbon technologies in agriculture and integrated climate risk planning for agriculture, fisheries, and forestry sectors. Despite the critical role of these sectors, they are often overlooked in climate change research. This study is highly relevant in view of the Climate Change Act (RA 9729), which mandates the mainstreaming of climate change in government policy formulations, including agricultural policy; and the PDP, which, as mentioned, commits to a green transition for the economy, including for agriculture. Consistent with this, the current Secretary of Department of Finance (DOF) has expressed interest in adopting policy instruments towards this green transition, even considering carbon taxes (DOF 2024).

This study addresses the following policy questions:

1. What are the potential impacts of climate change on Philippine agriculture? What are its current and potential contributions to climate change?
2. What options should government invest in to adapt to the effects of climate change in agriculture? What kinds of policies and investments should the government undertake to mitigate GHG emissions from agriculture?
3. What are the likely impacts of undertaking these options?
4. Which options should government pursue in relation to climate adaptation and mitigation for agriculture?

Climate change affects the supply of agricultural goods, thereby altering resource allocation in the economy through supply and demand interactions. Similarly, implementation of climate adaptation and mitigation measures impact agricultural supply, while also imposing fiscal cost. These supply and demand impacts can be captured in scenario analysis using computable general equilibrium (CGE) modeling. Based on the scenario analysis, the study will address the fourth question, making recommendations for policy going forward.

2. Climate change: impacts and causes

Climate Change refers to the long-term change in climate, based on average temperature, rainfall, and frequency of extreme weather events (NICCDIES n.d.). Before discusses its relationship to agriculture, we first cover the basic science behind climate change.

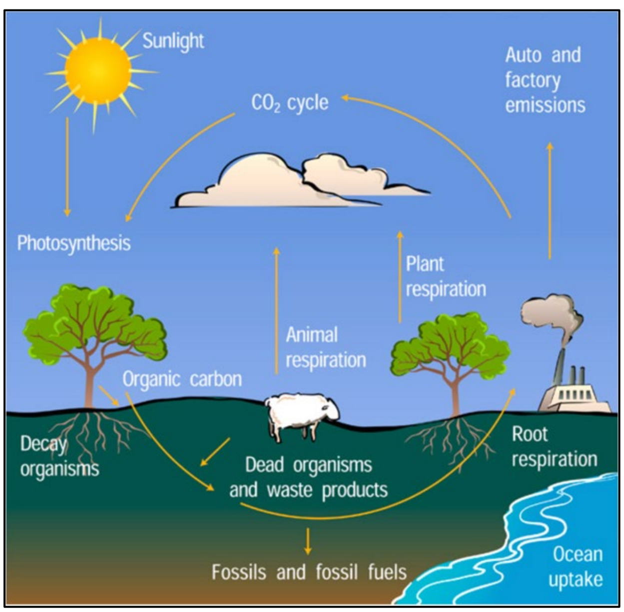
2.1 What Do We Know About Climate Change?

Some argue that climate change is a natural phenomenon, as observed throughout Earth's history before human existence. However, it is by now well established the increase in global temperatures since the industrial period is very likely caused by anthropogenic greenhouse gas (GHG) emissions. Increased human activities, such as burning of fossil fuels, have contributed to changes not only in global temperatures but also in sea level rise, wind patterns, and other aspects of the climate (IPCC 2007a). By the time of the IPCC's Sixth Assessment Report, human activities were unequivocally identified as a principal cause of global warming, with temperatures rising 1.1°C above pre-industrial levels (1850–1900) during the period 2011–2020 (IPCC 2023).

"Greenhouse gases" are so-called because their presence in the atmosphere essentially slows the rate at which heat coming from the sun and striking the earth radiates back out into space. The warming of the atmosphere leads to warming of land surfaces, oceans, and has other impacts like changing of the climate. The key changes in the climate are observed in the temperature, rain and snowfall patterns, extreme weather events (e.g. cyclones). Other impacts are observed on the physical landscape (rising sea level due to melting of glaciers) and biosphere (changes in habitat, migration patterns, or extinction of some species) University of California Museum of Paleontology. (n.d.c).

The origin and role of GHGs in climate change in turn requires an understanding of the carbon cycle (Figure 1). *Carbon cycle* is a process through which carbon is exchanged and distributed among the Earth's oceans, atmosphere, soil, and living organisms, which can occur over periods ranging from just hours to millions of years.

Figure 1: The carbon cycle



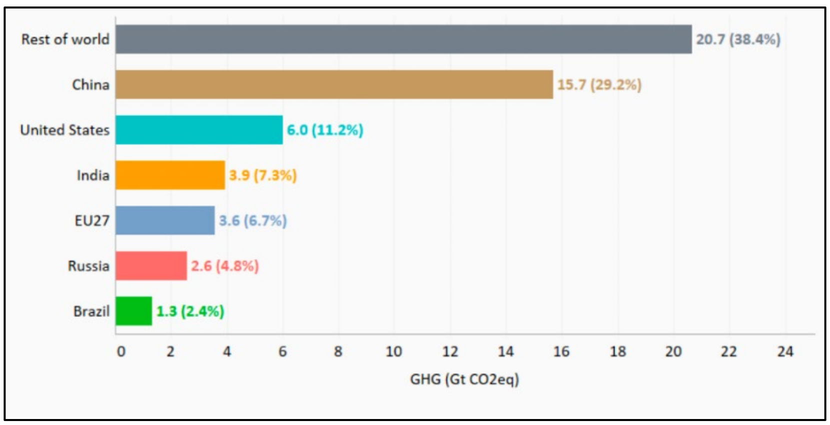
Source: University Corporation for Atmospheric Research (n.d.)

Carbon takes the form of carbon dioxide when it is in the atmosphere. It is absorbed by plants during photosynthesis. Animals and humans consume plants and absorb carbon contained in them. Carbon goes back to the atmosphere when animals and humans breathe out (process of respiration) and goes back to the soil when they excrete their waste. When organisms die and decompose, the carbon in their bodies return to earth. After millions of years, these remains turned into fossil fuels such as coal, natural gas, and petroleum. However, since the Industrial Revolution, humans found that burning fossil fuel can produce energy to power machines. The return of carbon from the ground back to the atmosphere has therefore dramatically increased, hundreds or even thousands of times faster than the rate of burying the carbon to the ground (University of California Museum of Paleontology, n.d.).

Apart from carbon dioxide, methane and nitrous oxide are the other major greenhouse gases being measured annually by countries and global bodies like the Intergovernmental Panel on Climate Change (IPCC). To have a common scale for aggregating GHG emissions, they are converted into their carbon dioxide equivalent (IPCC 2021 and Greenhouse Gas Protocol 2024).

Comparing the levels to 1850-1900 (pre-industrial period), the GHG concentrations have risen much faster in recent decades. China, India, Russia, Brazil, the European Union, and the United States are the largest emitters (Figure 2). The share of the Philippines in the total global GHG emissions in 2020 was only 0.5 percent. On a per capita basis (Figure 6), the country with the highest GHG emissions over the period 1970 to 2022 is United States, followed by Russia; although their trends appear to be going down (Crippa et al 2023). China surpassed average per capita global GHG emissions in mid-2000s, and has been on an increasing trend ever since.

Figure 2: GHG emissions and contribution of the major emitting economies and the rest of the world, 2022(in Gt CO2-eq)



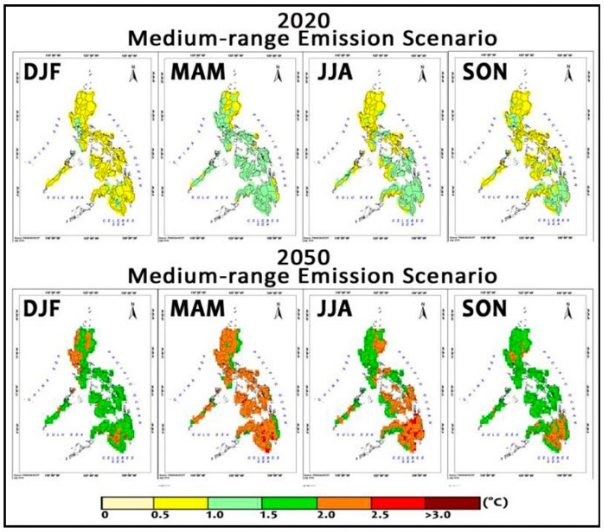
Source: Crippa et al (2023 p.5)

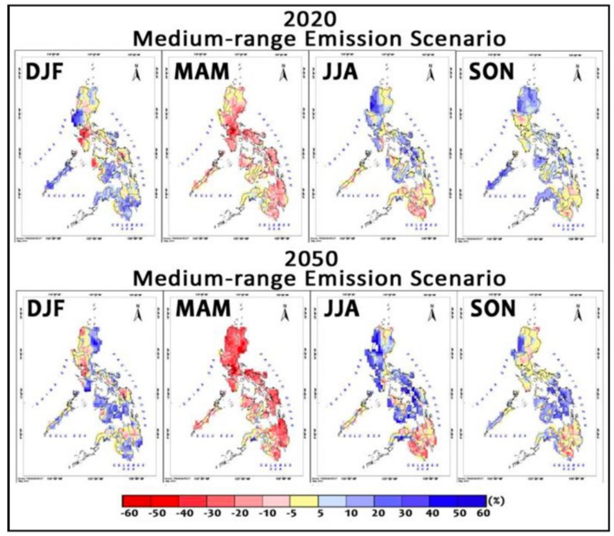
2.2 Climate change and Agriculture

The Philippines is projected to have hotter temperature and more variable rainfall. Figure 3 shows two sets of climate maps of the Philippines under a medium-range emission scenario for 2020 and 2050 based on PAGASA's projection. Seasonal temperature changes (left) and rainfall variations (right) are shown across different periods: DJF (December-February), MAM (March-May), JJA (June-August), and SON (September-November). The maps illustrate projected warming across the country by 2050, especially during MAM and JJA, as well as notable shifts in precipitation patterns, with significant increases and decreases in rainfall depending on the season and region (PAGASA 2011).

Figure 3: Changes in temperature and rainfall, 2020 vs. 2050

Changes in temperature (in degrees Celsius, °C)	Changes in rainfall (in % increase or decrease)

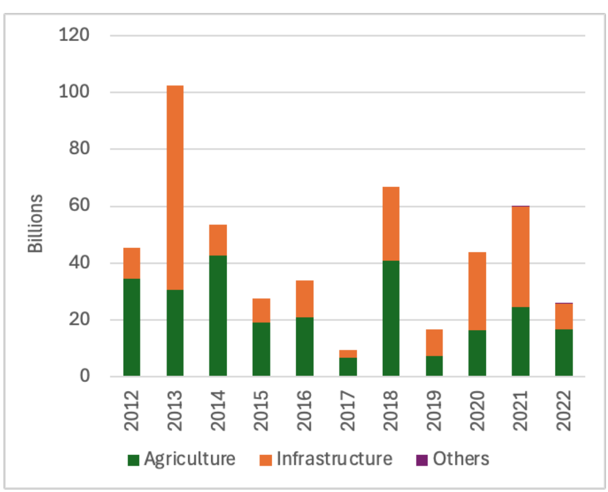




Source: PAGASA (2011, p.25)

The Philippines experiences catastrophic natural calamities almost annually and climate-related disasters are expected to worsen. As an archipelagic island country, the Philippines is exposed to various climatological, hydrological, and meteorological risks. For example, in a given year, an average of 20 tropical cyclones enter the Philippine Area of Responsibility (CCC and DENR 2023). Many of these cyclones wreak havoc in the country leaving massive damage to lives and property. Figure 4 shows the damage to properties data from 2012 to 2022 covering agriculture, infrastructure, and other types of properties. On average, damages amount to PHP 44 billion annually. Agricultural damages account for 60 percent, while followed by Infrastructure at 40 percent (PSA 2023).

Figure 4: Value of damages due to natural extreme events, 2012-2022, in PHP billions



Source: PSA (2023)

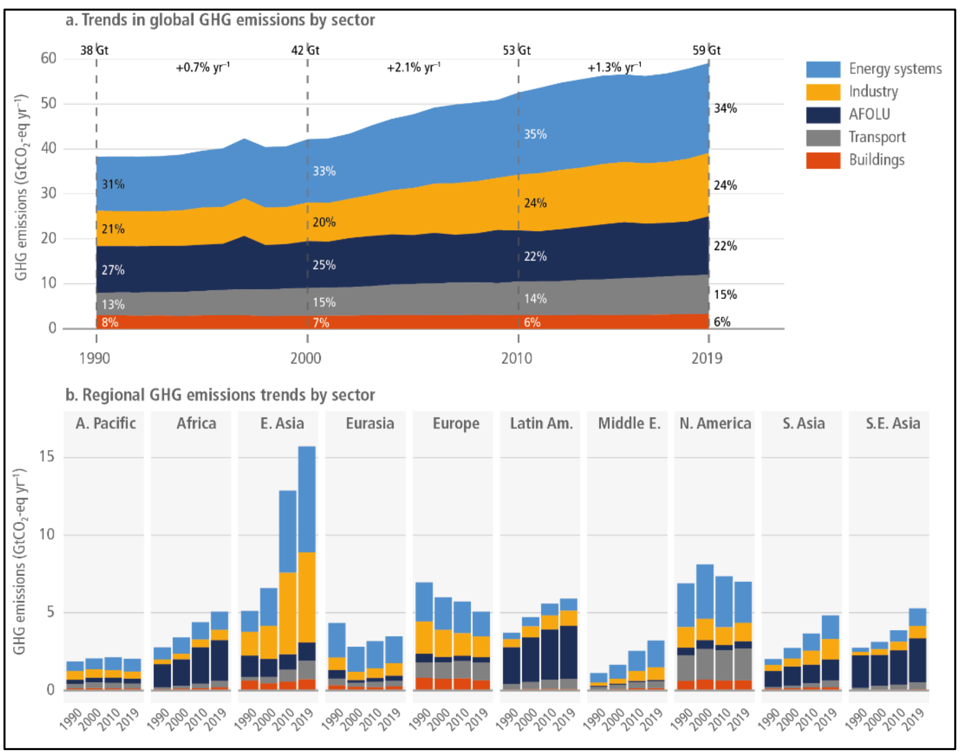
Extreme weather events like super typhoons are expected to be more frequent, stronger, and be experienced in new locations and in different timing due to the changing climate (IPCC 2021b). Thus, it is also anticipated that bigger damages will be incurred with more frequent and stronger typhoons visiting the Philippines.

Impacts of climate change on agriculture varies by location. Figure 9 illustrates the observed climate change impacts on human and ecosystem systems globally and regionally. It highlights adverse effects on water availability, food production, health, infrastructure, and ecosystems, with varying levels of confidence in attribution to climate change. In Asia, climate change has adverse and positive impacts on physical water availability and agriculture/crop production. Livestock and fisheries in Asia is projected to suffer due to climate change.

In the Philippines and Indonesia, significant agricultural challenges include delayed harvests, lower yields, poorer quality, more pests and diseases, stunted growth, livestock deaths, and reduced farm income (Stevenson et al., 2013 as cited in Shaw et al 2022). In terms of fisheries, South and Southeast Asia, including the Philippines, Thailand, Malaysia, and Indonesia, are projected to face reduced productivity due to climate change, with rising temperatures of about 2°C by 2050 (Nong, 2019; Barange et al., 2014 as cited in Shaw et al 2022).

On the other hand, the agriculture sector is also among the top emitters of GHGs. On a global scale, agriculture, forestry, and other land use (AFOLU) sector used to be the second largest in 1990 at 27 percent of global emissions, following Energy sector at 31 percent (Figure 6). After three decades, AFOLU decreased to being third highest emitter at 22 percent. Energy systems and Industry sector were at 34 percent and 24 percent, respectively. Disaggregating by region, Southeast Asia, Africa, and the Latin America are observed to have increasing emissions from AFOLU sector (Parmesan et al 2022).

Figure 5: Trends in global GHG emissions by sector and by region, 1990-2019



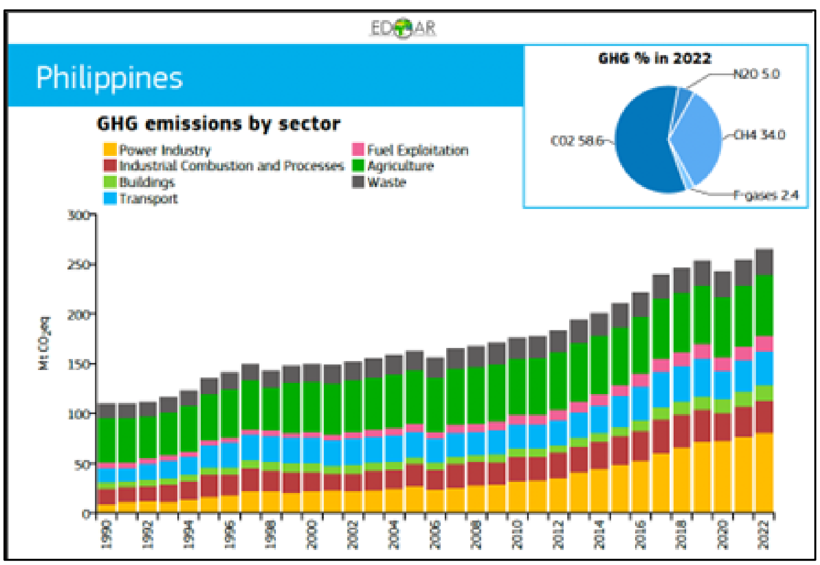
Source: Parmesan et al (2022, Figure 2.13)

Agriculture is a direct source of greenhouse gases. Smith et al. (2007 as cited in Sajise et al 2019)) highlighted the primary GHGs emitted by the agricultural sector as: carbon dioxide (CO2), which arises from microbial decay or combustion of plant materials and soil organic matter; methane (CH4), produced by the digestive processes of ruminant livestock, manure storage, and rice cultivation in waterlogged conditions; and nitrous oxide (N2O), generated from the transformation of nitrogen in soil and manure, especially under moist conditions and with surplus nitrogen (Sajise et al 2019).

It is important to note that the energy sector supports other industries, which may lead to an underestimation of greenhouse gas emissions in sectors like AFOLU (Agriculture, Forestry, and Other Land Use) and Industry. Apart from the looking at agriculture together with Forestry and Land Use, some studies also look at the agrifood system. According to FAO (2022), the share of agrifood system in total emissions dropped from 38 percent in 2000 to 31 percent in 2020. This was largely due to faster growth in non-food emissions. The share of farm-level emissions in total agrifood systems emissions would account for nearly half, followed by pre- and post-production processes at 30 percent, and land use change at 20 percent (FAO 2022).

For the Philippines, Figure 7 shows that over the period 1990 to 2022, the GHG emissions of the country has more than doubled. In 2022, the Philippines' GHG emissions was at 265 Mt[1] CO2 equivalent. Among the GHG types, more than half (60%) is CO2, followed by methane at 34 percent, and nitrous oxide and F-gases at 5 percent, and 2.4 percent, respectively. Figure 11 also shows that the share of the power sector has increased significantly, while the agriculture (second highest) has been consistently large. Agriculture sector dominates the emissions of Methane and nitrous oxide. Methane (CH4) and nitrous oxide (N2O) are potent greenhouse gases, with CH4 primarily emitted from agricultural practices like livestock and rice cultivation and from oil and gas sector leaks, while N2O largely arises from the use of both synthetic and organic fertilizers in agriculture (Ritchie et al 2022).

Figure 6: Philippines' GHG emissions by sector, 1990-2022, in MtCO2eq



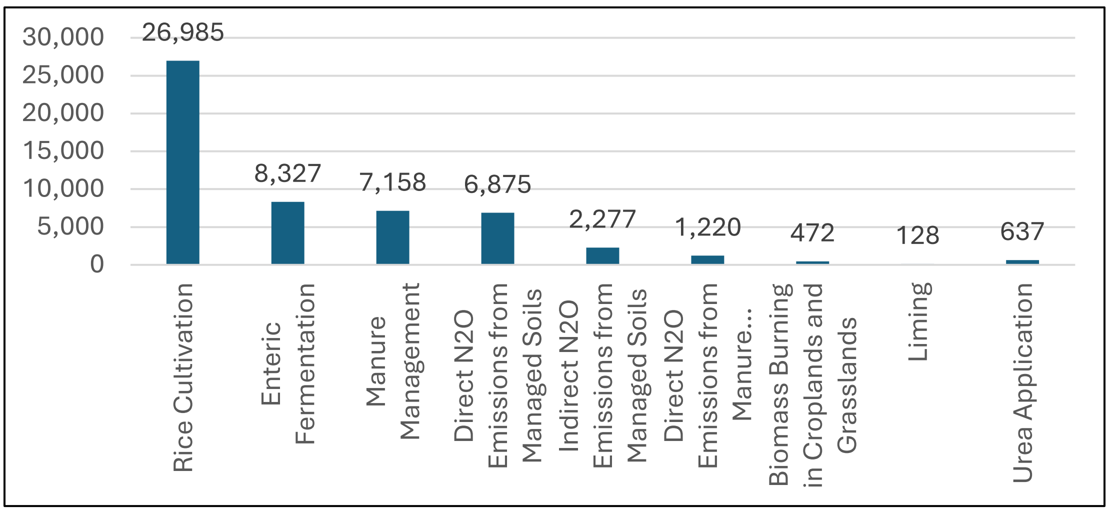
Source: Crippa et al (2023)

[1] Megatonnes (106 tonnes or 1 tera gramme) mass of a given (greenhouse gas) substance (Crippa et al 2023)

Figure 8 shows the top three contributors of 2020 emissions under the agriculture sector, which are rice cultivation (50%), enteric fermentation (15%), and waste management (13%). The dominance of rice in GHG emission contrasts with the global pattern, where ruminants are the main contributors. In rice cultivation, methane is emitted when bacteria in places where there is no oxygen break down organic materials (like rice straw residue) in flooded rice fields (see Figure 15). Methane is primarily released through rice plants during the growing season (Greenhouse Gas Protocol 2022). The Philippines has the highest methane emission intensity compared to its Asian neighbors (see Figure 20). Nitrous oxide, another GHG type, is released when rice plants have poor absorption of nitrogen-based fertilizers, which are overused by farmers usually (Umali-Deininger 2022). To address this, the International Rice Research Institute (IRRI) developed the CF-Rice, a carbon footprint calculator for rice products (IRRI, n.d.).

Enteric fermentation on the other hand is a natural process that occurs in the stomachs of ruminant animals, such as cattle, sheep, and goats, during digestion (See Figure 16). These animals have microorganisms in their stomach (rumen) that break down plant materials into simpler molecules for absorption. Unfortunately, this process produces methane as a by-product, which is then released into the atmosphere when the animals burp or exhale (IPCC 2022).

Figure 7: GHG Emissions by agriculture subsector, in Gigagrams of CO2 equivalent (Gg CO2e)



Source: PSA (2024)

The third highest GHG emission under the agriculture sector comes from animal waste/manure management. Livestock urine and manure release methane and nitrous oxide when they break down without oxygen, like in manure piles or ponds. Nitrous oxide is formed when nitrogen in the waste goes through a process in wet, airless conditions, which often happens on large farms with lots of animals, such as dairy farms and pig or chicken farms (Department of Primary Industries and Regional Development 2021).

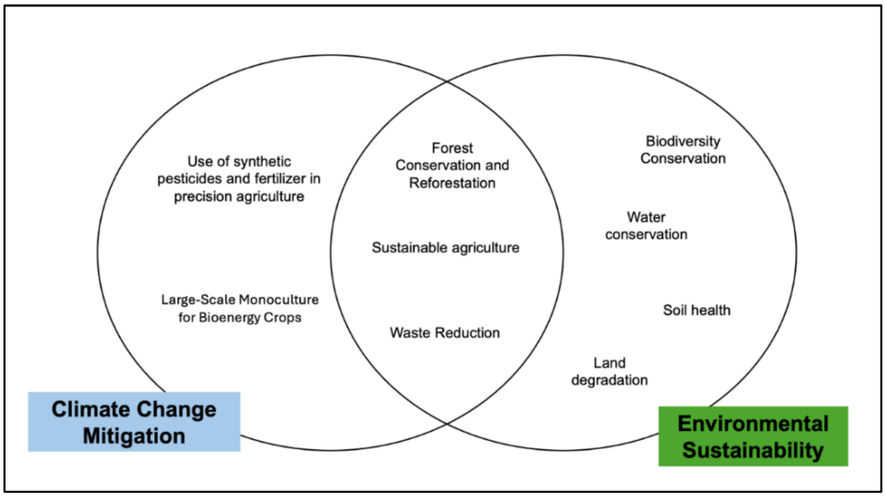
3. Agriculture-related mitigation and adaptation technologies

3.1 Overview and conceptual Framework

Adaptation focuses on adjusting systems and societies to the impacts of climate change, helping them cope with its adverse effects (IPCC, 2022). *Mitigation* refers to actions aimed at reducing greenhouse gas emissions or enhancing carbon sinks, directly contributing to environmental sustainability (IPCC, 2022).

There is a significant overlap between efforts to address climate change and broader environmental sustainability goals (Figure 8). Pursuing environmental sustainability through resource conservation, pollution reduction, and habitat protection inherently impacts climate change mitigation by lowering carbon emissions and protecting carbon sinks like forests and wetlands. While mitigation can be costly upfront, the long-term benefits of integrating sustainability measures lead to more resilient ecosystems and lower emissions, which support both climate goals and sustainable development. Climate adaptation is also closely linked to disaster resilience, especially in countries like the Philippines, which faces both climate-related hazards (typhoons, floods) and non-climate events (earthquakes, volcanic eruptions)

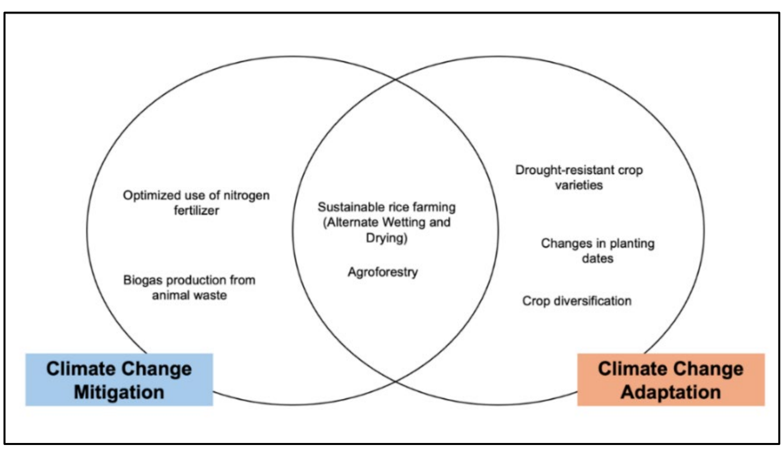
Figure 8: Venn Diagram of Climate Change Mitigation and Environmental Sustainability



Source: Authors' illustration

Combining mitigation and adaptation strategies in agriculture addresses both current and future climate risks. Techniques like Alternate Wetting and Drying (AWD) in rice production reduce water usage and methane emissions, while agroforestry and reforestation sequester carbon, enhance biodiversity, and provide alternative income, thereby increasing the climate resiliency of agriculture (Figure 13).

Figure 9: Venn Diagram of Climate Change Mitigation and Adaptation



Source: Authors' illustration

Taking a combined approach of adaptation with mitigation offers greater long-term benefits by addressing both the current impacts of climate change and reducing future risks through lower emissions. Examples of "Adaptation-Only Efforts" include building sea walls, enhancing disaster preparedness). While necessary, they do not address the underlying causes of climate change, and the costs may escalate as climate impacts worsen. Meanwhile, "Adaptation with Mitigation" not only builds resilience to current climate risks but also addresses future risks by cutting emissions. Investments in mitigation may be costly initially but reduce the need for extensive future adaptation by slowing the pace of climate change. Initiatives like reforestation enhance both emission reductions and climate resilience, which offers a more cost-effective solution in the long run.

3.2 Adaptation strategies

UNEP published another publication focusing on adaptation measures for the agriculture sector (2011). The UNEP guidebook outlines key adaptation technologies for agriculture to address climate change impacts, organized into six main areas (Clements et al 2011):

1. Planning for Climate Change and Variability: Technologies and practices include climate change monitoring systems, seasonal to interannual prediction, decentralized community-run early warning systems, and index-based climate insurance.
2. Sustainable Water Use and Management: Key technologies include sprinkler and drip irrigation, fog harvesting, and rainwater harvesting, which enhance water efficiency without reducing yields.
3. Soil Management: These methods prevent soil degradation without reducing productivity and are generally cost-effective. Techniques like slow-forming terraces, conservation tillage, and integrated nutrient management.
4. Sustainable Crop Management: These strategies support production and resilience without negatively impacting yields. Technologies such as crop diversification, drought-tolerant varieties via biotechnology, ecological pest management, and improved seed and grain storage help crops adapt to climate variability.
5. Sustainable Livestock Management: These strategies help maintain livestock health and productivity without reducing output. Technologies include selective breeding through controlled mating and improved disease management.

Adaptation measures in the fisheries sector vary between capture fisheries and aquaculture. For capture fisheries, adaptation strategies focus on improving resilience to climate change by enhancing management systems and promoting sustainable fishing practices. One key measure is the implementation of ecosystem-based management, which helps adjust fishing practices to account for shifting fish stocks due to changing water temperatures and ocean conditions. Additionally, improving monitoring and early warning systems for extreme weather events can help protect fisheries and reduce economic losses. Diversifying the livelihoods of fishing communities is also crucial to increase resilience, allowing communities to rely on multiple sources of income when fish stocks are affected by climate change. Strengthening international cooperation in managing transboundary fish stocks is another important step, especially as fish species migrate due to changing ocean conditions (Barange et al 2018).

In aquaculture, adaptation measures emphasize increasing the sector's ability to cope with environmental changes, such as rising water temperatures and altered precipitation patterns. Improving water management systems, such as recirculating aquaculture systems (RAS), can help reduce the vulnerability of aquaculture operations to changes in water availability and quality. Selecting more resilient species or genetically improving farmed species to withstand warmer temperatures and disease outbreaks is another critical measure. Additionally, enhancing biosecurity practices to prevent and control diseases that are likely to increase with climate change is essential. Integrating aquaculture with other farming practices, such as agro-aquaculture, can also increase resilience by creating more sustainable and diversified systems that can better withstand climate-related stressors (Barange et al 2018). Daw et al (2009) summarize additional adaptation measures for mitigating climate change impacts on fisheries (Annex A).

3.3 Mitigation strategies

In 2012, UNEP compiled a guidebook outlining various technologies for climate change mitigation in the agricultural sector. These technologies, aimed at reducing greenhouse gas emissions, enhance crop productivity, reduce reliance on synthetic fertilizers, and lower water consumption. The guidebook provides detailed descriptions of both mature and emerging technologies, addressing their advantages, disadvantages, and potential barriers to dissemination. Below is the summary of these technologies; for more detailed information on each technology type (Uprety et al 2012).

In crop management, Agricultural Biotechnology for Carbon Sequestration boosts yields and carbon storage but faces high costs and GMO resistance. Cover Crop Technology improves soil health and is cost-effective but requires practice changes. Nitrogenous Fertilizer Management reduces emissions and costs but needs careful application and training. Organic Nitrous Oxide Mitigation lowers emissions but may reduce yields, with organic practices requiring expertise. Nitrification Inhibitors reduce emissions and increase yields but are costly. Slow-release Fertilizers lower emissions but have high initial costs. Conservation Tillage reduces labor and boosts soil carbon but may increase herbicide use. Biochar improves soil health and stores carbon but is expensive. Efficient Irrigation Systems enhance water use and can increase yield but have high setup costs (Uprety et al 2012).

Rice Production Management cuts methane emissions but requires substantial changes and infrastructure (Uprety et al 2012). One example is the alternate wetting and drying (AWD) technology. AWD is considered an effective mitigation measure, though its impact on yield depends on soil type and proper implementation of the technique (Uprety et al. 2012; Gao et al. 2024). Some studies show that properly implemented safe AWD, which involves maintaining a 15 cm below-soil water level threshold, does not reduce yields and may even increase them under certain conditions. This highlights AWD's potential as an effective rice irrigation strategy (Allen and Sander 2019).

In livestock management, Improved Feeding Practices and Feed Optimization reduce methane emissions and improve productivity but require changes in feed preparation and may raise costs. Genetically Modified Rumen Bacteria could cut methane but faces regulatory and public hurdles (UNEP 2012). In manure and biosolid management, Covered Manure Storage reduces methane and retains nutrients but is expensive to install. Biogas Digesters convert waste into energy but need steady management and maintenance (Uprety et al 2012).

An FAO report outlines mitigation options for the fisheries sector. Mitigation measures in the fisheries sector vary between capture fisheries and aquaculture. In capture fisheries, reducing fuel consumption is a key strategy. This can be achieved by improving vessel efficiency through better engine design, larger propellers, and optimized vessel shapes. Another measure involves reducing vessel speeds, which not only cuts down on fuel use but also decreases emissions. Additionally, shifting towards more sustainable fishing practices and optimizing gear to reduce bycatch can minimize the environmental impact of capture fisheries. The use of renewable energy on vessels, such as solar or wind power, has also been identified as a potential long-term mitigation strategy (Barange et al 2018). Agriculture is also a source of renewable energy. Biogas facilities for example are largely self-sufficient and able to provide steady energy (Pawlowski et al 2020). Other examples are biofuels such as ethanol from sugarcane and diesel from coconut.

In aquaculture, improving feed conversion ratios is a primary focus for reducing emissions. The industry can also adopt renewable energy sources, such as solar or wind, to power operations, and use energy-efficient equipment. Additionally, integrated multi-trophic aquaculture systems, where different species are farmed together to maximize resource efficiency, can help reduce the sector's overall carbon footprint. Other measures include improving water-use efficiency and utilizing recirculating aquaculture systems (RAS), which require less water and energy compared to traditional methods. By adopting these strategies, aquaculture can significantly lower its greenhouse gas emissions while maintaining or improving productivity (Barange et al 2018).

A cost-efficiency analysis of the Nationally Determined Contribution (NDC) Implementation Plan shows that agriculture is among the most cost-effective sectors for GHG reduction, with a cost of 4.87 mUSD per mmtCO2e, second only to the Industrial Processes and Product Use (IPPU) sector. In contrast, sectors like transport require much higher investments for similar emissions reductions, at 488.93 mUSD per mmtCO2e. This highlights the financial prudence of focusing on agriculture, particularly rice and livestock, for GHG mitigation (CCC and DENR, 2024). Some measures, such as Alternate Wetting and Drying (AWD) and nature-based solutions in livestock-manure management, show promising cost-efficiency. However, these estimates are indicative only, as cost data for several other solutions are not yet available (CCC and DENR 2023). Addressing climate change through a comprehensive sustainability approach ensures that both environmental and economic factors are prioritized. An intensified approach, combining sustainability and adaptation, involves implementing technologies and practices that enhance the resilience of agricultural systems.

3.4 Domestic measures related to climate change

Domestic policies

Since 1991, before the 1994 United Nations Climate Change Convention, the Philippines has actively combated climate change, including reducing GHG emissions. It established the Inter-Agency Committee on Climate Change and later ratified the Kyoto Protocol in 2003, which led to numerous climate-focused laws and policies (Tiongco, 2019) (Table 1).

In 2009, Republic Act (RA) No. 9729 otherwise known as **Climate Change Act** was enacted and was later amended by RA 10174 in 2011. The main features of the Climate Change Act of 2009 are: 1) the creation of the **Climate Change Commission**, which is an independent body tasked with coordinating and monitoring climate change-related programs across government agencies; 2) mainstreaming Climate Change into national, sectoral, and local plans and policies; 3) development of a Framework Strategy and National Action Plan to serve as guide for mitigation and adaptation efforts; 4) focus on vulnerable communities in climate adaptation efforts; and 5) integration with Disaster Risk Reduction. In the amended law, a People's Survival Fund was created to provide long-term financing for climate adaptation projects. The law also provided funding sources and creation of a PSF board under the Climate Change Commission to manage the said fund.

Table 1: National and local policies related to climate change and year of implementation

Legislation/Policy/Plan	Year
Creation of the Inter-Agency Committee on Climate Change	1991
Signing of the United Nations Framework Convention on Climate Change	1994
Ratification of the United Nations Framework Convention on Climate Change Ratification of the Kyoto Protocol	2003
Creation of the Presidential Task Force on Climate Change	2007

Legislation/Policy/Plan	Year
Enactment of the Climate Change Act (RA 9729)	2009
Creation of the Climate Change Commission (CCC)	
Formulation of the National Framework Strategy on Climate Change (NFSCC), 2011–2028	2010
Mainstreaming climate change in the Philippine Development Plan 2011–2016	
Enactment of the Philippine Strategy on Climate Change Adaptation; Disaster Risk Reduction and Management (DRRM) Act (RA 10121)	
Formulation of the National Climate Change Action Plan (NCCAP), 2011–2028	2011
Creation of Cabinet Cluster on Climate Change Adaptation and Mitigation	2012
Enactment of the People's Survival Fund Act (RA 10174)	
Mainstreaming guidelines on integrating disaster risk reduction and climate change adaptation concerns into the Environmental Impact Statement systems	2013
Mainstreaming climate change in the Department of Agriculture programs, plans, and budgets	
Development and implementation of guidelines in tagging/tracking government expenditures on climate change in the national budget process	
Guidelines in tagging/tracking climate change expenditures in the local budget (DBM-CCC-DILG JMC No. 2014-01)	2014
Institutionalizing Philippine Greenhouse Gas Inventory Management and Reporting System (Executive Order No. 174)	
Guidebook on the Formulation of Local Climate Change Action Plan (LCCAP) (Books 1 & 2) published by DILG-LGA	
Housing and Land Use Regulatory Board (DHSUD) publishes guidelines for mainstreaming climate change and disaster risks in comprehensive land use plans	2014
Joint Memorandum Circular issued to encourage LGUs to identify, prioritize, and tag climate change programs and projects in Annual Investment Programs	2015
DILG publishes Local Planning Illustrative Guide to include climate change considerations in Comprehensive Development Plans	2016
Ratification of the Paris Agreement	2017
DILG-LGA and CCC publish Enhanced LGU Guidebook on the Formulation of the LCCAP (Books 3 & 4)	
DBM adds Virtual Process Guide for Climate Change Expenditure Tagging in the annual Local Budget Memorandum	2020
Institutionalization of Climate Resilient Agriculture (DA Memorandum Circular 4)	

Sources: Tiongco (2019), Jose (2023), and DA (n.d.)

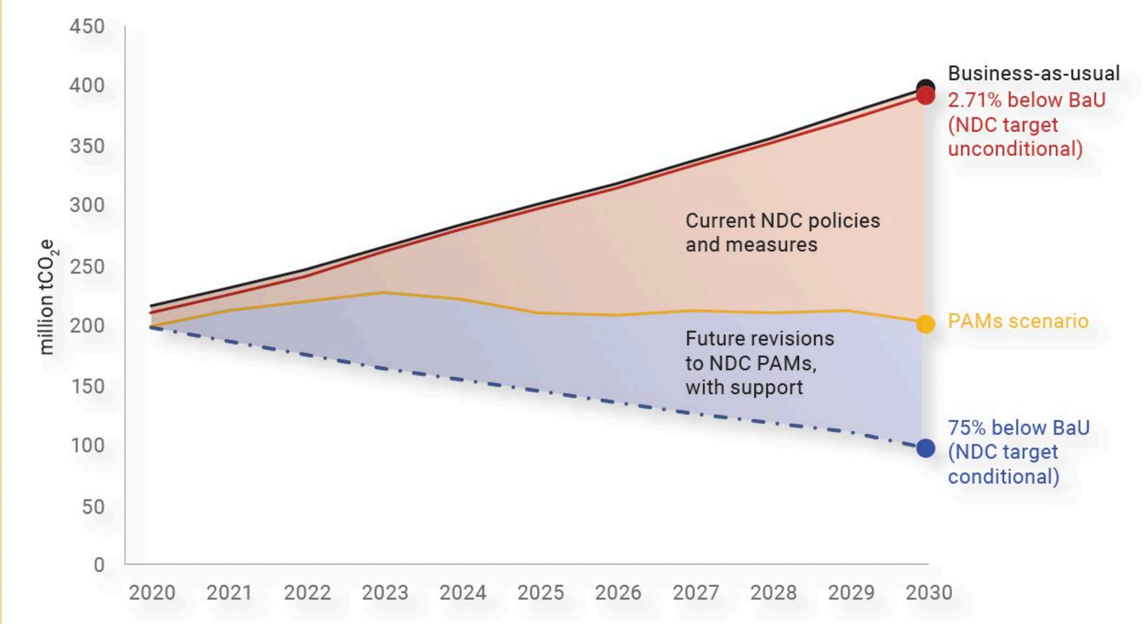
In 2010, National Framework Strategy on Climate Change (NFSCC) 2010-2022 was signed. It provides an overarching vision and principles for climate change planning and action (CCC 2010). The Framework aimed to guide national and sub-national development planning, including the Medium-term Philippine Development Plan (MTPDP) and Regional Development Plans. Within a year of its adoption, the National Climate Change Action Plan (NCCAP) was planned to be developed to outline specific strategies, which will help local government units prepare their Local Climate Change Action Plans (LCCAP).

By 2011, the National Climate Change Action Plan (NCCAP) was developed. The NCCAP translates the NFSCC into more concrete actions and strategies as it outlines the country's agenda for adaptation and mitigation from 2011 to 2028. Its goal is to enhance the adaptive capacities of both women and men, strengthen the resilience of vulnerable sectors and ecosystems to climate change, and pursue gender-responsive, rights-based sustainable development while maximizing mitigation opportunities. NCCAP focuses on seven thematic priority areas, namely, food security, water sufficiency, ecosystem and environmental stability, human security, climate-friendly industries and services, sustainable energy, and knowledge and capacity development (CCC 2011).

In 2021, the Climate Change Commission submitted the first Philippines' Nationally Determined Contribution (NDC) to UNFCCC. The NDC serves as a guide for the Philippines' long-term development towards climate resilience and a low-carbon future. It outlines the country's actions to contribute to the goals of the Paris Agreement, aiming to keep global temperature increases below 2°C and striving for 1.5°C. The NDC also seeks to promote economic development and industrialization while contributing to global climate stabilization efforts. In 2021, the Philippines submitted its NDC, committing to a 75 percent target for greenhouse gas (GHG) reduction and avoidance by 2030 (Figure 13). This commitment consists of 2.71 percent unconditional reductions, achieved through the nation's resources, and 72.29 percent conditional reductions, dependent on the Means of Implementation to be provided by developed countries (CCC n.d.).

The business-as-usual (BaU) scenario projects total emissions to reach 3,340 million metric tons of CO2 equivalent (mmtCO2e) from 2020 to 2030, based on the Philippine Development Plan (PDP) 2017–2022 and AmBisyon Natin 2040. However, due to the COVID-19 pandemic, actual emissions in 2020 were lower than expected, with similar deviations forecasted for 2021 and 2022. The gap between projected and actual emissions for the first three years is estimated at 1 percent to 1.5 percent of the baseline (CCC and DENR 2023).

Figure 10: The Philippines NDC under a Business-as-Usual Scenario



BaU = business-as-usual, NDC = nationally determined contribution, PAMs = policies and measures. tCO_2e = ton of carbon dioxide equivalent.
Source: Government of the Philippines.

Source: CCC and DENR (2023)

In 2013, the Department of Agriculture (DA) issued a memorandum titled "Mainstreaming Climate Change in the DA's Programs, Plans, and Budgets", which establishes seven Systems-Wide Programs to address climate change in agriculture and fisheries. The seven Systems-Wide Programs are 1) Mainstreaming Climate Change – Adaptation and Mitigation Initiatives in Agriculture; 2) Climate Information System; 3)

Philippine Adaptation & Mitigation in Agriculture Knowledge Toolbox; 4) Climate-Smart Agriculture Infrastructure; 5) Financing and Risk Transfer Instruments on Climate Change; 6) Climate-Smart Agriculture & Fisheries Regulations; and 7) Climate-Smart Agriculture Extension System (DA n.d.a).

While the agricultural sector in the Philippines has not committed to any unconditional emission reduction targets, an estimated 211 million metric tons of CO2 equivalent (mmtCO2e) reductions can be realized through various policies and measures (PAMs). The emissions could be further reduced due to offsetting through vast coconut plantation activities in 3.6 million hectares. Key mitigation interventions include alternate wetting and drying of rice fields, the use of renewable energy, improved livestock manure management through biodigesters, and the application of precision agriculture. These measures aim to reduce methane and nitrous oxide emissions, with significant investments allocated, such as USD 53 million under the 2023 General Appropriations Act for livestock manure management. Overall, the agricultural sector focuses on high-impact interventions to reduce emissions and promote sustainable practices (CCC and DENR 2023).

The NEP 2024 allocates PHP 350 million for mainstreaming Climate Resilient Agriculture (CRA) in regional programs and projects, and PHP 150 million for the Balik Probinsya, Bagong Pag-asa Program, both focused on developing climate-resilient crop and livestock production systems and technologies under the DA OSEC.

Adaptation and Mitigation Initiative in Agriculture (AMIA). The Adaptation and Mitigation Initiative in Agriculture (AMIA), the Department of Agriculture's flagship climate change program since 2013, aims to build climate-resilient livelihoods and communities in the agriculture and fisheries sectors. Using a Climate Resilient Agri-Fisheries (CRA) approach, the program helps local communities manage climate risks while pursuing sustainable livelihoods. . To build resilience, several CRA practices are being adopted in AMIA villages (see Figure 27). The most common practice is farm diversification, implemented in 181 villages, followed by the use of climate information services in 173 villages, which helps farmers make informed decisions based on weather and climate data. Organic agriculture practices are adopted in 114 villages, contributing to sustainability and reducing environmental impact. The use of stress-tolerant varieties, which are better equipped to withstand adverse conditions, is implemented in 83 villages. Water management technologies are being used in 41 villages, which is crucial for mitigating the impacts of water scarcity and managing irrigation more effectively (DA n.d.a). Oversight of AMIA is provided by the DA Climate Resilience Agriculture Office (CRAO), formerly known as the DA Systems-wide Climate Change Office (SWCCO).[2] CRAO also managed the Balik-Probinsya, Bagong Pag-asa (BP2) Program to support rural development during the COVID-19 pandemic. Today, CRAO continues promoting climate change mainstreaming in agriculture, providing both policy and operational support through the AMIA Program (DA n.d.a).

Adapting Philippine Agriculture to Climate Change (APA) Project (2024). Building over AMIA's accomplishments, the tripartite project consisting of DA, PAGASA, and FAO called the Adapting Philippine Agriculture to Climate Change was signed in September 2024. This seven-year project (2023-2030) aims to intensify and expand the efforts to build climate resilient communities (FAO 2024). The project enables farmers to adopt climate-resilient practices, build sustainable businesses, and aims to strengthen regulations, improve market systems, and scale climate-resilient agriculture nationwide. This project is financed by a GCF grant of USD 26.3 million and co-financed by the Philippine government (DA and PAGASA) with USD 12.9 million. Around 1.25 million farmers are estimated to benefit from this project (DA 2024). APA anticipates a 1.86 metric ton reduction in carbon dioxide equivalent (MtCO2e)

[2] DA institutionalized climate resilient agriculture (CRA) through DA MC 4 titled "Institutionalization of Climate Resilient Agriculture" s. 2020, renaming the SWCCO office to CRAO, which became responsible for advancing the CRA agenda.

over 20 years due to the implementation of CRA practices and improved land use (USDA-FAS 2023). In the GCF website, it indicates a 4.4 million tons of emissions avoided because of the project (Green Climate Fund, n.d.).

Climate finance and investment

Climate finance refers to funding from public, private, and alternative sources aimed at supporting actions for climate change mitigation and adaptation. Developed countries are responsible for providing financial assistance to developing nations, as per the UNFCCC, Kyoto Protocol, and Paris Agreement. (UNFCCC n.d.c). Developing countries can leverage various climate finance tools, including grants, loans, bonds, carbon trading, and taxes, to fund projects that reduce emissions and enhance climate resilience. This section however focuses on domestic climate finance.

The Philippines has institutionalized Climate Change Expenditure Tagging (CCET) for tracking climate budgets at national and subnational levels. Following a World Bank-supported study, joint DBM-CCC issuances in 2013 and 2015 mandated NGAs, SUCs, and GOCCs to track climate-related spending. In 2014, CCC, DBM, and DILG issued guidance for local governments to tag climate programs in their annual investment plans. CCET data helps assess resource needs and informs climate policies and programs (NICCDIES n.d.b).

Government funding for climate change and disaster resilience increased from PHP195 billion in 2017 to PHP289 billion in 2022, yet its percentage of the total budget dropped from 6.99% to 5.77% (PDP, Ch 15). The Philippine government allocated approximately USD 5.5 billion annually to climate change-related expenditures in 2021 and 2022, increasing to over USD 8 billion in 2023. However, only a small portion (9.75%) of this climate-tagged budget from 2020 to 2023 was linked to NDC actions, with the majority (USD 975 million or 94%) going to railway projects. Based on the NDC Implementation Plan, the Philippines needs significant investment, estimated at USD 72 billion (PHP 4.1 trillion), to meet its NDC targets. Most of the required funding is for the energy sector (USD 36.5 billion) and transport sector (USD 33 billion). Domestic and international climate finance covers only a small portion, so private sector contributions will be essential (CCC and DENR 2023).

The latest climate-tagged budget was for National Expenditure Program FY 2024. DPWH leads with PHP 308 billion, focusing solely on adaptation (Table 2). DOTr has a strong focus on mitigation, receiving PHP 159 billion. DA comes third, with PHP 32.86 billion, most of which goes to adaptation (PHP 30.36 billion), supporting climate-resilient agriculture and production systems. Other departments like DENR and BSGC have smaller allocations, with a mix of both adaptation and mitigation projects.

Table 2: Climate-tagged budget by department and by agency, in PHP billions

	Adaptation	Mitigation	Total
Department of Public Works and Highways	308.08	0.00	308.08
Department of Transportation	0.73	157.85	158.58
Budgetary Support to Government Corporations	18.04	0.64	18.68
National Food Authority	9.00	0.00	9.00
Philippine Crop Insurance Corporation	4.50	0.00	4.50
National Power Corporation	0.84	0.47	1.32
National Housing Authority	1.00	0.00	1.00
Sugar Regulatory Administration	0.65	0.00	0.65
Cagayan Economic Zone Authority	0.50	0.00	0.50

	Adaptation	Mitigation	Total
Philippine Coconut Authority	0.31	0.16	0.47
Philippine Rice Research Institute	0.43	0.00	0.43
Philippine Fisheries Development Authority	0.39	0.00	0.39
Development Academy of the Philippines	0.24	0.00	0.24
Authority of the Freeport Area of Bataan	0.14	0.00	0.14
Center for International Trade Expositions and Missions	0.03	0.00	0.03
National Tobacco Administration	0.02	0.00	0.02
National Dairy Authority	0.01	0.00	0.01
Tourism Promotions Board	0.00	0.00	0.00
Department of Agriculture	30.36	2.50	32.86
Office of the Secretary	28.83	2.44	31.27
Agricultural Credit Policy Council	0.75	0.00	0.75
Bureau of Fisheries and Aquatic Resources	0.33	0.02	0.35
Philippine Center for Post-Harvest Development and Mechanization	0.28	0.00	0.28
National Fisheries Research and Development Institute	0.16	0.00	0.16
Philippine Carabao Center	0.02	0.03	0.04
Fertilizer and Pesticide Authority	0.00	0.01	0.01
Philippine Council for Agriculture and Fisheries	0.00	0.00	0.00
Department of Environment and Natural Resources	6.22	3.90	10.12
Office of the Secretary	5.62	3.45	9.07
Environmental Management Bureau	0.32	0.45	0.77
Mines and Geosciences Bureau	0.20	0.00	0.20
Palawan Council for Sustainable Development Staff	0.04	0.00	0.04
National Water Resources Board	0.03	0.00	0.03
National Mapping and Resource Information Authority	0.02	0.00	0.02

Note: Climate Change Expenditure Tagging of NEP 2024.. Only the top 5 departments are shown in this table.

Source: CCC (2024)

The Department of Agriculture (DA) has a total climate-tagged budget of PHP 32.86 billion for 2024, of which PHP 30.36 billion is allocated for adaptation efforts, and PHP 2.50 billion is designated for mitigation activities. The major adaptation programs include incorporating climate change considerations into agricultural policies and systems, with a substantial PHP 21.41 billion budget. This allocation covers the concreting and rehabilitation of Farm-to-Market Roads (FMR) with PHP 16.96 billion, the Philippine Rural Development Project (PRDP-AF2) receiving PHP 3.39 billion, and smaller amounts for FMR network planning, monitoring, and related activities. An additional PHP 5.04 billion is devoted to the development of climate-resilient crop and livestock systems, which emphasizes livestock, high-value crops, rice, and corn programs. Moreover, the provision of agricultural equipment and facilities is a key priority under this adaptation budget.

For mitigation, the DA's primary focus is on manure management and methane capture in animal husbandry, with a PHP 2.44 billion allocation. A smaller amount of PHP 5 million is dedicated to the Philippine Carabao Center's efforts to support the intensification of the National Upgrading Program, which contributes to the DA's goal of reducing emissions in livestock production (CCC, 2024)

4. Scenario analysis for adaptation and mitigation

4.1 Past scenario analysis

Pradesha and Robinson (2019) previously explored a different set of scenarios using CGE and dynamic computable general equilibrium (DCGE). Their analysis found that climate change suppresses long term economic growth, causing welfare losses of PhP145 billion per year, on average, to 2050. It also reduces the size of economy, whereby GDP is estimated to be reduced by almost 1 per cent in 2050. Locally, the climate shock reduces crop productivity, thereby lowering national agricultural production. They also analyzed three adaptation which focus on improving agricultural productivity in efforts to mitigate the high costs of climate change. Overall, investments in improving rice productivity and expanding irrigation infrastructure generate the highest benefits in mitigating the adverse impacts of climate change. Moreover, these productivity-enhancing investments render the rice support program provided by the National Food Authority (NFA), then active at the time, entirely superfluous. Finally, cost–benefit analyses of investment in irrigation infrastructure indicate clear gains from early investment, with benefit–cost ratios of 1.38, as opposed to 1.26 when investment is delayed.

4.2 Scenario analysis for the study

The scenario analysis implemented in this study share some broad similarities with Pradesha and Robinsson (2019) in terms of examining impacts of adaptation strategies. Unlike their study, we also examine mitigation strategies, as well as examine a broader set of agricultural sectors, including fisheries. The following describes a) the model used, which is the Agricultural Model for Policy Evaluation (AMPLE) CGE version; b) the framing of the scenarios; and c) assumptions behind the scenarios.

The AMPLE CGE

The AMPLE CGE is structured around a base year equilibrium for 2018, where both supply and demand equations are solved to determine key endogenous variables such as production quantities, prices, export and domestic market quantities, and quantity of labor and capital demanded on the supply side, and consumption demand, intermediate inputs demand, investment goods demand, and consumer prices on the demand side. The CGE sectors cover the major agriculture commodities, including aquaculture and capture fisheries, which has hitherto been omitted in past scenario analysis.

Exogenous variables or model inputs include base year data from a Social Accounting Matrix (SAM), supply and demand parameters like productivity levels and preferences, world prices, and government policies. The dynamics of the model are explored through changes in labor and capital endowments, world prices, and productivity, with particular attention to the negative shocks from climate change, calibrated to reflect its impact on productivity.

The model is designed to project dynamic equilibriums into the future, extending to 2045 etc., allowing for the examination of long-term economic outcomes. Calibration ensures that the model accurately reproduces base year market equilibriums by reverse-engineering parameter values, while income dynamics are modeled as exogenous to demand functions but endogenous within the overall CGE framework (because households earn income from selling their factor endowments to producers).

Description of scenarios

Annual equilibrium solutions were obtained from 2018 to 2045. Policy experiments begin in 2025, under the following scenarios:

- **Reference/Baseline:** This scenario represents the continuation of economic and population trends, as well as the incorporation of climate change. It assumes a business-as-usual approach with deteriorating growth of 1 percent per year starting in 2025.
- **Climate change adaptation scenario:** This scenario involves modified shifters due to the adoption of adaptation measures, which may have budgetary implications and will be incorporated into the fiscal side of the model. The adaptation measures completely offset the impacts of climate change, effectively simulating a scenario equivalent to "no climate change." As a result, there is no deterioration in productivity growth, ensuring sustainability. This scenario is assumed to be funded by increased government expenditure, amounting to PHP 30 billion per year.
- **Climate change adaptation and mitigation scenario**: This scenario identifies priority mitigation measures for agriculture and estimates their supply-side implications. It also incorporates the fiscal outlays required for these measures, integrating them similarly to the climate change adaptation scenario, ensuring both adaptation and mitigation strategies are accounted for in the model. For instance, the Alternate Wetting and Drying (AWD) technique results in a 40 percent reduction in GHG emissions for rice production. In the livestock sector, there is a targeted 50 percent reduction in emissions for hogs and 20 percent for cattle, achieved through the promotion of animal manure as part of integrated nutrient management for crops. The technologies are initially adopted in 2025 and fully adopted by 2030, with no additional spending required, as the technology promotion is incorporated into adaptation programs. Importantly, **these measures have no impact on productivity**; unlike in the energy or fuel sectors, mitigation in agriculture through the aforementioned technologies does not necessitate scaling back economic activity.

Assumptions by scenario

Table 3 presents the alternative supply-side productivity trends assumed under the various scenarios. Under the **reference scenario**, annual productivity growth rates are assumed to reflect current conditions and typical trends observed, consistent with existing levels of climate investments and interventions. Growth rates for most subsectors remain modest, constrained by climate variability, limited technological advancement, and other factors that restrict productivity improvements.

The Adaptation scenario incorporates higher annual productivity growth rates based on the assumption that adaptation measures are implemented. The higher growth rates in this scenario are reflective of the anticipated positive impacts of adaptation investments on agricultural performance. Subsector-specific assumptions are provided below:

- **Traditional Crops and Specific Crops (Palay, Maize)**: In the adaptation scenario, productivity for crops such as palay and maize is assumed to increase significantly. These gains are primarily due to improved crop management practices, enhanced access to quality inputs, and technologies that make crops more resilient to climatic stress.
- **Animal products**: For livestock, poultry, and fisheries, the adaptation scenario includes assumptions of increased productivity driven by selective breeding, disease management, and optimized farming practices.

Adaptation strategies are not implemented for free. It is assumed that implementation these scenarios involves approximately **doubling** the expenditures of DA for climate-tagged projects, namely from Php 32.9 billion to Php 62.9 billion.

Table 3: Annual productivity growth trends, historical and scenario assumptions (%)

	Historical trend (2002-2023)	Implicit change (25 years)	Reference scenario	Adaptation scenario
Palay	1.16	33	0.78	1.00
Maize	2.75	97	2.06	2.54
Coconut	-0.45	-11	-0.45	0.00
Sugarcane	1.38	41	1.04	0.99
Banana	-0.04	-1	-0.15	0.00
Mango	-0.31	-7	-0.31	0.00
Pineapple	1.11	32	1.00	0.95
Coffee	-2.83	-51	0.00	0.00
Cassava	1.21	35	1.21	1.15
Other crops	-3.32	-57	-1.65	0.00
Sweet potato	1.34	39	1.34	1.27
Other fruits	-3.63	-60	0.37	0.35
Leafy & stem vegetables	0.60	16	0.46	0.58
Fruit vegetables	0.87	24	0.87	0.97
Onion	3.33	127	2.66	2.53
Hog	-0.21	-5	-0.21	0.00
Cattle	0.18	5	0.18	0.17
Other ruminant	0.37	10	0.37	0.35
Other livestock	0.37	10	0.37	0.35
Chicken	2.32	78	2.32	2.21
Eggs	5.80	309	2.20	2.20
Marine capture	-0.43	-10	0.00	0.50
Inland capture	1.89	60	0.00	0.50
Aquaculture	2.95	107	2.95	2.80
Hog	-0.21	-5	-0.21	0.00
Cattle	0.18	5	0.18	0.17
Other ruminant	0.37	10	0.37	0.35

Source: Authors' calculations

For GHG emissions per annum, it is assumed that Irrigated palay emits 6.6 tons per ha of CO2-equivalent, while rainfed palay emits 3.6 tons per ha. Meanwhile Hog emits 30 tons CO2-equivalent, Cattle emits 1,270 tons CO2-equivalent, and Other ruminants, 710 tons CO2-equivalent. Under Adaptation-with-mitigation, the coefficients of Irrigated palay gradually decline to 4 tons CO2-equivalent, while Rainfed palay remains essentially unchanged. Meanwhile, for Hog, Cattle, and Other ruminants, coefficients gradually decline to 10 tons per head for Hog, 64 tons per head for Cattle, and 36 tons per head for Other ruminant (all in CO2-equivalent).

4.3 Discussion of simulation results

This section discusses the outcomes of the simulation models that were applied to evaluate the impact of different adaptation strategies on the Philippine agriculture sector. The results are presented across several dimensions, including productivity growth, land use, per capita consumption, and greenhouse gas (GHG) emissions. The findings help elucidate the potential benefits of adopting more intensive climate adaptation and mitigation measures compared to maintaining the current practices.

Output trends

The simulation results highlight the impact of different trends in productivity growth between the reference scenario and the adaptation scenario. Table 4 presents trends in output based on value added at constant 2018 prices. Under the reference scenario we see large changes over a twenty-year time frame, with 270 to 280 percentage change over a twenty-year period for palay, a similar change for maize, and even larger change for coconut. Changes are even larger for sugarcane, though from a smaller base; the lowest expansion is for banana. The adaptation scenario indicates faster growth for key crops such as palay and maize.

Table 4: Projections for value added, traditional crops 2018-45, PHP billions (constant 2018 prices)

	2018	2025	2030	2035	2040	2045	Percentage change, 2025-45
Reference scenario							
Irrigated Palay	380	457	574	837	1,226	1,732	279
Rainfed Palay	97	129	171	235	338	506	293
Maize	97	129	171	235	338	506	293
Coconut	83	85	91	120	143	469	452
Sugarcane	28	28	30	47	74	115	310
Banana	137	148	163	228	312	354	139
Adaptation scenario							
Irrigated Palay	380	457	557	751	1,015	1,409	208
Rainfed Palay	97	129	181	249	450	811	530
Maize	97	129	181	249	450	811	530
Coconut	83	85	94	113	132	156	84
Sugarcane	28	28	28	29	29	29	5
Banana	137	148	168	198	224	262	77

Source: Authors' calculations

Table 5 presents output trends for livestock, poultry, and fisheries. Under the reference scenario, without additional adaptation measures, increases are noted for all the animal products, with least changes over a twenty-year period for Other ruminants, and the largest for Marine capture (reflecting long term improvements from existing management measures). However, the adaptation scenario shows a **faster growth** in value added for specific subsectors, including **other ruminants, chicken, eggs, and aquaculture**. These are attributed to the introduction of additional adaptation measures.

Table 5: Projections for value added, animal products, in Php billions (constant 2018 prices)

	2018	2025	2030	2035	2040	2045	Percentage change, 2025-45
Reference scenario							
Hog	166	206	269	329	422	490	138
Cattle	23	24	26	30	37	52	120
Other ruminant	31	31	31	31	31	32	3
Other livestock	55	72	94	123	170	237	231
Chicken	133	174	210	250	257	319	84
Eggs	27	35	41	43	44	45	29
Marine capture	112	162	231	357	569	883	444
Inland capture	10	12	13	20	30	48	298
Aquaculture	86	108	117	120	120	120	11
Adaptation scenario							
Hog	166	206	225	337	420	549	166
Cattle	23	24	25	24	22	20	-16
Other ruminant	31	31	31	34	35	35	14
Other livestock	55	72	87	52	86	139	94
Chicken	133	174	218	376	482	608	250
Eggs	27	35	42	48	78	144	316
Marine capture	112	162	256	370	578	800	393
Inland capture	10	12	13	18	28	41	239
Aquaculture	86	108	120	149	164	182	68

Source: Authors' calculations

Palay area trends

Figure 11 presents trends in palay area, which is highlighted owing to its major contribution to agricultural GHG emissions. Under the **reference scenario,** palay cultivation area initially increases, but eventually it contracts. Meanwhile for the a**daptation Scenario**, there is more prolonged period of increase in the palay area, with a less pronounced decline. This indicates that adaptation efforts, such as enhanced access to climate-resistant seeds, help sustain palay production and maintain agricultural land for this essential crop for a longer period.

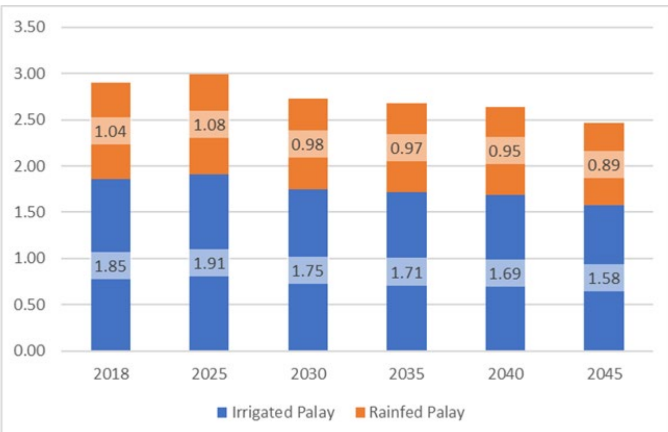
Per capita consumption trends

The simulation evaluates per capita consumption growth under the reference and adaptation scenarios across different food types, including crops, livestock, and processed food (Tables 6, 7, and 8). For crops: growth in per capita consumption is positive for all crops, except coconut. The fastest growth rates are for sweet potato and onion, while the slowest were for sugarcane and mango. Growth rate of rice is just about 3 percent on average, with consumption growth accelerating from the mid-2030s onward.

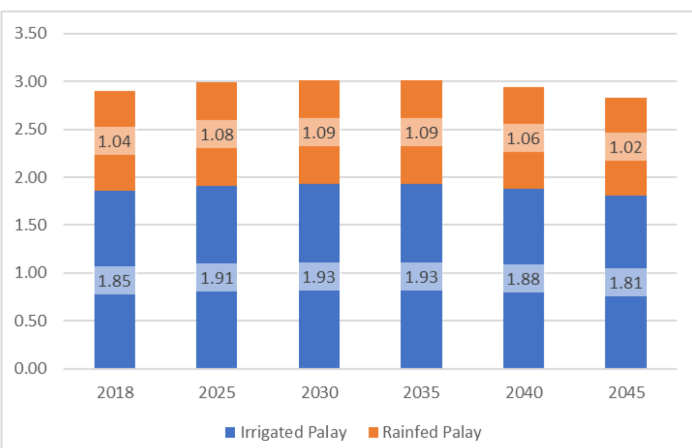
Growth in per capita consumption of many crops is faster under the adaptation scenario compared to the reference scenario. This indicates that adaptation measures—such as improved agricultural practices and crop diversification—have successfully increased crop production and food availability. However, some crops undergo slower consumption growth, namely Mango, Leafy vegetables, and Onions.

Figure 11: Projections for Palay Area by scenario, 2018-45, in ha

a) Reference scenario



b) Adaptation scenario



Source: Authors' calculations

Table 6: Projections for annual growth in per capita consumption, by scenario, crops (%)

	2019-25	2026-30	2031-35	2036-40	2041-45	2019-45
Reference scenario						
Rice	2.6	3.0	1.3	2.4	5.2	2.9
Corn	4.4	6.2	6.7	8.1	7.4	6.5
Coconut	2.1	3.3	4.9	5.2	-1.1	2.9
Sugarcane	5.1	7.8	4.6	5.2	3.2	5.2
Banana	2.8	5.8	5.4	6.3	6.4	5.3
Mango	3.2	5.2	4.9	6.3	4.7	4.9
Cassava	4.1	5.2	4.9	6.1	6.2	5.3
Sweet potato	9.2	15.1	5.2	7.1	12.3	9.8
Leafy & stem vegetables	2.1	3.2	5.1	6.1	6.3	4.5
Fruit vegetables	2.9	4.2	4.2	5.3	5.9	4.5
Onion	3.5	4.8	6.4	6.4	9.2	6.1
Alternative scenario						
Rice	2.6	3.7	2.0	3.9	5.0	3.5
Corn	4.4	6.4	4.7	3.8	4.9	4.8
Coconut	2.1	3.4	3.0	4.3	5.6	3.7
Sugarcane	5.1	8.2	7.8	8.9	8.3	7.6
Banana	2.8	5.6	4.1	6.4	7.7	5.3
Mango	3.2	4.8	2.2	3.8	4.9	3.8
Cassava	4.1	5.0	3.8	3.8	4.8	4.3
Sweet potato	9.2	15.2	2.1	3.5	4.3	6.9
Leafy & stem vegetables	2.1	3.2	4.1	6.4	7.6	4.7
Fruit vegetables	2.9	4.2	3.8	5.6	6.9	4.7
Onion	3.5	5.1	5.0	4.7	5.9	4.8

Source: Authors' calculations

Animal products: Growth rate of per capita consumption is also found for animal products, with the fastest for Chicken, Aquaculture, and Eggs. Growth in per capita consumption is faster under the Adaptation scenario for Hogs, Cattle, Other ruminants, Eggs, Marine capture, and Aquaculture. This reflects the impact of adaptation measures in improving production efficiency and the resilience of these sub-sectors.

Table 7: Projections for annual growth in per capita consumption, by scenario, animal products (%)

	2019-25	2026-30	2031-35	2036-40	2041-45	2019-45
Reference scenario						
Hog	2.6	6.6	1.8	5.5	8.3	5.0
Cattle	3.8	6.6	4.3	6.2	6.8	5.5
Other ruminant	5.1	8.2	7.1	8.9	9.0	7.7
Chicken	4.9	8.9	8.2	11.6	8.5	8.4
Eggs	4.7	7.6	8.2	10.0	8.6	7.8
Marine capture	2.0	2.8	3.1	3.0	3.4	2.8
Aquaculture	4.9	7.5	8.4	9.3	9.2	7.9
Alternative scenario						
Hog	2.6	7.7	-1.1	6.5	7.6	4.7
Cattle	3.8	7.2	2.8	7.8	8.6	6.0
Other ruminant	5.1	8.5	4.3	8.2	9.3	7.1
Chicken	4.9	8.6	1.0	9.6	11.4	7.1
Eggs	4.7	7.5	3.8	7.6	8.2	6.3
Marine capture	2.0	2.7	2.2	3.5	5.2	3.1
Aquaculture	4.9	7.6	5.6	7.8	8.1	6.8

Source: Authors' calculations

Processed Food Products: Under the reference scenario, per capita consumption growth is very high for Fats & oil, although growth is also quite rapid for Processed fruit and vegetables, and Sugar & sugar products. The lowest consumption growth is shown by Rice & corn. Meanwhile, under the Adaptation scenario, most processed food products exhibit faster growth in per capita consumption, indicating enhanced food processing capabilities and improved market availability. However, Fats & oil experience a slowdown in consumption growth.

Table 8. Projections for annual growth in per capita consumption, processed foods (%)

	2019-25	2026-30	2031-35	2036-40	2041-45
Reference scenario					
Processed meat & fish	3.6	5.5	3.4	4.3	4.8
Processed fruit & vegetables	4.1	5.4	5.2	6.5	6.1
Fats & oil	2.6	3.6	5.7	4.8	16.6
Milk & dairy	2.6	3.6	5.1	6.5	4.9
Rice & corn	1.2	1.6	1.6	2.2	3.1
Other food	2.7	3.9	7.5	8.9	4.8
Sugar & sugar products	2.4	3.4	5.9	6.4	5.4
Alternative scenario					
Processed meat & fish	3.6	5.6	2.7	5.9	6.9
Processed fruit & vegetables	4.1	5.6	3.7	5.5	6.3
Fats & oil	2.6	3.6	4.1	4.9	5.8

Milk & dairy	2.6	3.7	3.2	5.0	6.1
Rice & corn	1.2	1.8	1.7	3.1	4.0
Other food	2.7	4.3	4.9	4.2	5.0
Sugar & sugar products	2.4	3.4	4.6	4.3	6.6

Source: Authors' calculations

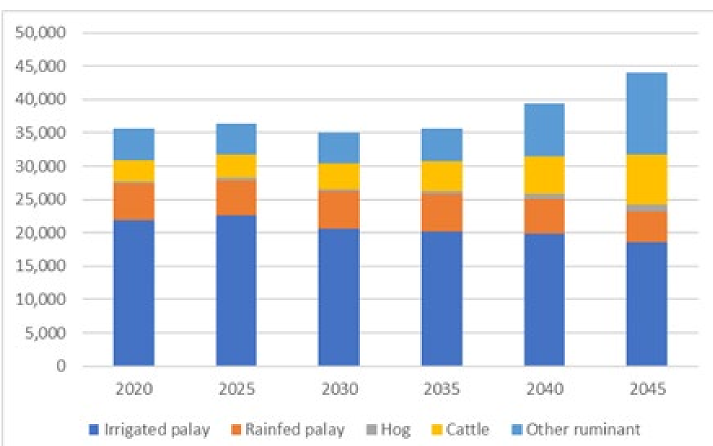
Trends in GHG emissions from agriculture

The impact of agriculture on GHG emissions is evaluated under both Reference and adaptation scenarios, as well as an Adaptation with mitigation scenario. Note that supply and demand outcomes under the latter is identical to that under the Adaptation scenario, hence the following will consider only trends in GHG emissions, measured by CO2-equivalent.

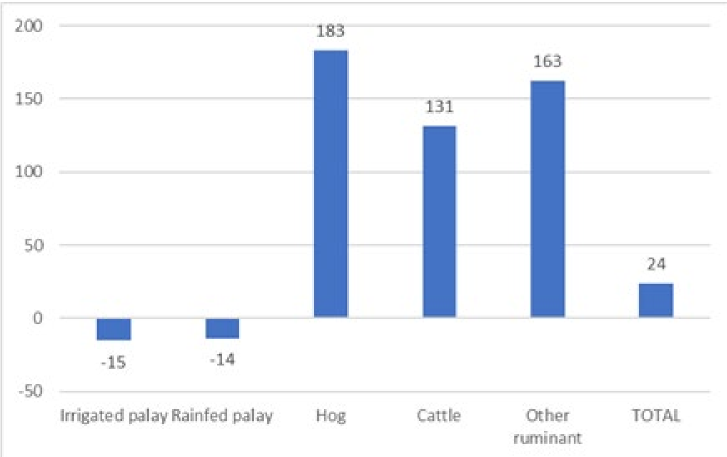
Figure 12 shows GHG emissions under the reference scenario. There are increases in overall GHG emissions from the agriculture sector, though the amount emitted is about 10 megatons higher than in 2020. The contribution of emissions from Palay actually decreases over time, owing to the decline in Palay area. There is however a notable increase in emissions from hog and cattle production, as seen in the growth rates over the period 2020 - 45. The increase in emissions from hog and cattle production suggests that the expansion of livestock activities is becoming a more significant source of emissions compared to Palay. This trend reflects the growing environmental impact of livestock production as demand for animal products rises.

Figure 12: Projections for GHG emissions from agriculture, 2020 – 45, Reference scenario

a) In '000 tons CO2-equivalent



b) In percentage change

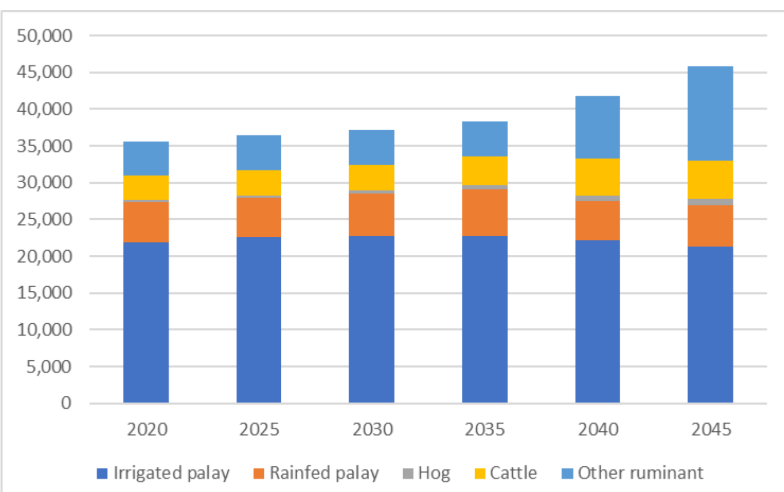


Source: Authors' calculations

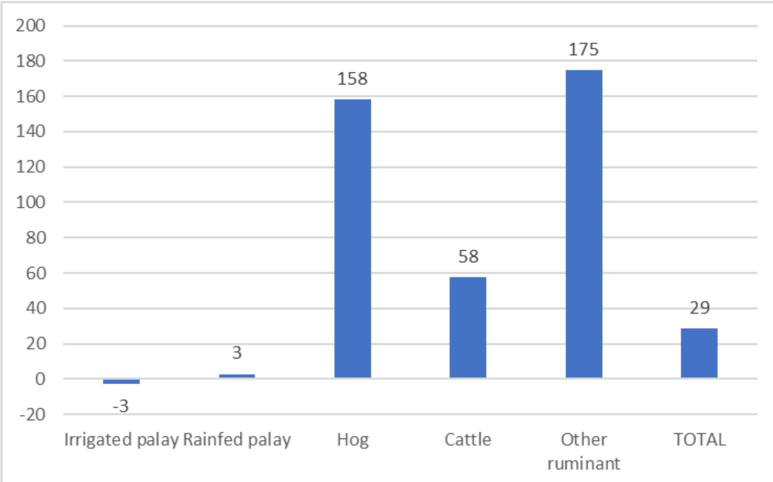
Figure 13 presents GHG emissions under the Adaptation Scenario. Despite the implementation of adaptation measures, GHG emissions from agriculture continue to rise, showing a 29 percent increase compared to 24 percent in the reference scenario. This suggests that adaptation measures alone, such as increasing productivity or improving resilience, are insufficient to prevent rising emissions and may even contribute to higher emissions due to increased agricultural activity. That is, climate adaptation, while beneficial for increasing resilience and productivity, does not address the emissions challenge effectively on its own. Instead, the intensified agricultural activities driven by adaptation measures may inadvertently lead to higher emissions.

Figure 13: Projections for GHG emissions from Agriculture, Adaptation scenario (2025-2045)

a) in '000 tons CO2-equivalent



b) In percent change

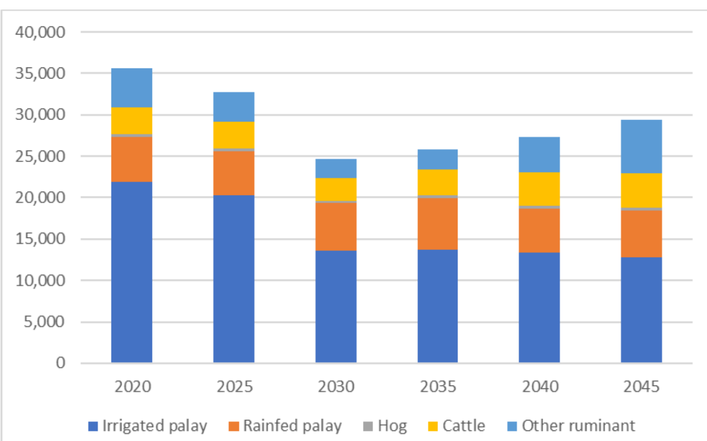


Source: Authors' calculations

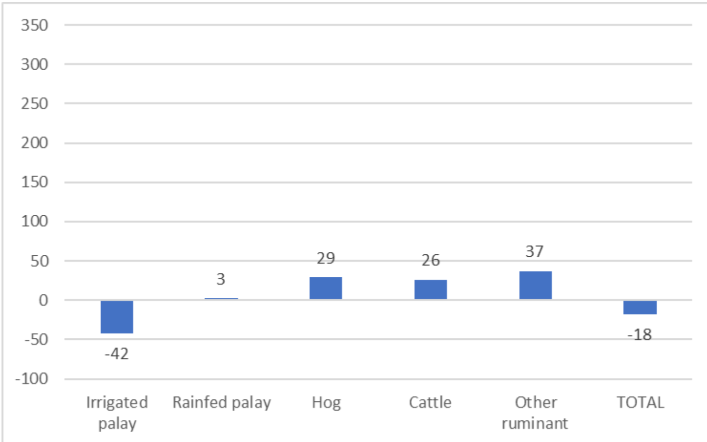
Finally, Figure 14 shows GHG emissions under the Adaptation-with-mitigation scenario. When adaptation measures are combined with mitigation strategies, there is an 18 percent overall reduction in GHG emissions compared to 2025-45 projections. This indicates that adding targeted mitigation efforts—such as carbon sequestration practices, manure management, or emission-reducing technologies—can effectively counteract the emissions increase seen with adaptation alone. Meanwhile, the increases in GHG emissions from livestock are notably slower, indicating that mitigation efforts are effective at limiting emissions from the livestock sector, which is otherwise a major contributor to GHG emissions.

Figure 14: Projections for GHG Emissions from agriculture, Adaptation-with-mitigation scenario, 2025-2045

a) In '000 tons CO2-equivalent



b) In percentage change



Source: Authors' calculations

5. Conclusions

5.1 Synthesis

It now well-established that climate change is real and is unequivocally driven by human activities, particularly the burning of fossil fuels and other anthropogenic greenhouse gas (GHG) emissions. The IPCC has confirmed a 1.1°C rise in global temperatures since the pre-industrial period. Agriculture plays a dual role in this scenario, being both a victim and a contributor. Although the Philippines contributes only 0.49 percent to global GHG emissions, its agriculture sector constitutes 23 percent of the country's emissions, which cannot be ignored. Globally, advanced countries, such as the United States and China, are the largest contributors to GHG emissions, making them central figures in both causing and mitigating climate change.

Currently, the Philippines contributes less than 1 percent to global GHG emissions, but it ranks first in the 2024 risk index due to its extreme vulnerability to climate change impacts, such as frequent and more intense tropical cyclones and rising sea levels. On a positive note, the Philippines has demonstrated its commitment to global climate agreements by submitting its Nationally Determined Contribution (NDC) in 2021. This NDC pledges a 75 percent reduction in GHG emissions by 2030, of which 2.71 percent is unconditional and 72.29 percent is conditional on external financial and technical support. However, despite the country's commendable efforts, more funding and technical assistance are necessary to achieve these goals. There is also a pressing need for larger polluting nations to provide mitigation funds to help vulnerable countries like the Philippines adapt, which highlights the issue of social justice. Any adaptation efforts undertaken by the Philippines must be realistic and focused on both economic and social dimensions.

Looking forward, the aim is to significantly reduce GHG emissions by 2030, in line with the Sustainable Development Goals (SDGs) and the Philippines' NDC commitments. Achieving sustainable agriculture is essential, balancing economic growth with environmental sustainability. The agricultural sector needs to adopt practices that promote productivity while minimizing its carbon footprint.

To reach these targets, the adoption of cost-effective technologies is crucial. Among the most effective GHG mitigation strategies in agriculture are **Alternate Wetting and Drying (AWD)** in rice cultivation and **improved manure management** in livestock farming. AWD can significantly reduce methane emissions by optimizing water usage in rice fields, a major source of methane in Philippine agriculture. Similarly, improved manure management, such as using biogas digesters, reduces methane emissions from livestock waste while converting waste into energy. These technologies, while effective, need greater support for widespread adoption, especially among small farmers.

These mitigation efforts must also be balanced with the need to avoid productivity losses. AWD, for example, not only reduces emissions but also conserves water without negatively impacting rice yields. In the case of manure management, practices like covered storage and biogas digesters reduce GHG emissions while improving nutrient recycling, which further enhances farm productivity.

Government spending on adaptation measures could result in faster growth in agricultural output, especially in crops, livestock, and poultry. Projections suggest that with adaptation strategies, Agricultural Gross Value Added (GVA) could grow 0.38 percentage points faster. However, while adaptation can increase productivity, it may also lead to higher GHG emissions from agriculture unless paired with effective mitigation technologies like AWD and manure management. These technologies are not only capable of reducing emissions but also ensuring that agricultural productivity is maintained or even enhanced in the process.

While mitigation and adaptation efforts can be costly, the pursuit of environmental sustainability as a whole significantly extends the benefits of these investments. Policies that promote sustainable practices not only reduce emissions but also contribute to ecosystem resilience, disaster risk reduction, and social well-being. Countries like the Philippines, where the exposure to climate-related and non-climate disasters is high, must prioritize integrated strategies that combine adaptation, mitigation, and sustainability for a more cost-efficient and effective climate response. Decision-makers must recognize that sustainability measures, though initially costly, go a long way in building resilience across sectors and must be pursued to achieve lasting climate and disaster resilience.

5.2 Policy recommendations

These policy recommendations reflect the growing need for proactive climate action in agriculture, which ensures that the sector adapts to climate change impacts while contributing to the country's mitigation efforts.

1. **There is a critical need for more refined and accurate estimates of GHG emissions across economic sectors,** particularly those related to agriculture, industry, and services, using input-output relationships. This will help in identifying the specific sources of emissions and understanding how these sectors interact, enabling better-targeted policies and resource allocation for climate adaptation and mitigation strategies.
2. **It is essential to introduce climate adaptation measures for agriculture that enhance the sustainability of crops, livestock, and fisheries production.** These measures are not new, but their urgency has increased under the current and projected impacts of climate change. The cost of inaction is far greater now, as climate risks to the agriculture sector threaten not only production but also food security and livelihoods. While these adaptation strategies will lead to overall growth in the agriculture sector, it should be noted that there is no guarantee that individual sub-sectors will benefit equally due to general equilibrium effects, which may create uneven outcomes across different areas of agricultural production.
3. **Introducing mitigation technologies in agriculture is also a priority.** Many options are available that do not involve greater costs or reduced productivity. Technologies such as Alternate Wetting and Drying (AWD) for rice cultivation and improved manure management in livestock farming are prime examples. These technologies offer the potential to significantly reduce emissions without sacrificing agricultural output, ensuring that the sector remains productive and competitive while

contributing to national climate goals. For both Adaptation and mitigation, the additional cost is relatively modest on the balance, hardly making a dent on agricultural outcomes and fiscal burden.

4. **The Philippines should consider formally incorporating agriculture into its unconditional Nationally Determined Contributions (NDC), which focus on low-cost technologies that offer long-term sustainability**. Measures such as AWD for rice cultivation and animal manure management are already included in the NDC Implementation Plan as cost-effective and have been proven to reduce emissions without negatively affecting productivity. By prioritizing these technologies, the Philippines can ensure that its agricultural sector contributes to both national and global climate goals while maintaining economic sustainability in the long term.

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