Technical Assistance to Strengthen R&D for Climate Change Resilience of Agriculture in the Philippines

Reference: CPH1064

Policy review and appraisal of the agriculture R&D landscape in the Philippines in context of Climate Change.

Draft report - version 2.

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Part 1 – Policy review, R&DE landscape in Philippines in context of climate change

Project summary

Project duration	**June 2023 to June 2024 – 1 year.**
Reporting period	March to June 2024
Global objective	Support to Philippines's agriculture and fisheries sector for Climate Change resilience.
Context	The Philippine government's R&D support for agriculture in general and for climate-resilient agriculture in particular, has been minimal. In a context of a policy loan to the Government of Philippines for Climate Change, AFD is providing technical assistance to create a dialogue for facilitating policy reforms which will enhance government's support for climate-resilient agriculture and fisheries sectors.
Specific objective	This Technical Assistance (TA) will provide support for R&D policy reforms and the implementation of climate-smart technologies and practices for high-value crops, fisheries, a livestock, and poultry. CIRAD is engaged to provide R&D support to the Department of Agriculture (DA). This technical support will assist the Department of Agriculture of the Philippines in fulfilling its policy action and outcome commitments under Reform Area 2 (resilience to climate impacts enhanced) of the Subprogram 2 of the Philippine Climate Change Action Program (CCAP), co-financed by AFD and ADB.
Donor	Agence Française de développement
Beneficiary	Government of the Philippines, Department of Agriculture
Geographic scope	Philippines
Two main components	Component 1: Comprehensive policy review and appraisal of the agriculture R&D landscape in the Philippines. Two main deliverables: a main report and a policy brief. Component 2: Capacity building for Philippine agricultural research on specific themes: • 2.1 Genetic expert CRISPR/Cas9 -Training in France • 2.2 Mango data acquisition, analysis - (Pixfruit & Soyield). • **2.3 Research project on aquaculture** • 2.4 Research on lignocellulosic wastes and by products • 2.5 Sugarcane technologies transfer and R&D
Scope of this report	Component 1: Policy review and appraisal of the agriculture R&D landscape in the Philippines (in context of climate change) – see ToRs in Annex 6.

1. Overview of AF R&D in Philippines

1.1 Exposure of Philippine agriculture to climate change

The Philippines is one of the most exposed countries on the planet. It is ranked 4th of the Long-Term Climate Risk Index (CRI). FAO (2022) noted that most of the country and particularly about 70% of its population are exposed to climate risks. The economic impact on the agriculture and fisheries sector is considerable. Climate shocks affect agriculture by damaging infrastructure, crops, and livestock.

The Philippines' agriculture and fishery sectors are vulnerable to a range of environmental challenges, including rising temperatures, excessive rainfall, floods or drought, extreme weather events such as typhoons, resulting into landslides, forest-fires, disease outbreaks on crops, aquaculture and livestock. These factors, including the effects of CO_2 increase, are likely to have a significant impact on these sectors. In 2019, the Philippines had the highest Agricultural GHG Emissions Intensity as compared to other Asian countries with an emission intensity of 2.231 kg CO2eq/USD.

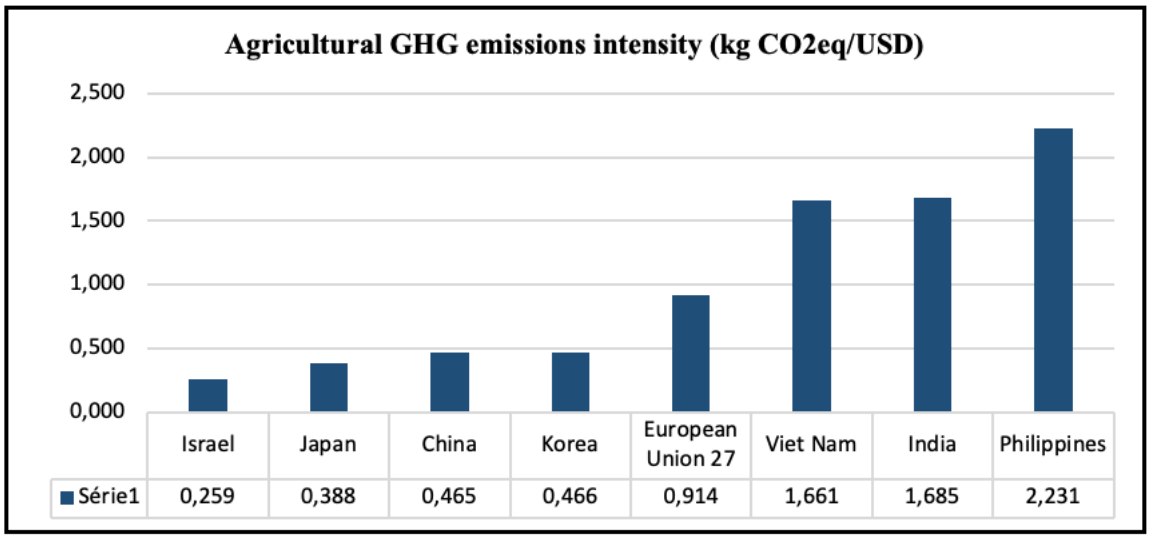


Figure 1: Agriculture GHG emission intensity (kg CO2eq/USD) (*Source: OECD Statistics on GHG Emissions 2022)*

Rising temperatures affect crop and livestock yields, increase pests and reduce the productivity of the agricultural workforce. Rising temperatures and changing precipitation patterns will particularly affect rain-fed crop yields. Overall, climate change will reduce agricultural productivity in the Philippines by between 9% and 21% (Pulhin and Tapia, 2016), which is substantial.

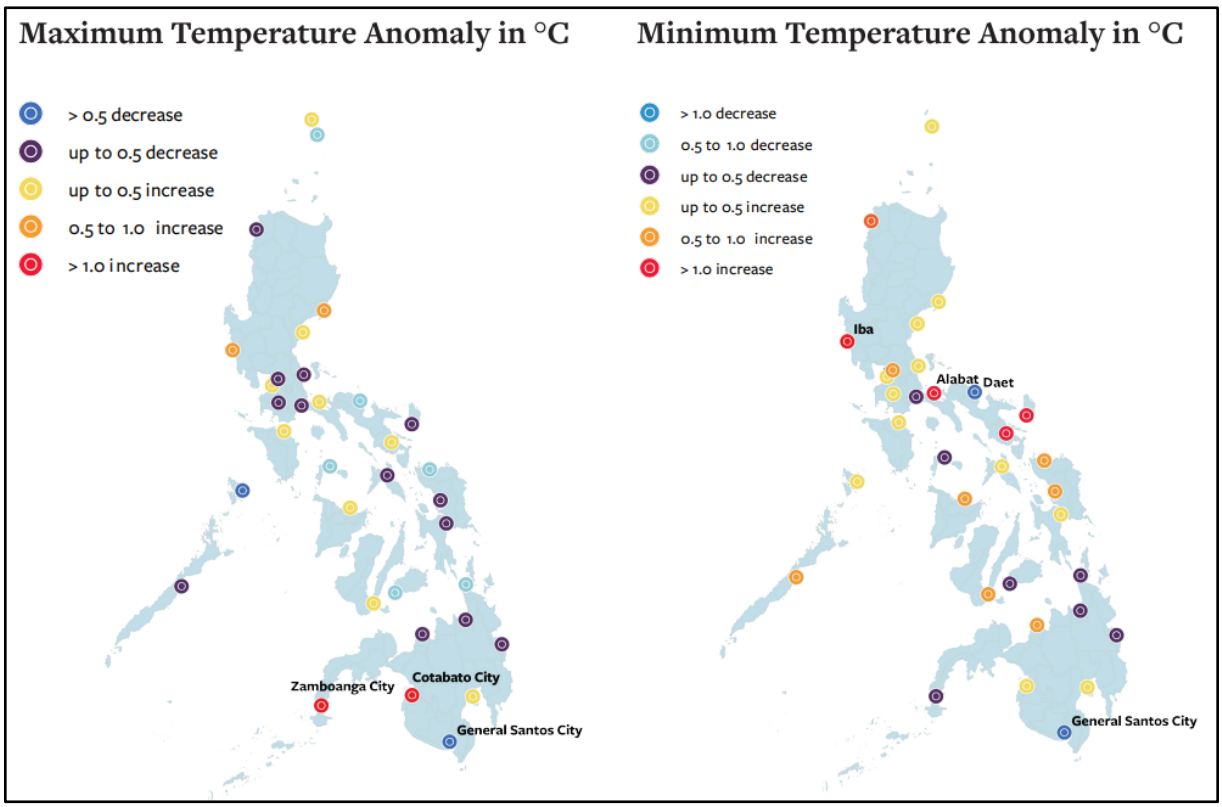


Figure 2: Annual daytime (left) and nighttime (right) temperature anomalies per selected PAG-ASA stations in 2021 Source: [The State of the Philippine Climate – OML Center (omlopezcenter.org)]

Typhoons affect rice production. The main rice-growing provinces of Nueva Ecija, Isabela, Pangasinan, Iloilo, Cagayan Valley and Camarines Sur are already highly exposed to typhoons, and a southward shift of typhoons poses increased risks to the rice-growing provinces of the Visayas and even Mindanao (Alliance of Bioversity International and CIAT, and WFP, 2021).

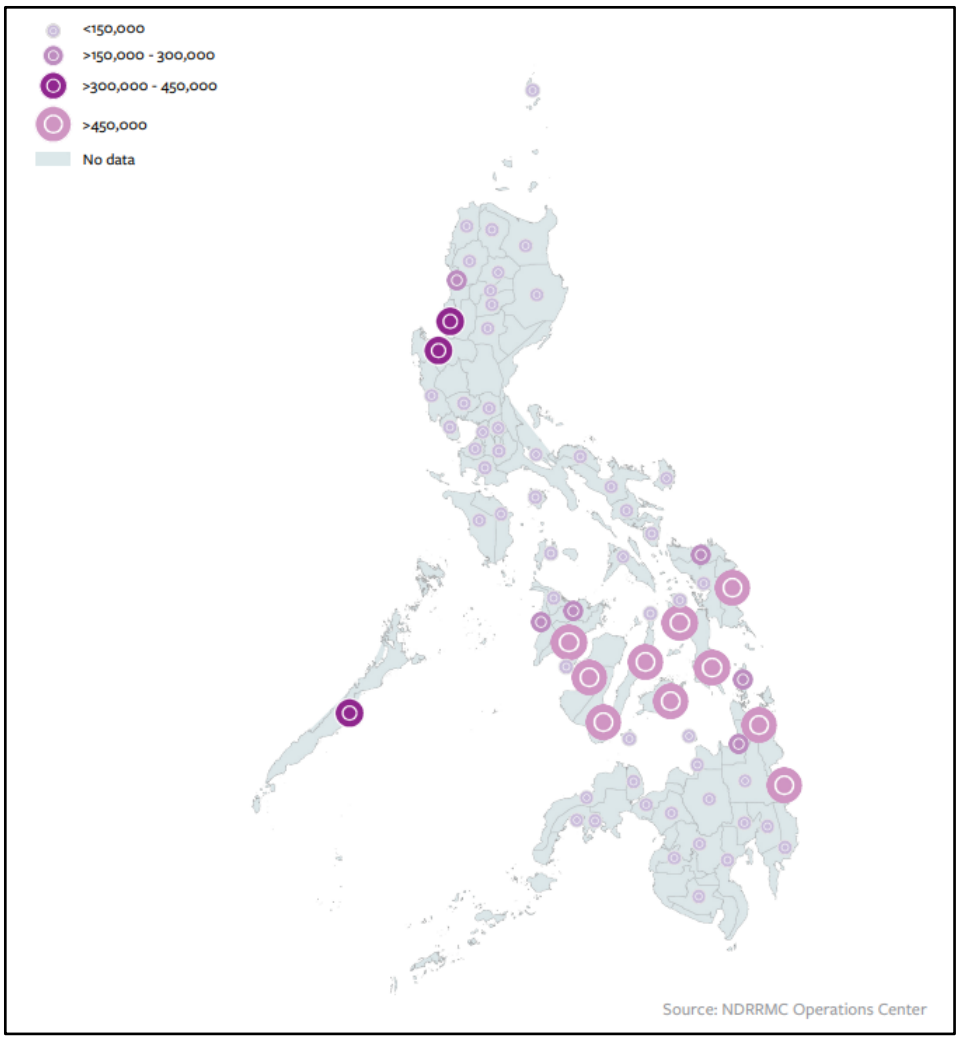


Figure 3: Total affected population due to Tropical Cyclones and other associated hazards per province in 2021 (Source: [The State of the Philippine Climate – OML Center (omlopezcenter.org)])

Extreme weather events are also damaging the infrastructure needed for agricultural and aquaculture production. Between 2010 and 2019, about 63% of the estimated $9 billion in damages from extreme natural events and disasters was caused to agriculture (WB from PSA, 2020a).

Increased CO_2 in the atmosphere leads to acidification of the oceans, destruction of marine shellfish and changes in marine food chains, ultimately reducing fish stocks. Marine hazards such as saltwater intrusion will also have a major impact on coastal fisheries, particularly in marginalized communities in the Visayas and Mindanao (Bioversity International Alliance and CIAT, and WFP, 2021).

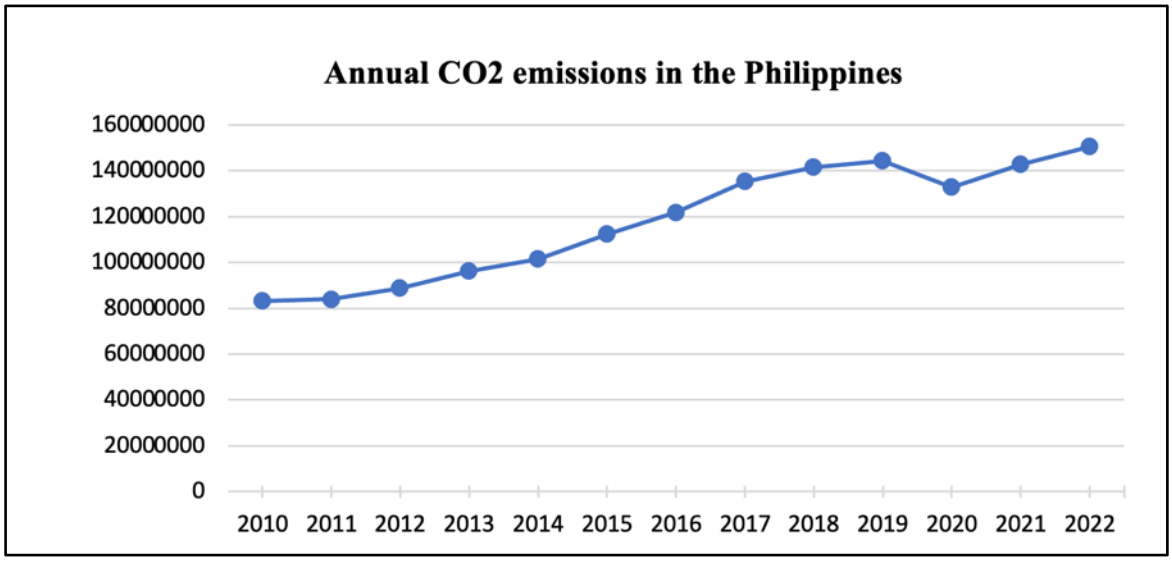


Figure 4: Annual CO2 emissions in the Philippines (Source: [CO_2 emissions - Our World in Data])

The impact of climate change is uneven across crops and regions. By 2050, according to Thomas (2019), irrigated rice yields will be virtually unchanged, while for rainfed rice, yield losses will be around 6% in the Visayas and only 1% in Mindanao. The most affected crops will be, in order, corn, sugar, rice, and bananas. Irrigated sugarcane yields are also expected to decline as it is grown in water-scarce areas; changes in rainfall are likely to exacerbate this problem. While coconut plantations will not experience significant yield losses, corn yields may decline by 20-25%, depending on the region.

As a result, food resources will come under pressure. The largest decline in per capita consumption from baseline is projected for the food staple maize, followed by rice, sugar, and fruits and vegetables. Areas suitable for the production of many crops will shrink, forcing farmers to switch crops or stop production altogether. The area devoted to fruit and vegetables may increase (WB, 2022).

In the Philippines, rice is a major crop. However, it is vulnerable to floods, droughts and soil degradation. Corn, which tends to be grown in mountainous areas, is sensitive to changes in temperature and rainfall, and its production is affected by both drought and excessive rainfall (DA 2022 b). Coconut plantations are exposed to storms and high winds (DA, 2022 c). Banana plantations are sensitive to temperature extremes, drought, wind and excessive rainfall, as well as stresses that can cause disease (DA, 2022). On the other hand, sugarcane is exposed to excessive heat (some plantations reached 44°C in 2024), drought, and plant diseases. Fruit plantations, such as mango, are sensitive to temperature variations and extreme weather conditions such as wind, excessive rain or drought, which can reduce production or damage trees (CCC, 2023).

At sea, changes in water temperature, ocean currents and acidification, affect marine habitats and the distribution of fish species, leading to fish migrations. The result is a decline in fish stocks and a reduction in fishermen's livelihoods. Rising sea levels contribute to the degradation of mangroves and coral reefs, affecting stocks of many fish and shellfish. Increased storms and typhoons can damage aquaculture infrastructure, harbors, and boats, affecting fishermen's activities. Overall, climate change is disrupting marine ecosystems and biodiversity, contributing to a decline in fisheries productivity.

Species migrating as a result of climate change provoke conflicts among fishers, disrupt local ecosystems, and pose problems for the management of marine resources (CCC, 2023).

1.2 Government Priorities for Agriculture and Fisheries in context of Climate Change

- *Government Priority for Agriculture and Fisheries*

The agriculture and fishery sectors are a priority for the Philippines, as emphasized in President Ferdinand Romualdez Marcos Jr.'s inaugural message on June 30, 2021, where he stated that the country's agricultural sector "cries for urgent attention." In 2022, agriculture accounted for 8.9% of the gross domestic product (GDP) as reflected in Table 1 and Figure 5 (PSA, 2023), a significant decrease from its 23% share in 1982 as well as in the recent years.

Industry	**2018**	**2019**	**2020**	**2021**	**2022**
Agriculture, forestry, and fishing	*9.7*	*9.2*	*10.2*	*9.6*	*8.9*
Industry	30.6	30.4	29.2	29.9	29.7
Services	59.8	60.4	60.7	60.5	61.4
Gross Domestic Product	100.0	100.0	100.0	100.0	100.0

Table 1: Percent Share to GDP, by Industry, Philippines, 2018-2022 (at Constant 2018 Prices) - Source: Philippine Statistics Authority (PSA, 2023)

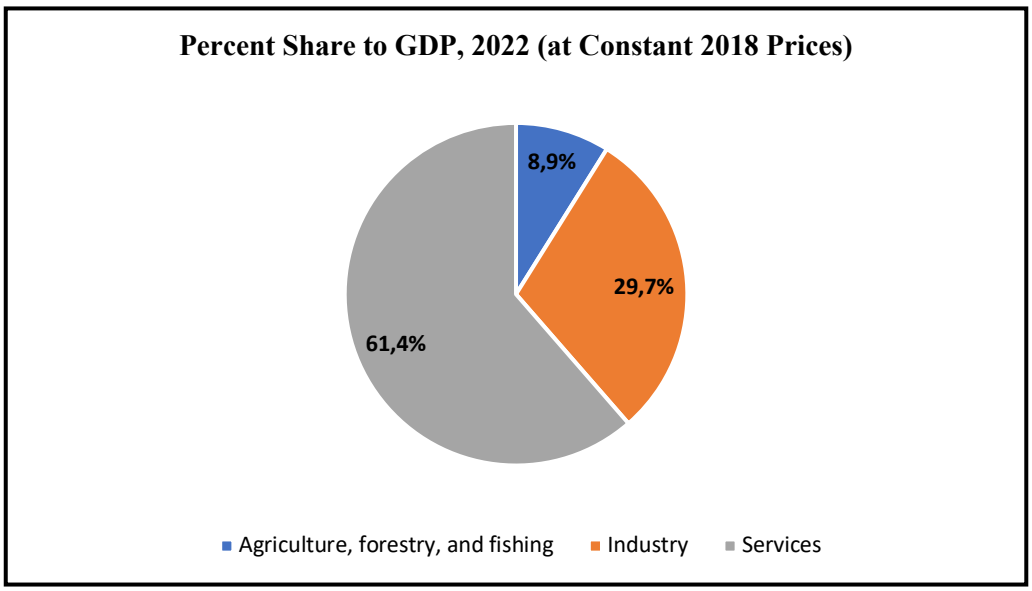


Figure 5: Percent Share of Agriculture, forestry and Fishing to GDP, 2022 (at Constant 2018 Prices – Source PSA)

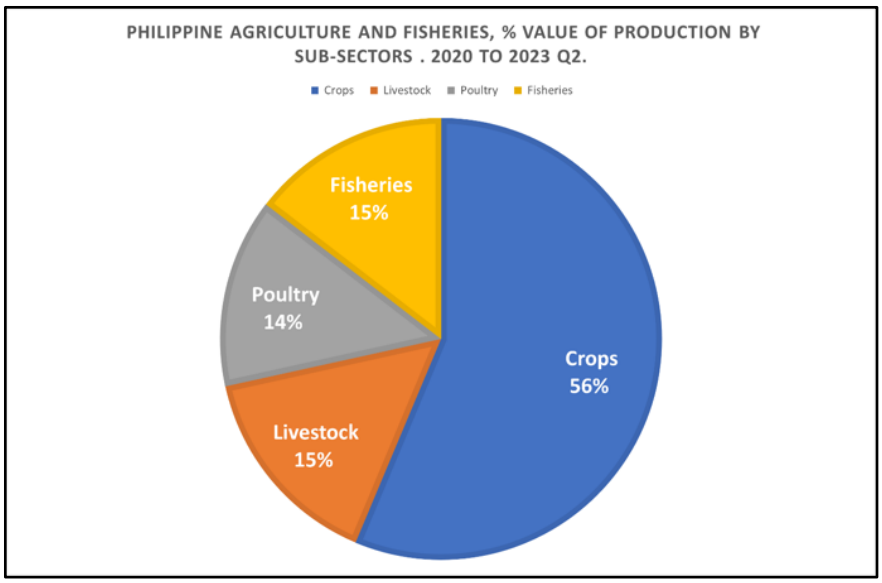


Figure 6: The value of production in Philippine agriculture and fisheries by subsectors (Source: PSA)

The trade deficit widened to -$11.8 billion in 2022 from -$7.0 billion in 2018 (Table 2) (PSA,2023). This expanding deficit makes the country increasingly vulnerable to the international food market given fragile global food security system, series of health and geopolitical crises, and the long-term risk posed by climate change - which is not just a crisis but the foremost risk to life on our planet.

Industry	**2018**	**2019**	**2020**	**2021**	**2022**
Agriculture and Fishery Exports	6,117.84	6,677.06	6,199.96	6,820.91	7,499.59
Agriculture and Fishery Imports	13,141.24	13,531.78	12,575.59	15,706.75	19,303.00
Trade Balance	-7,023.39	-6,854.72	-6,375.63	-8,885.84	-11,803.41

Table 2: Agriculture and Fisheries Trade Balances of the Philippines, 2018-2022 (Export and Import in FOB million USD)
Source: Philippine Statistics Authority (2023)

The Department of Agriculture (DA) and its many offices, the Department of Environment and Natural Resources (DENR), the Department of Agriculture and Agrarian Reform (DAR), and the Bureau of Fisheries and Aquaculture (BFAR) are the agencies in charge of the agriculture and fisheries sector. The National Economic and Social Development Council (NEDA) is responsible for coordinating the activities of these different agencies. It produces a national plan, The Philippine Development Plan, which brings together the government's priorities. This national plan draws upon existing plans produced by the various agencies responsible for the AFF sector, including the National Agriculture and Fisheries Modernization and Industrial Plan 2021-2030 (NAFMIP).

The government's priorities for the agriculture and fisheries sector are set out in the NAFMIP and The Philippine Development Plan 2023-2028 (NEDA, 2023). To respond to the perennial agriculture and fishery sector challenges, the NAFMIP defined National priorities highlighting the need to further transform the agriculture and fishery (A&F) sector in the Philippines, building upon the previous plans grounded in the National A&F Modernization Act (AFMA). The NAFMIP highlights that the sector has

not undergone sufficient reform, citing examples such as the disproportionate allocation of government support: nearly 50% for rice, 13% for sugar, 30% for pigs and poultry, leaving only 7% for other priorities, including essential investment in bananas, coconuts, vegetables, fruits, and climate change.

The NAFMIP is not solely focused on production growth-oriented; it also aims to double smallholder farmers' and fishers' incomes to meet their family needs, considering also their environmental impacts and climate risks, among others. A key strategy to reach this goal involves diversify farming, creating more value adding ventures, and connecting farmers to value chain actors by attracting large private investments. At the local level, one of the strategies is to establish Agri-Fishery Industrial Business Corridors, supported by five pillars: (1) farm and fisheries clustering and consolidation, (2) linking farmers to market, (3) infrastructure development, (4) investment promotion and agribusiness development, and (5) climate change resiliency and natural resource management. Overall, the NAFMIP calls for mobilizing P 8.0 trillion across the 10 years planning duration to achieve the sector's transformation.

The National Development Plan devotes a chapter to the Agriculture, Fishery, and Food (AFF) sector, incorporating the main ideas of the NAFMIP. Three challenges were identified:

1. The sector does not generate decent incomes for its actors along the value chains, particularly at the beginning of the chain for farmers and fishermen, most of whom are unable to escape poverty.
2. The sector does not ensure the sustainable use of natural resources. Farming and fishing practices contribute to the depletion of natural land (particularly deforestation that causes flooding, landslides and soil erosion), coastal and marine resources. Paradoxically, while the sector depends on natural capital as inputs particuarlysoil andwater resources, it contributes to their degradation, which is compounded by the effects of climate change.
3. The final challenge lies at the other end of the value chains, with consumers, who are not guaranteed good nutrition and health by this system.

Based on its findings, this National Development Plan proposes a strategy organized around four outcomes: 1) Enhanced efficiency of AFF production enhanced, 2) Expended access to market and AFF-based enterprises expanded, 3) Improved resilience of AFF value chains improved, and 4) Strengthened agricultural institutions.

Improving the efficiency of the sector requires far-reaching changes in agricultural systems. This includes diversification of farm incomes to make better use of land, water and human capital, in order to increase farm incomes and create more jobs with higher wages. Such changes entail adopting alternative farming models such as agroforestry, agroecology, and precision farming, as well as diversifying production. Additionally, improved technologies are needed to reduce disease threats, enhance sustainability and yields, build resilience to climate change, and reduce input costs to increase farm and non-farm incomes. Measures like systematic composting, utilizing agricultural waste and biological materials for energy and fertilizers, are also crucial components. The plan underscores the importance of increased investment in research and development. Furthermore, it ourlines strategies for grouping farms and fisheries to take advantage of economies of scale.

Market access and business development based on AFF means, for example, opening up new income

opportunities for smallholders, such as for upland communities, agroforestry and the establishment of commercial forest plantations, or for fishing communities, whose activities are often seasonal, opening up and promoting viable livelihood options such as adaptive aquaculture, agrotourism, salt production or agricultural activities.

- *Government Priority for Adaptation in the Agriculture and Fisheries Sector*

Improving the resilience of value chains includes both the development and adoption of climate and disaster-resilient technologies. The plan emphasizes the necessity to increased investment in research, development and extension (RDE) to minimize the impacts of climate change and disastters. This includes the promotion of climate-resilient technologies and nature-based solutions. Propoosed strategies encompass the advancement of improved crop and livestock varieties, adoption of water-saving irrigation systems, implementation of soil erosion control technologies, and utilization of environmentally-controlled crop production systems. Additionally, enhancing resilience requires the establishment of systems to anticipate and analyze the risks associated with climate change.

Strengthening the institutions that serve this AFF sector is obviously the keystone of this strategy. The National Development Plan points to the need to streamline public RDE to eliminate duplication between the various agencies involved.

Two recent documents outline the government's priorities on climate change. The first and most important is the National Adaptation Plan of the Philippines 2023-2050 (NAP,2023), while the second is the Nationally Determined Contribution (NDC) of the Philippines, which primarily focus on mitigation policies. This report will mainly discuss NAP, althoughrecent documents for both policies have been prepared and will serve as references.

The NAP defines the country's priorities for adaptation to climate change. These priorities are divided into eight sectors, starting with Agriculture, fisheries and food security.

Alongside Agriculture, fisheries and food security, the seven other sectors for climate change adaptation and resilience are: 1) Water Resources, 2) Health, 3) Ecosystems and Biodiversity, 4) Cultural Heritage, Population Displacement and Migration, 5) Lands Use and Human Settlements, 6) Livelihoods and Industries, 7) Energy, Transport, and Communications. It is evident that these sectors exhibit a certain degree of interconnection. The NAP recognizes the vital role that ecosystems and biodiversity play in sustaining life and the AFF sector. By protecting and restoring these ecosystems, the Philippines can conserve biodiversity, clean air and water, and help mitigate climate change. This, in turn, improves the resilience of the AFF sector to the effects of climate change and ensures the sustainability of ecosystem services necessary for the activities of smallholders and fishermen. Ultimately, the conservation of ecosystems is a prerequisite for the country's food security. The NAP also notes that four of the eight sectors—agriculture and fisheries, land use and human settlements, energy, transport and communications, livelihoods and industry—face significant economic costs associated with inaction, necessitating urgent action. The cost of inaction in the AFF sector alone is estimated at hundreds of PHP billion.

Agriculture, fisheries and food security are key sectors in the Philippines. Agricultural land covers more than 40% of the country. Agriculture sector is producing 75% of the food consumed in the country but food resources are still a concern as 10% of Filipinos still suffer from food insecurity.

Commodities	2015	2016	2017	2018	2019
Rice	88.9	95.0	93.4	86.2	79.8
Corn	91.3	90.0	94.3	88.4	94.6
Coconut	100.0	100.0	100.0	100.0	100.0
Sugarcane	100.0	100.0	100.0	100.0	100.0
Coffee	33.0	31.9	44.3	29.0	32.4
Cacao	97.5	104.9	99.8	106.6	129.3
Calamansi	100.0	100.0	100.1	100.1	100.1
Papaya	101.1	101.0	101.4	102.2	103.5
Pomelo	100.2	100.0	100.0	100.0	100.0
Tomato	100.0	100.0	100.0	100.0	100.0
Garlic	13.0	11.0	10.1	8.7	7.9
Onion	84.5	47.6	84.6	61.5	90.5
Cabbage	100.0	100.0	100.0	100.0	100.0
Eggplant	100.0	100.0	100.0	100.0	100.0
Ampalaya	100.0	100.0	100.0	100.0	100.0
Peanut	28.4	27.5	25.1	24.7	25.0
Mongo	52.2	52.2	49.2	49.0	50.0
Cassava	100.0	100.0	100.0	100.0	100.0
Sweet potato	100.0	100.0	100.0	100.0	100.1
Potato	85.5	85.2	85.3	83.4	81.9
Beef	70.8	67.3	64.3	61.0	59.7
Carabeef	66.3	68.5	67.3	65.1	71.7
Pork	89.8	89.4	87.5	86.1	87.1
Chevon	100.0	100.0	100.0	100.0	100.0
Chicken (dressed)	87.3	84.7	96.1	93.6	94.1
Duck (dressed)	99.1	99.2	99.4	99.3	99.5
Chicken egg	100.0	100.0	100.0	100.0	100.0
Duck egg	100.0	100.0	100.0	100.0	100.0
Milkfish	100.8	100.8	100.6	101.0	101.4
Roundscad	99.9	99.6	98.6	96.9	78.1
Tilapia	100.0	100.0	99.9	99.9	99.9
Tuna	81.6	83.9	83.6	81.4	76.5
Shrimps & Prawns	104.0	107.0	113.1	103.2	103.7
Crabs	121.0	127.8	140.0	128.7	116.7
Oyster	101.1	100.2	101.4	100.6	100.1

Table 3: Agri Self-sufficiency ratio (SSR) of selected agricultural commodities, Philippines, 2015-2019 (in percent) Source: Philippine Statistics Authority (2022),

The sector accounts for 8.9% of the country's Gross Domestic Product (GDP) and employs a quarter of the country's labor force (Table 4), with 30% of these farmers and fisherfolk living in poverty. The average size of a Philippine farm in 2012 was only 1.29 hectares, which significantly limits the potential for productivity gains from economies of scale (Briones 2021, see NAP page 226). This poverty is one of the causes of the vulnerability of these populations to climate change (see Adaptation plan).

Item	**2018**	**2019**	**2020**	**2021**	**2022**
Population[1/]	105.76	107.29	108.77	110.2	111.57
Labor Force	43.46	44.2	43.88	47.7	49.56
..Employment	41.16	41.94	39.38	43.99	46.89
....Agriculture	***10***	***9.33***	***9.75***	***10.66***	***10.84***
....Share to employment (%)	***24.3***	***22.2***	***24.8***	***24.2***	***23.1***
Unemployment	2.3	2.26	4.5	3.71	2.67

Table 4: Population, Labor Force, and Employment, Philippines: 2018-2022 (in million persons) Source: Philippine Statistics Authority (2022)

[1/] Updated projected mid-year population based on 2015 POPCEN

The NAP proposes five strategies, all of which apply to the agriculture and fisheries sector:

1. The first strategy focuses on strengthening the resilience of infrastructure. It is necessary to strengthen the resilience of water infrastructure, irrigated areas, roads and seaports to withstand the disruptions caused by climate change in AFF sector.

2. To face climate change, it is necessary to safeguard the livelihoods of smallholder farmers and fisherfolk through social protection and regulation, as they are vulnerable populations because they are poor and highly exposed to the effects of climate change.

3. Decentralize decision-making by empowering local governments and communities will help taking adaptation measures at the local and community level.

4. The fourth strategy is to establish integrated governance for adaptation. Adopting adaptation solutions requires a multi-stakeholder and multi-disciplinary approach. This strategy emphasizes the importance of fostering coordinated cooperation between stakeholders along value chains, policy makers and institutions across horizontal and vertical chains of command.

5. Finally, the last strategy proposes the development of nature-based solutions. Given the Philippines' wealth of natural resources, this strategy emphasizes the importance of prioritizing the use of nature-based solutions, where possible, to build climate resilience and protect vulnerable populations. The current trend of choosing adaptation measures based on gray infrastructure such as seawalls, which often have negative impacts, needs to be

corrected. In agriculture and fisheries, nature-based solutions include agroforestry, agroecology, the protection or restoration of mangroves, and the development of technologies that minimize the use of pesticides and other inputs, which are also sometimes costly. This requires adaptation measures based on the best available science and the knowledge of indigenous peoples.

The last point is particularly important as the Philippines' ecosystems and biodiversity are exceptional. They provide ecosystem services that enhance the resilience of the aquaculture, agriculture and fisheries sectors, while protecting communities from climate risks. However, these ecosystems have been severely degraded in recent decades, both as a result of anthropogenic development activities and already as a result of climate impacts. It is of paramount importance to protect and restore these ecosystems in order to enhance the resilience of the agricultural and fisheries sectors in the face of climate change.

The NAP has analyzed the risks of impact from various climate change factors, including temperature rise, drought, sea-level rise, extreme precipitation, winds and tropical cyclones. It notes that these impacts will increase significantly between now and 2050 and presents the priority objectives for the country. The aforementioned objectives can be grouped into the following categories

1. Achieving productive and resilient agriculture and fisheries. This necessitates the utilization of optimal practices and technologies tailored to climate change, with the objective of maintaining food self-sufficiency, diversifying or replacing crops, livestock and aquaculture, and enhancing agricultural infrastructure, with due consideration for the gender dimension. This outcome also requires investment in R&DE to obtain adapted and resilient species.

2. The second anticipated outcome pertains to the prudent management of natural resources to support the ecosystem services that sustain agriculture, aquaculture and fisheries. This includes integrated pest management to combat emerging climate change pests, reduced pesticide-use through biological control, precision agriculture and aquaculture that minimizes agricultural and aquaculture waste, and RDE activities on soil conservation, water-efficient irrigation, climate-resilient crop varieties, circular agriculture and aquaculture, and integrated mangrove aquaculture systems.

3. The third outcome is to ensure that the livelihoods of farmers and fishermen are guaranteed in the context of climate change.

- *Government Priority for Mitigation in Agriculture and Fisheries*

The Republic of the Philippines Nationally Determined Contribution (NDC) outlines the country's GHG reduction commitments. The NDC is focused on climate change mitigation, but the Philippine government has not committed to unconditional emission reduction targets for the AFF sector. The government estimates that the agricultural sector's emissions of 211 million tons of CO2-e can be offset by ongoing plantation activities, such as the planting of 3.6 million hectares of coconuts, which has considerable sequestration potential.

SECTOR	TOTAL	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Agriculture	**539.1**	49.5	49.5	49.4	49.4	49.3	49.1	49	48.8	48.6	48.4	48.2
Wastes	**286.1**	23.3	23.9	24.4	24.9	25.5	26	26.5	27.1	27.6	28.2	28.7
IPPU	**279.8**	15.8	18	18.5	20.7	22.4	24.4	26.6	29	31.6	34.7	38.1
Transport	**689.2**	42.9	45.9	49.1	53.1	57.2	61.1	65.4	70.3	75.6	81.2	87.4
FOLU	**-113.4**	-24.4	-21.6	-18.8	-15.9	-13.1	-10.3	-7.5	-4.7	-1.9	0.9	3.8
Energy	**1659.5**	109.9	116.6	125.5	134.4	143.4	151.5	159.4	167.4	175.5	183.8	192.3
TOTAL:	**3340.3**	**212.8**	**228**	**243.9**	**262.1**	**280.3**	**297.3**	**314.9**	**333.3**	**352.5**	**372.7**	**393.9**

Table 5: Baseline Scenario: GHG Emissions, in Mt CO2e, Philippines Source: OECD Statistics on GHG Emissions (2022)

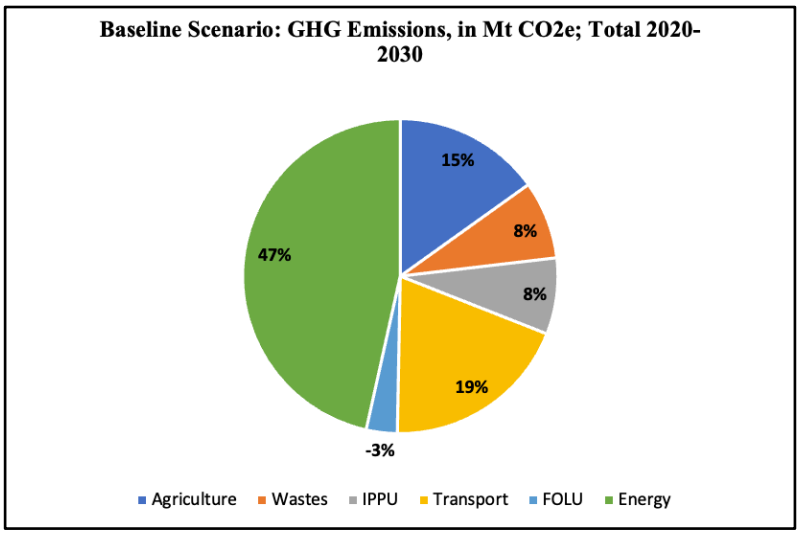


Figure 7: Baseline Scenario: GHG Emissions, in Mt CO2e; Total 2020-2030

However, the NDC allows to identify some government priorities for changing agricultural practices, with the aim of contributing to climate change mitigation in the AFF sector.

1. One of the main sources of carbon emissions from the agricultural sector in the Philippines is irrigated rice. The alternate rice cropping system has the potential to significantly reduce greenhouse gas (GHG) emissions, particularly methane (CH_4) and nitrous oxide (N_2O), two of the main GHGs produced by agriculture. In flooded rice fields, methane is produced by anaerobic decomposition processes of organic matter. However, when rice fields are occupied by dry crops, methane production is reduced. The government plans to adopt this technique on all rice fields, which represents 3.21 million hectares (NDC).

2. The use of natural solutions and selection interventions in livestock enteric fermentation is the second most effective measure for reducing GHG emissions from the AFF sector. Other measures that can help reduce emissions are also contributing to adapting and improving the efficiency of agricultural production systems. Cropland management and precision farming with biotech crops can reduce NO2 emissions from cultivated soils. For instance, practices such as planting deep-rooted plants, nitrogen-fixing trees, cover crops, and using biochar all

contribute to soil health, carbon sequestration, and better nutrient management. These techniques are commonly found in agroforestry and agroecology.

3. Finally, plantations, such as coconut plantations or forest plantations, contribute to carbonsequestration. Their association with crops can also contribute to adaptation by creating cropping systems that are more resistant to wind or excessive temperatures.

1.3 AFF R&D priorities for CC adaptation

- *Government Research Priorities for Agriculture and Fisheries*

Two key entities, The Department of Agriculture (DA) and The Department of Science and Technology (DOST), are responsible for coordinating research for agriculture and fisheries, the first with a core mandate for agriculture and the second for science. Research priorities for the agriculture and fisheries sector are defined through a consultative process involving national agencies under DA as the Bureau of Agriculture Research (BAR) or the Bureau of Fisheries and Aquatic Resources (BFAR), Academic and Research Institutions as universities, colleges and stakeholder groups and industry associations, as well as International Organizations as ASTI or FAO.

The R&D priorities for the agricultural sector in the Philippines were set out in two important documents: the "*National Agriculture and Fisheries Research for Development (2021-2030)"* (DA 2021) and the "*National Harmonized Research and Development Agenda (2022-2028*)" (DOST, 2022). The general objectives of these documents align with the national plans, with priorities established through a coordinated effort and consultation between the different agencies. Considering their respective mandates, DOST prioritized basic and applied research, while the DA-BAR focuses on applied research and extension. Priorities are defined by commodities, but DOST also incorporates some transversal priorities. In the crop sector, for example, there has been a shift in research priorities towards the principles of Climate Smart Agriculture (CSA), encompassing smart farming approaches, optimization of nutrient and water management, development of climate-resilient technologies, intercropping, integrated farming systems, and decision support systems (DOST, 2018).

Crops R&D Agenda Priority Projects
Crop improvement through conventional and new breeding techniques (NBT)
Field verification and adaptability trials of improved crop varieties and/or technologies
Surveillance and management of pests and diseases of selected crops
Postharvest innovations to extend the shelf life of priority crops
Product development and value addition
Smarter Approaches to Reinvigorate Agriculture as an Industry in the Philippines (SARAI)
Roll out of mature technologies
Livestock R&D Agenda Priority Projects
Native Animal R&D Program (Pig, Poultry (Itik Pinas, Muscovy duck, Chicken, Cattle)
Halal Goat R&D Program
Animal genetic improvement
Reproductive biotechnologies
ASF diagnostics, surveillance and vaccine development
Early detection technologies for emerging animal diseases
Breed registry and traceability systems
Innovative food/feed product development
Forage and pasture development
Aquatic R&D Agenda Priority Projects
Aquatic Genomics R&D
Pilot testing of technologies, systems and other products of aquatic research
Fish disease diagnostic tools and vaccines
Alternative feeds and feed additives for improved nutrition of aquatic species
Product development from various aquatic species (including marine toxins)
Rollout/commercialization of aquatic technologies
Climate Change Adaptation and Mitigation and Disaster Risk Reduction Priority Projects
Technology development for resilient and adaptive communities and ecosystems
Enhancement of adaptation and mitigation capacity of vulnerable communities
Knowledge management portal for information and resources on climate change adaptation
S&T Action Frontline for Emergencies and Hazards (SAFE)
Online EWS (Early Warning Systems) for key agricultural commodities
Rehabilitation and climate change proofing of vulnerable agri-aqua and natural resource areas
Identification/Mapping/Biophysical Profiling of vulnerable ecosystems
Inclusive Science for Livelihood in the Agri-aqua Sector (ISLAs)
Quick response S&T- based assistance to AANR communities affected by hazards
Carbon neutral technologies
Role of forestry in disaster risk reduction

Table 6: Priority Projects for 2022-2028 based on the Harmonized National Research and Development Agenda (HNRDA) 2022-2028 - Source: DOST HNRDA (2022)

- *Government Research Priorities for Agriculture and Fisheries and climate change*

In the context of climate change, research and development priorities must align with several government priorities. These include 1) resilience to the impacts of climate change, 2) increasing production efficiency to ensure the country's food self-sufficiency, and 3) improving living conditions and incomes for smallholders and fishermen. Priorities must be set in a sort of triangle, with the three previous poles at the apexes. While climate change mitigation may not be a main priority, but can be a welcome additional outcome for the Philippines.

With the above, the following research priorities have been identified:

1. Those based on nature, so as to preserve the resilience it offers. Research on agroecology, agroforestry, integrated landscape and natural resource management, mangrove restoration, biological control, precision agriculture and aquaculture that that creates synergy between agriculture, forestry and the environment and minimizes agricultural and aquaculture wasteswaste, among others.
2. The research that will enable the production of more efficient crops, without relying much on pesticides or genetically modified organisms (GMOs).
3. The research which will enhance value chain efficiencies while improving livelihood of smallholders and fishermen, with a particular focus on gender.

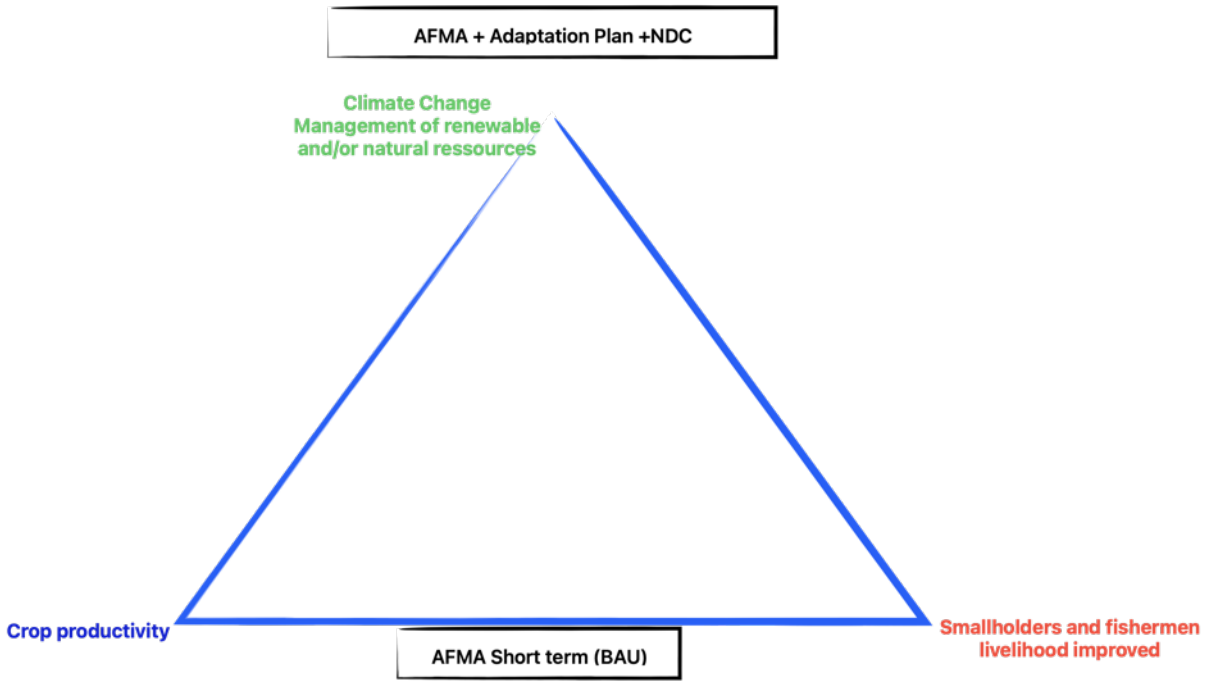


Figure 8: Status of research priorities in relation to 3 key government AFF priorities in the context of Climate Change

According to the ASTI's projections for the Philippines, prioritizing research investments focused on fruits, vegetables, livestock and aquaculture could yield faster and more sustainable growth over the

next 30 years compared to a singular focus on rice (Stads, 2021). This kind of research can simultaneously improve farmers' incomes and be integrated into agroforestry production systems.

2. R&D demand for climate change resilience

2.1 Organization of the Philippines AF R&DE systems

Agricultural and Fisheries research in the Philippines is highly fragmented as noted by Stads & al (2007 a) who count 24 government agencies and 55 HEIs engaged in such mandate. In addition to the divisions that exists in many countries between government research agencies, research conducted in Higher Education Institutions (HEIs[1]), and research conducted by associations or private companies, there is also a division of research within the government itself at the central level and through their many decentralized agencies. The result is a lack of coordination between these different research institutions, regional disparities, and great difficulty in assessing the real research effort in the Agriculture and Fisheries sectors. Furthermore, this fragmentation has the potential to spread already limited financial resources too thinly. In the following sections, we will take a closer look at the organization of R&DE systems in the Agriculture and Fisheries sectors, as well as the related government's priorities including adaptation to climate change.

The AFF R&DE system in the Philippines encompasses most of the services of the Department of Agriculture (DA) and some in the Department of Science and Technology (DOST), as well as the various research centers, universities and colleges, the private sector, Local Government Units (LGUs) and the extension services responsible for agricultural research and extension.

[1] HEI's include both public and private institutions. Public HEIs are composed of: 1) State Universities and Colleges (SUCs); and 2) Local Colleges and Universities (LCUs) while Private HEIs are composed of 1) Sectarian: Owned and operated by religious organizations; and 2) Non-sectarian: Independent institutions not affiliated with a particular religion. SUCs in the diagram is therefore a subset of HEIs.

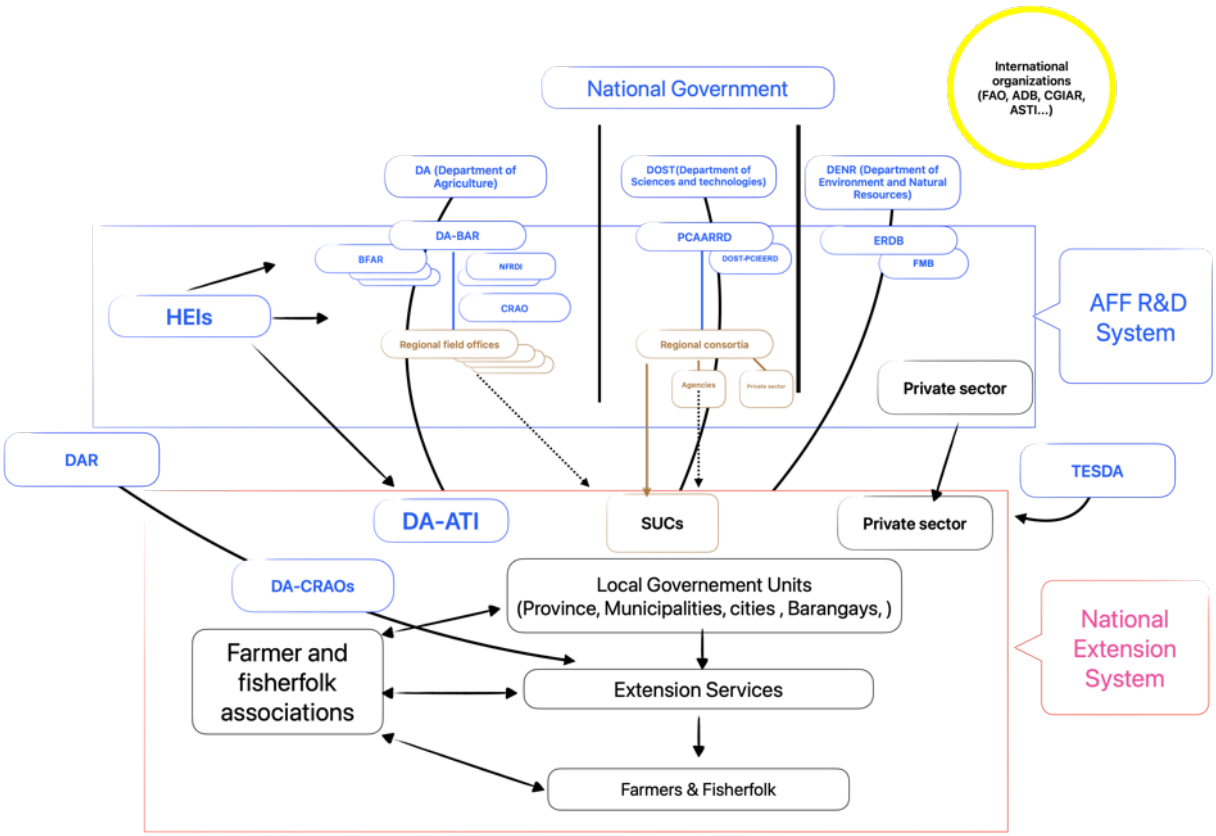


Figure 9: Fragmentation of National R&DE System in the Philippines (Sources: Author from discussions and Baconguis, 2023 ; Stads 2007 a, b)

- *National level*

At the central level, two entities, The Department of Agriculture (DA) and The Department of Science and Technology (DOST), are responsible for coordinating research for agriculture and fisheries, the first with a core mandate for agriculture and the second for science.

The Department of Agriculture (DA) is responsible for policy framework, regulation, public investment and research and extension in agriculture, while the DA has a specialized research bureau, the DA-BAR, it has also various R&DE activities, which are spread across the DA's 9 bureaus[2], 8 attached agencies[3],

[2] DA 9 bureaus: 1) Agriculture Training Institute (ATI), 2) Bureau of Agriculture and Fisheries Engineering (BAFE), 3) Bureau of Agriculture and Fisheries Product Standards (BAFPS), 4) Bureau of Animal Industry (BAI), 5) Bureau of Agriculture Research (BAR), 6) Bureau of Fisheries and Aquatic Resources (BFAR), 7) Bureau of Plant Industry (BPI), 8) Bureau of Soils and Water Management (SWM), 9) Philippine Rubber Research Institute (PRRI).

3 DA 8 Attached agencies: 1) Agriculture Credit Policy Council (ACPC), 2) Fertilizer and Pesticide Authority (FPA), 3) National Fisheries Research and Development Institute (NFRDI), 4) National Meat Inspection Service (NMIS), 5) Philippine Carabao Center (DA-PCC), 6) Philippine Center for Postharvest Development and Mechanization (PHilMech), 7) Philippine Council for Agriculture and Fisheries (PCAF), 8) Philippines Fiber Industry Development Authority (PhilFIDA).

8 attached companies[4] and 15 regional field offices. Under DA, The Climate Resilient Agriculture Office(CRAO) is the office tasked to provide strategic direction and oversight in mobilizing the DA's resources and capacities towards achieving its climate resilient agriculture agenda. This agenda encompasses creating climate-resilient food systems and achieving sustainable increases in productivity, food self-sufficiency and incomes of farmers and fisherfolk, all in the face of a constantly-changing climate. The DA CRAO implements the flagship program of the DA for climate adaptation and mitigation, known as the Adaptation and Mitigation Initiative in Agriculture or AMIA Program. The overarching vision of the AMIA Program is a climate-resilient Philippine agriculture with empowered and prosperous farmers and fisherfolk.

The National Fisheries Research and Development Institute (NFRDI), under the DA, is responsible for research and development for fisheries and aquaculture to improve the practices of stakeholders in the sector. It assesses fish stocks and aquatic resources and collects environmental and economic data to ensure the sustainability of fisheries and aquaculture activities. It provides technology transfer programs and extension services. It is the main agency for advising the government and guiding policy in the sector.

Within the Department of Science and Technology (DOST), the Philippine Council for Agricultural, Aquatic, and Natural Resources Research and Development (PCAARRD) formulates policies, plans, and programs for scientific and technological research on agricultural, aquatic, and natural resources. PCAARRD has eight technical research divisions[5].

Other entities are engaged in research and development activities related to the agriculture and fisheries sector including:

- Higher education institutions (HEIs) also engage in research and extension activities. The Philippines has four national multi-product agricultural and fisheries research universities: 1) University of the Philippines Los Baños (UPLB) - Located in Los Baños, Laguna. UPLB is renowned for its research and education programs in agriculture, food science, forestry and the environment, 2) Central Philippine University (CPU) - Based in Iloilo City, CPU is also known for its agriculture, fisheries and forestry programs, 3) Central Philippine University - Visayas Institute of Agriculture and Technology (CPU-IATFV) - This CPU-affiliated institute is located in Kabankalan City, Negros Occidental, and focuses on teaching and research in agriculture and fisheries, 4) Central Philippine University - Southeast Asian Institute of Agricultural Technology (CPU-ASTI) - Based in Kabankalan City, Negros Occidental, this institute specializes in agriculture and related sciences. Their funding comes from a variety of sources, including government departments (DOST, DA, DNER) via their various agencies, as well as from the private sector and international research organizations. Many research centers are located in HEIs.

4 DA 8 Attached Corporations: 1) National Dairy Authority (NDA), 2) National Food Authority (NFA), 3) National Irrigation Administration (NIA), 4) National Tobacco Administration (NTA), 5) Philippine Coconut Administration (PCA), 6) Philippine Fisheries Development Authority (PFDA), 7) Philippine Rice Research Institute (PhilRice),8) Sugar Regulatory Administration (SRA).

5 PCAARRD' eight (8) technical research divisions are: 1) Agricultural Resources Management Research Division (ARMRD); 2) Crops Research Division (CRD); 3) Forestry and Environmental Research Division (FERD); 4) Inland Aquatic Resources Research Division (IARRD); 5) Livestock Research Division (LRD); 6) Marine Resources Research Dvision (MRRD); 7) Technology Transfer and Promotion Division (TTPD); and 8) Socio Economics Research Division (SERD).-

- Some State Universities and Colleges (SUCS) have specialized institutes and research centers as well. The SUCS are either national, regional or provincial units, but they are autonomous and therefore independent of each other. The country's four national multi-product research universities have limited institutionalized links with regional research universities or regional R&D centers and institutes. SUCS funding comes mainly from government research budget (CPBRD, 2022).

- In addition to SUCs, some private universities also conduct research and development projects in agriculture and fisheries getting funding support from various sources. Notable among these are the Xavier University – Ateneo de Cagayan in Cagayan de Oro City, through its College of Agriculture and the Siliman University in Dumaguete City particularly under its College of Agriculture and Marine Sciences (CAMS).

- The DOST-PCIEERD, The Philippine Council for Industry, Energy, and Emerging Technology Research and Development, under DOST, aims to support the development of priority sectors, including agriculture, fisheries, and renewable or natural resource management.

- The Department of Environment and Natural Resources (DENR) is responsible for the conservation and management of the country's natural resources. The DENR's Ecosystems Research and Development Bureau (ERD) is the principal research and development unit of the DENR which focuses its RDE activities on the five major ecosystems of the Philippines, such as the forests, upland farms, grassland and degraded areas, coastal zone and freshwater, and urban areasERDB) .

- Farmer and fisherfolk associations collaborate with research institutions to develop and disseminate new agricultural or fishing technologies that can enhance productivity and sustainability.

- Private companies as large agri-food companies have established research laboratories to meet their needs. These laboratories are sometimes in partnership with HEIs or SUCS. Some provide services to the public for a fee. They are, at the same time, part of the R&D system and the Extension System

As discussed in Chapter 1, national agencies, through government objectives and the planning system, drive the priorities of the agricultural R&DE system. However, this system is also influenced by HEIs, private, and multinational companies. The private sector is often the origin of new technologies and also of research demands in the agricultural inputs sector, such as seeds, fertilizers, animal feed, livestock, or fish. Government agencies and SUCs are also partners with the private sector through special programs.

- *RDE of National Agencies at Local level*

National agencies conduct research at decentralized levels. The division between the DA and PCARAARD is also reflected at this level:

- DA Regional Field Offices (RFO) serve as the DA national level's relay for promoting agricultural development. Each RFO has an integrated regional agricultural research center focusing on farming systems research, crops, and livestock.

- At the regional level, the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) relies on a network of state universities and colleges (SUC), government agencies, and private companies.

In addition, the Agricultural Training Institute (ATI) functions as the extension branch of the Department of Agriculture (DA). As stated on its website, ATI was established under Executive Order No. 116, issued in 1987. Its main responsibilities include training agricultural extension workers and other stakeholders within the agriculture and fisheries sector. ATI ensures that the training programs meet the actual needs of the agricultural community and effectively communicate research findings to farmers through tailored training and extension activities (https://ati2.da.gov.ph/ati-main/content/our-mandates[6]).

- *Role of LGUs in AFF extension*

The Local Government Units (LGUs) in the Philippines are the administrative divisions below the national government. These LGus are organized at different levels: Provinces are the highest level, followed by Cities and Municipalities, and finally Barangays, which are the smallest administrative divisions. All LGUs are responsible for the delivery of basic public services within their jurisdictions. In particular, LGUs are responsible for providing agricultural and fishery extension services.

Normally, the provincial government is expected to take the lead in planning and organizing the delivery of extension services to all municipalities under its jurisdiction. In practice, however, municipalities often plan and implement agricultural and fisheries extension services independently. The authority of the provincial government is not strong enough to impose its directives on the municipalities, especially when the leaders belong to different political factions. Consequently, municipal LGUs frequently operate independently in planning and implementing their agricultural and fisheries extension services. This situation can present challenges for the effective dissemination of agricultural policy directives from the central government and contributes to the AFF RDE fragmentation.

- *Farmer associations*

Farmers associations collaborate for AFF RDE despite having many other responsibilities, these include: advocacy and representation, access to resources (seeds, fertilizers, equipment, fishing gear, boats, safety equipment and financial services), capacity building and training, marketing and distribution, community development (by supporting infrastructure projects), risk management (insurance scheme, emergency fund to anticipate impacts of climate change, crop failure), networking and collaboration (sharing knowledge and best practices), regulation and standardization to improve product quality and safety. This stakeholder group is essential to the system, as it has a deep understanding of the challenges faced by farmers and fishermen, and therefore of AFF R&D needs.

[6] According to ATI website: By virtue of Executive Order No. 116, series 1987, the ATI was created to be responsible for the training of all agricultural extension workers and other AF clients; ensure that trainings address the real needs of the agricultural sector, and that research results are then communicated to the farmers through the appropriate training and extension activities (https://ati2.da.gov.ph/ati-main/content/our-mandates)

- *Private companies*

The AFMA has succeeded in strengthening the role of the private sector in research and development (Briones, 2022). Private companies invest in RDE to develop new technologies and practices in agriculture and fisheries. These innovations include disease-resistant crop varieties, climate-resilient agricultural practices, efficient water management systems, and sustainable fishing methods. Biotechnology firms, for instance, work on genetically modified crops to enhance yields and reduce pesticide usage, while technology companies develop advanced fishing gear and aquaculture systems that improve productivity and reduce environmental impact.

They engage Public-private partnerships (PPPs) with public research institutions such as the Bureau of Agricultural and Fisheries Industries (BAFI) and the Philippine Rice Research Institute (PhilRice). These partnerships facilitate the sharing of resources, expertise, and infrastructure, leading to faster and broader dissemination of technological innovations.

They are key players in the commercialization of RDE outputs. They have the necessary networks and logistical capabilities to bring new seed varieties, improved fertilizers, and modern fishing equipment to market. Their involvement ensures that innovations reach farmers and fishers, enabling them to enhance their productivity and incomes. For example, agribusinesses may market high-yield seeds and efficient irrigation systems, while fisheries companies distribute advanced aquaculture technologies.

To ensure effective adoption of new technologies, private companies invest in training and capacity building for farmers and fishers. They organize workshops, seminars, and on-field demonstrations to educate local communities about the use of new methods and equipment. For instance, swine owners rely mostly on technologies and extension services from the private sector (Baconquis, 2023).

This approach contributes to technology adoption and strengthens the capacity of producers to innovate and improve their practices. Increasingly, private companies incorporate sustainable and responsible practices into their RDE efforts. They aim to develop solutions that not only boost productivity but also preserve natural resources and protect the environment. Projects may focus on reducing the carbon footprint of agriculture, conserving marine biodiversity, and promoting fishing techniques that minimize by-catch.

Companies play an important role in RDE in the Philippines. But private companies obviously have private interests that may conflict with those of small farmers and fishermen. This is why public RDE research is absolutely essential to safeguard the interests of the weakest players. Non-governmental organizations NGOs also have an important role to play in ensuring that companies work for the common good.

2.2 RDE and regional disparities

There are significant regional disparities in the Philippines in terms of research, development and extension in the fisheries and agriculture sectors. These disparities are influenced by geographical factors, climate, infrastructure, RDE institutional presence and capacity, local policies, access to extension services, private sector involvement and social factors such as conflicts.

There is a regional specialization of agricultural activities that influences associated RDE. The diversity of the Philippines' topography and climate leads to variations in agricultural and fishing practices. For example, the fertile plains of Luzon are better suited to rice and crop production, while the Visayas and Mindanao have more diversified agricultural activities due to the variety of climates and soil types. Coastal regions, especially those with rich marine biodiversity, are more focused on fishing and aquaculture. Luzon, for example, is home to a great deal of RDE on rice.

Some regions are more exposed to natural disasters such as typhoons, floods and volcanic eruptions, which can disrupt RDE activities and affect the implementation of innovations in agriculture and fisheries.

Wealthier regions, such as Central Luzon and Calabarzon, have more resources to invest in RDE activities. These regions benefit from better funding, advanced technologies and easier access to information. They benefit from better financing, advanced technologies and more robust infrastructures. In contrast, poorer regions, such as parts of Mindanao and Eastern Visayas, lack the financial resources and infrastructure to support significant RDE efforts.

RFO	**2018**	**2019**	**2020**	**2021**	**2022**	**TOTAL**
RFO CAR	59,961,000	48,253,000	47,858,000	34,446,000	34,377,000	**224,895,000**
RFO 1	68,944,000	109,877,000	77,945,000	91,024,000	94,872,000	**442,662,000**
RFO 2	176,586,000	129,182,000	117,491,000	98,236,000	110,575,000	**632,070,000**
RFO 3	117,978,000	87,100,000	70,671,000	68,763,000	85,783,000	**430,295,000**
RFO 4A	61,090,000	47,108,000	39,906,000	41,682,000	39,348,000	**229,134,000**
RFO 4B	58,966,000	59,399,000	59,965,000	90,653,000	49,232,000	**318,215,000**
RFO 5	180,576,000	69,583,000	108,099,000	91,936,000	121,058,000	**571,252,000**
RFO 6	83,065,000	79,089,000	74,375,000	83,482,000	70,303,000	**390,314,000**
RFO 7	83,070,000	68,203,000	67,819,000	70,996,000	65,137,000	**355,225,000**
RFO 8	63,036,000	48,230,000	52,942,000	38,736,000	39,794,000	**242,738,000**
RFO 9	71,564,000	63,260,000	66,846,000	65,076,000	47,935,000	**314,681,000**
RFO 10	60,599,000	53,669,000	50,300,000	47,087,000	50,183,000	**261,838,000**
RFO 11	64,324,000	47,663,000	43,939,000	44,409,000	49,627,000	**249,962,000**
RFO 12	64,924,000	57,483,000	57,875,000	58,377,000	57,052,000	**295,711,000**
RFO 13	39,927,000	37,047,000	34,065,000	31,984,000	32,525,000	**175,548,000**
TOTAL	**1,254,610,000**	**1,005,146,000**	**970,096,000**	**956,887,000**	**947,801,000**	**5,134,540,000**

Table 7: Regional Field Office funding for R4D based on the General Appropriations Act 2018-2022

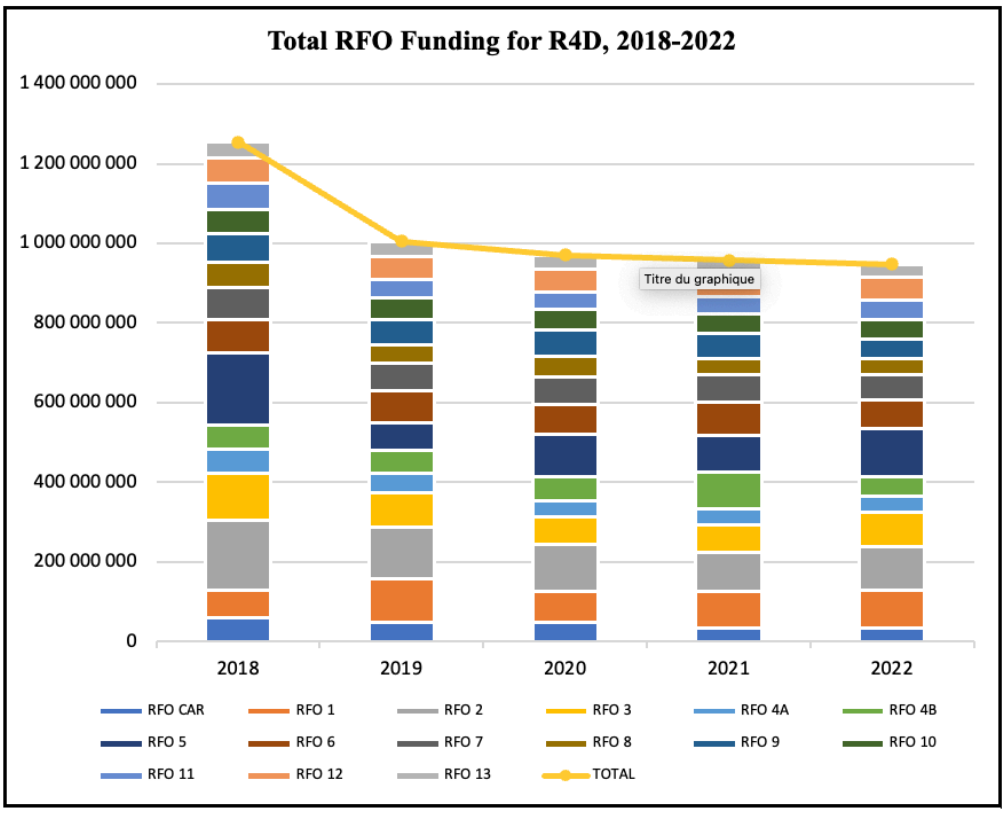


Figure 10: Total Regional Field Office Funding for R4D, 2018-2022

The availability of infrastructure such as roads, transport and communication networks influences RDE activities. Regions with better infrastructure can more easily disseminate research results, transport goods, and provide extension services. Remote and underdeveloped regions often struggle with these aspects, limiting their access to new technologies and innovations.

The presence of research institutes and universities varies from region to region. Areas with major agricultural and fisheries research institutions, such as in Los Baños, Laguna (home to UPLB and the International Rice Research Institute) and Iloilo (home to several fisheries research centers), have more robust RDE activities. Regions without these institutions lag further behind in terms of research results and innovation dissemination.

These various regional factors, favorable or unfavorable to AFF RDE, combine to create contrasting disparities, as shown by a few examples in the following table:

Regions	Institutions	Infrastructures	Challenges	Notes
Central Luzon (Region III)	++++ PhilRice	++++		Rice production, R&DE on high yield varieties
Calabarzon (Region IV A)	++++ UPLB	++++		R&DE on biotechnologies , crop and livestock, research facilities
Western Visayas (Region VI)	+++ Asian Fisheries Development Center (SEAFDEC)	+++ Investments in fisheries research facilities		Investments in Fisheries & aquaculture
Northern Mindanao (Region X)	+++ Mindanao Agricultural Research Center (MARC) and the Northern Mindanao Integrated Agricultural Research Center (NOMIARC).	+++ Growing infrastructure to support agricultural research and development.		high-value crops, livestock, and integrated farming systems.
Bicol Region (Region V)	+++ Bicol University and regional research centers	++ Collaborative efforts with national and international research bodies		Root crops (e.g., sweet potato, cassava), coconut, and abaca.
Ilocos Region (Region I)	+++ Mariano Marcos State University (MMSU) and other regional agricultural research centers.	+++ Strong extension services and community-based research programs.		Tobacco, garlic, and other high-value crops, as well as integrated farming systems.
Bangsamoro Autonomous Region in Muslim Mindanao (BARMM)	- There is a lack of strong, well-funded research institutions and limited private sector investment.	- Poor infrastructure, including roads and communication networks, restricts access to research facilities and extension services.	Ongoing conflicts and security concerns have historically hindered development efforts, including R&DE activities	These challenges have led to low levels of agricultural productivity and limited adoption of modern agricultural and fisheries practices.
2. Eastern Visayas (Region VIII)	- Limited presence of major research institutions and inadequate extension services.	-	The region is highly prone to typhoons and other natural disasters, which disrupt agricultural activities and damage infrastructure.	High levels of poverty limit both public and private investments in R&DE. The region struggles with low agricultural yields and underdeveloped fisheries sectors, compounded by frequent disruptions from natural disasters.
Caraga (Region XIII)	- Limited presence of R&DE institutions	- Poor transportation and communication infrastructure limit connectivity and hinder the implementation of R&DE programs.	Remote and difficult-to-access areas impede the flow of information and resources necessary for R&DE	High poverty rates and low levels of investment affect the capacity for innovation and technology adoption. Limited technological advancements reach local farmers and fishers.

Table 8: RDE regional disparities (sources : synthesis from Stads, 2007 b)

2.3 AFF RDE Planning

The coordination of the RDE system is essential for the effective governance of research; to achieve this, it is necessary to ensure that priorities are aligned and harmonized. AFMA has designated the DA as the leader of the RDE system and DA must coordinate with the DOST-PCAARRD (Briones 2022). But in practice, both DA and DOST are coordinating R&D, which could be perceived as a challenge.

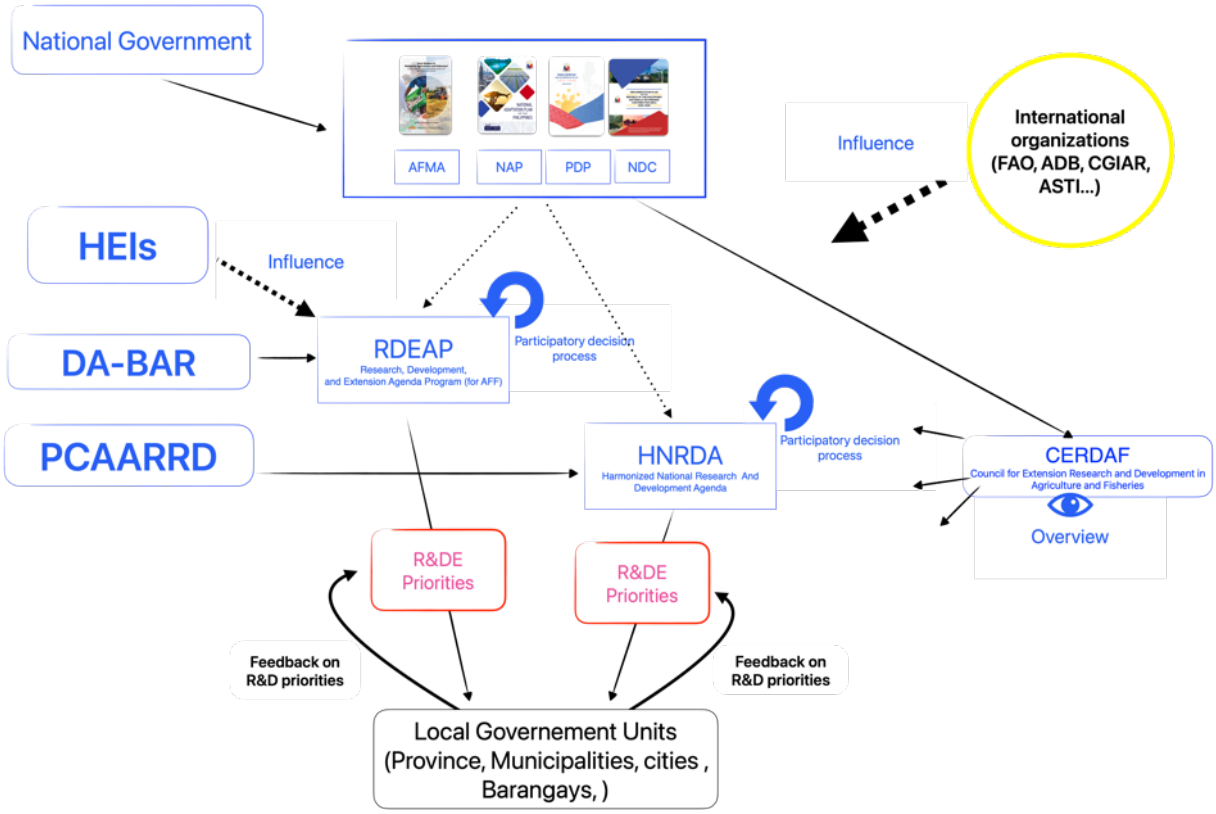


Figure 11: Planning AFF R&D decision process

The Council for Extension Research and Development in Agriculture and Fisheries (CERDAF) was established following the AFMA and is responsible for overseeing the implementation of an R&D and extension program via the Extension Research and Development in Agriculture and Fisheries and the National Extension System for Agriculture and Fisheries (Briones 2022). It appears that CERDAF is unable to exert significant influence over the R&DE decision process.

In addition, the AFMA has established a National Information Network (NIN) to collect data on agriculture and fisheries and make it more accessible in conjunction with research institutions. NIN shall be set up from the Department level down to the regional, provincial and municipal offices (Rowena, 2023). The NIN was scheduled for implementation in 1997, but it's full implementation has yet to be seen and fully maximized.

The DA's Bureau of Agricultural Research (BAR) and the DOST's PCAARRD sought to address the lack of a national agenda for agriculture, water and natural resources by developing RDE plan through multi-stakeholder consultations, each with different frameworks. The DA used the value chain approach as a framework for defining priority programs, while PCAARRD focused the development of cutting-edge technologies. Both agencies defined their priorities by products. To transfer their priorities, each of these agencies relies on a regional presence - either through the DA's RFO for the

BAR, or through consortia with HEIS, SUCS and private sector for the DOST (Baconguis, 2023).

BAR conducts multi-stakeholder consultations to develop priority agricultural programs, known as the Research, Development and Extension Program (RDEAP) 2016-2022. Using the value chain approach, this policy has focused on roadmaps as for staples, cash crops, plantations, poultry, livestock, beekeeping, fisheries and aquaculture[7]. The DA and its agencies have been tasked with implementing these roadmaps, with the exception of biofuels, which were to be covered by SUCS.

Under the National Harmonized R&D Agenda[8], the DOST analyzed the R&D needs and calculated the needed budgetary requirement over 7 years for the Agriculture, Aquatic and Natural Resources sector, which includes R&D in forestry, natural resources and the environment (DOST, 2022).

2.4 The players along the value-chains

It is important to differentiate between players in agricultural value chains and those linked to fisheries.

In Agriculture sector, the majority of farmers are smallholders who face numerous challenges, particularly limited access to technology, credit, and markets. In contrast, some large farms are managed quite differently, as they have resources, easy access to markets, and are often well integrated into modern value chains.

Input suppliers mainly supply farmers with seeds, fertilizers, and pesticides. There are two types of service providers in this sector: small local companies and multinationals. The latter have access to higher-quality products. For instance, in the corn sector, 82% of farmers are smallholders, with an average age of 49 and a farm size of approximately 0.54 ha. Due to the small size of farms, farmers in corn sector, are unable to achieve economies of scale, and yields are the lowest in the ASEAN region at 4.2 tons per hectare. The price of genetically modified seeds accounts for a significant 17% of production costs. The price of seeds has risen sharply by an average of 5.8% between 2002 and 2018. This indicates that the major players who control seeds have a quasi-monopoly position (Adriano, 2023).

Middlemen and traders play a crucial role in bringing farm produce to market. These middlemen enable small farmers to sell their produce, but are often in a position of power that allows them to exploit these small farmers. These traders occasionally extend credit to small farmers who encounter difficulties in obtaining loans from traditional financial institutions. This can result in a heightened level of reliance of these small farmers.

Processors are of different kinds, depending on the sector. In the case of corn value chain, corn is sold to millers who transform it into feed for livestock, poultry, or aquaculture. There are different categories of processors: some are industrial, such as San Miguel Foods, which specializes in the production of animal feed and supplies most of the country's demand for commercial animal feed, while others are small-scale, with processing carried out directly on the farm. In the case of chicken meat production, there is a high degree of concentration, with four to five companies holding over 50% of the market. These companies produce their own chicken feed, use contract growers to produce the chickens, and take care of sales, right up to supermarkets or retail outlets.

Retailers include local markets, supermarkets, and companies exporting agricultural products. Their

[7] These roadmaps are accessible at: https://www.da.gov.ph

[8] NHRDA: National Harmonized Research and Development Agenda (2022-2028)" (DOST, 2022)

demand for quantity and quality influences production and agricultural standards.

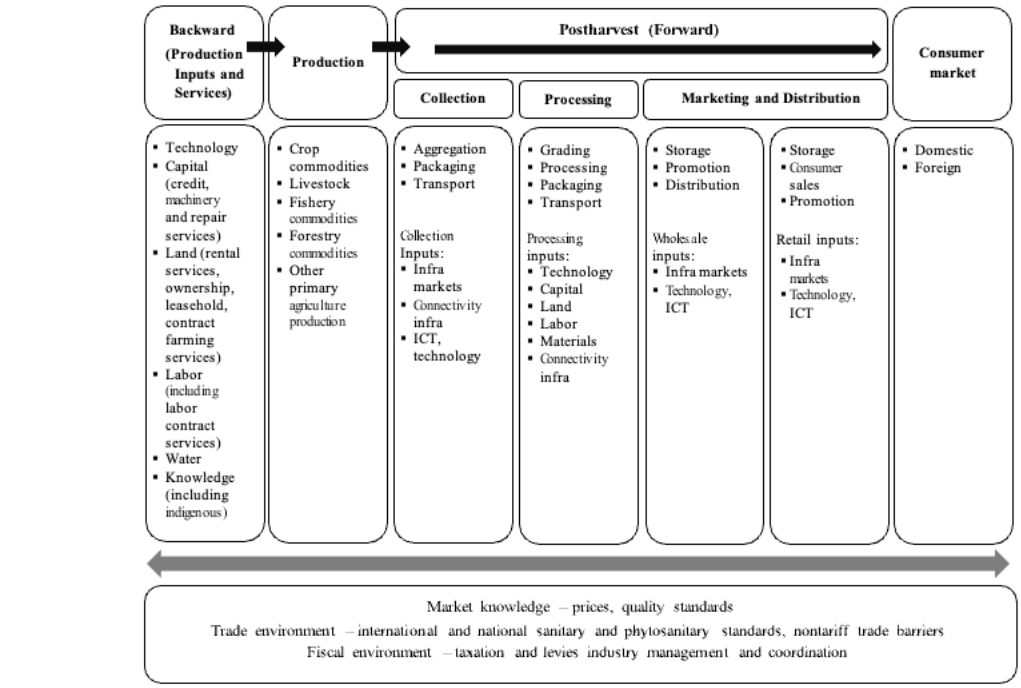
In the fisheries sector, a distinction is also made between small-scale fishermen, whose number dominates the sector and use traditional fishing methods, and commercial fishing companies. The latter use more advanced technologies and make a more significant contribution to catches, but sometimes pose problems for the sustainability of the resource and ecosystems.

Service providers in the fisheries sector supply fishermen with fishing gear, boats, nets, or feeds to aquaculturists. For example, in milkfish production, which is mainly from aquaculture, feed accounts for about 60% of total operating costs. Other inputs include the purchase of alvin from hatcheries, of which there are not enough in the Philippines; some alvin for milkfish are imported from Indonesia and Taiwan.

Traders and intermediaries, who enable fishermen to sell their products on the market, affect the income levels of fishermen, depending on their practices.

Processors play a pivotal role in the aquaculture value chain, utilizing a range of processing technologies, including preservation by salting, fermentation, smoking, freezing and canning, as well as the production of minced fish as surimi. However, in the Philippines, the milkfish industry is not yet sufficiently developed and is still often processed by home-based businesses, with the exception of a few industries focused on processing and exporting milkfish.

The AFMA policy has led to some notable successes, particularly in terms of improving access to technology services for large companies. However, there is still a significant challenge for small-scale farmers and fishermen, who continue to face limited access to credit and the market. Additionally, they remain highly vulnerable to exploitation by middlemen.



ICT = information and communications technology
Source: Adapted from ADB (n.d., p. 2).

Figure 12: Generic agriculture-based value chain components (Source: Adriano, 2023)

2.5 Bottle-necks in Extension services

Agricultural extension services in the Philippines are under the authority of local government units (LGU)[9]. Within DA thirty entities have extension programs: five DA' bureaus - ATI, BFAR, BAI, BPI, Bureau of Soils and Water Management (BSWM) ; five attached agencies - PhilFIDA, PCC, Philippine Center for Postharvest Development and Mechanization (PhilMech), PRRI, and National Fisheries Research and Development and Mechanization ; five corporations - NDA, NTA, PCA, PhilRice, and SRA; and all DA's 15 regional field offices. ATI has the explicit function of conducting nonformal education, with its regional training center. Dost-PCARRAAD, DAR, and SUCS are also engaged in extension work. Extension services are fragmented and based on commodities, with the rice program (35%) on top, followed by livestock (22%), high-value crops (21%), and corn (17%) (Baconguis, 2023).

In order to oversee the RDE system, AFMA established the Council for Extension, Research and Development in Agriculture and Fisheries (CERDAF). The law and its implementing regulations set the budget for extension services at 1% of gross value added in agriculture and fisheries, with another 1% also earmarked for R&D. However, CERDAF was unsuccessful, and AFMA was unable to address the complex and cumbersome bureaucracy of the public agricultural RDE system due to inadequate funding and a lack of priority. The effectiveness of LGUs extension services has been minimal (Briones, 2023).

As a result, agricultural or aquacultural extension activities face challenges in securing adequate funding, particularly for the recruitment, training, and equipping of extension workers. This hinders their ability to deliver quality services to small-scale farmers or fishermen. Although BAR's Human Resource Development Program contributes to improving the human resource pool of agriculture research, development, and extension professionals, there is a shortage of well-trained extension workers. In the field, these extensionists are tasked with covering vast territories about 10 barangays or 500 farmers/fisherfolks. They are poorly paid, the median extension workers income is PHP 14,165 per month (Baconguis, 2023). They lack the capacity to provide small farmers or fishing communities with the necessary services. There is a lack of opportunities for extension workers to enhance their knowledge, as there are few training opportunities available to them. A significant challenge is the absence of connections between research institutions and extension services, which limits the dissemination of new technologies and practices to the field. Additionally, the use of modern training and communication methods is still limited, with extension services relying on traditional communication channels that do not reach a wide audience. There is a need to integrate modern information and communication technologies (ICT) to improve knowledge dissemination. All these hinder the implementation of modern practices tailored to climate change in the agricultural and fisheries sectors, which in turn affects the productivity and sustainability of these sectors. There are 3 general solutions to these problems:

- Increase budgets for extension services to employ better-trained staff and provide ongoing training, thus improving access to and the quality of extension services for smallholders and fishing communities (Briones, 2023 ; Otsuka, 2021).
- Strengthen links between research and extension to accelerate the adoption of new technologies.
- Use ICT.

[9] "*The Constitution instituted autonomy for local governments (Article II, Section 25). This was eventually legislated by the Local Government Code (LGC) of 1991 under RA 7160, wherein agricultural extension services were devolved to local government units (LGUs), meeting the fourth Green Book recommendation* » (Briones, 2023 p 49).

More precisely, Briones (2023, p 71) suggests implementing the following measures to improve the effectiveness of RDE services: mobilizing CERDAF, closing the RDE funding gap, and establishing a monitoring and evaluation (M&E) system to hold the actors delivering RDE services accountable. He also suggested (p 77) reallocating expenditure support programs of AF sectors from specific agricultural commodities as rice or corn, to public goods and general services, such as extension services, R&D and market aids. These could also be direct benefits to small farmers, helping them to recover more quickly from climatic shocks.

3. Review and Analysis of the RDE

3.1. Government supports to AFF and RDE budgets (gaps and government priorities)

DA AFF RDE and Total AFF RDE of the Philippines

The AFMA had set the R&D budget at 1% of GVA in agriculture and fisheries (Briones, 2023), this was to be done in 2001, with an equivalent amount to be allocated to extension services. The budget shall be allocated on a multiyear basis and based on R&D grants. The minimum of 1% was never reached for R&D.

Government support for AFF R&D represents a relatively small portion of the government's General Support Service (GSS) for the AFF sector. This share, in relation to the overall government budget for supporting the agricultural sector, has fluctuated over time but remains low at around 3 to 4 %, it was 10 % in 2000 and is about 20 % in Europe (see figure below from OCDE GSSE). Over the same period, the share of extension services was maintained at 15-20% of AFF GSS.

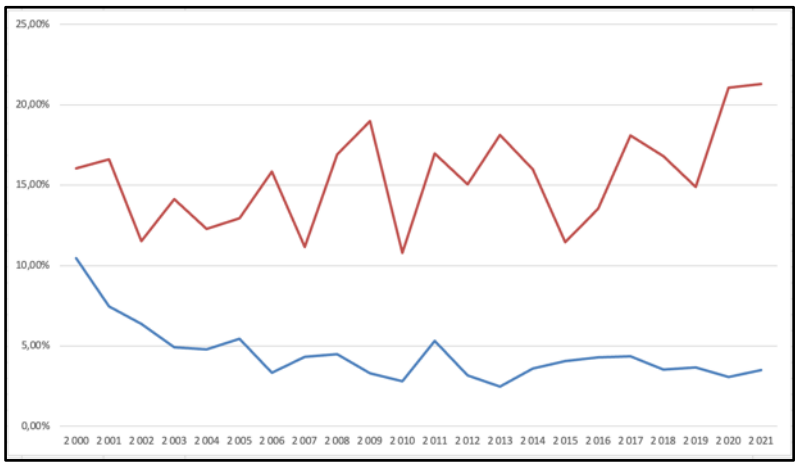


Figure 13: Government support for AFF RDE: ratio of R&D expenditures (in blue) or Extension (in red) on AFF General support service GSSE (Sources OCDE)

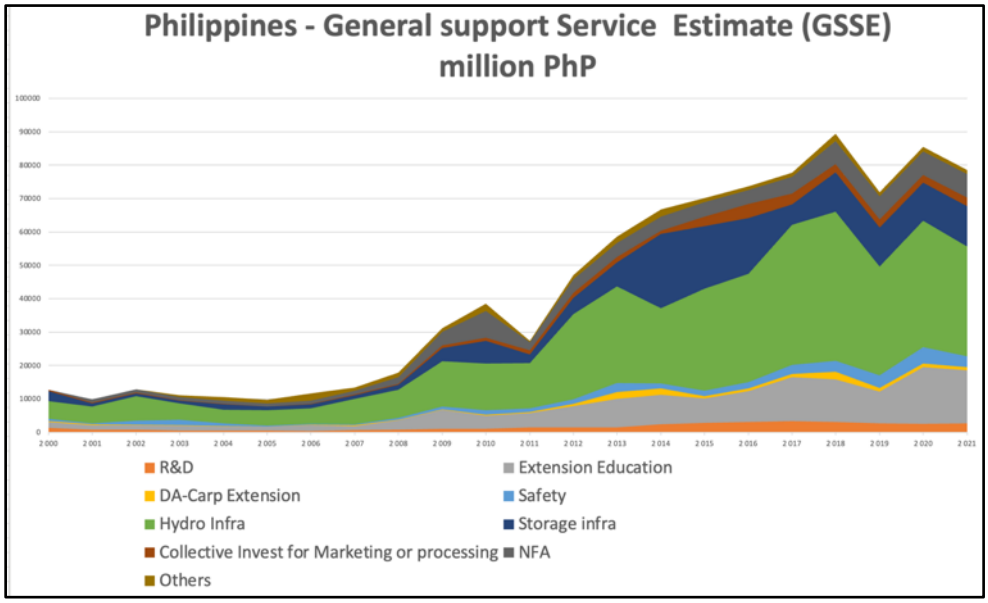


Figure 14: Breakdown of General support service Estimate (GSSE) for The Philippine agriculture and fisheries sector at current prices. Source of data: OECD (2022).

Furthermore, government support for R&D represents only a portion of total R&D expenditure in the Philippines. In addition to government support, higher education institutions (HEIs), the private sector, and non-governmental non-profit organizations contribute to national AFF R&D efforts. This share of the government's R&D budget varies, depending on private sector investments, which can vary greatly from one year to the next. In 2018, this government share represented 63% of total R&D expenditure (Source DOST).

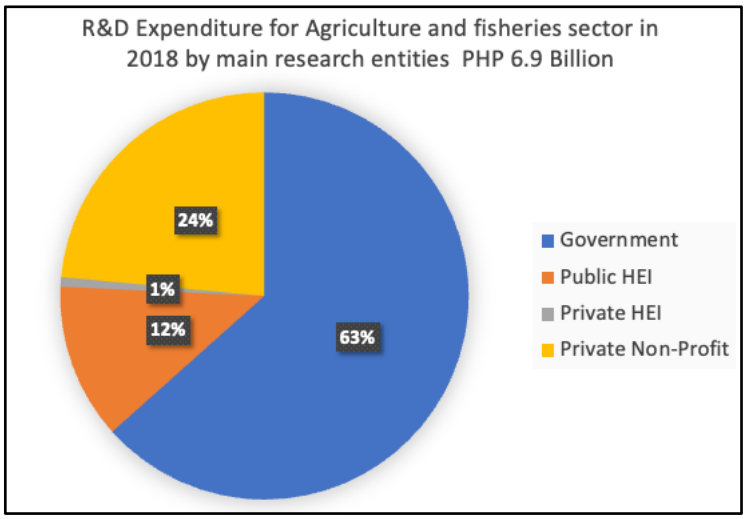


Figure 15: AF R&D expenditure by research entities in Philippines (calculated from DOST 2018 data)

However, government support for AF R&D consists mainly of the AF R&D budgets of the Department of Agriculture through its research office, DA-BAR, the DOST through the PCAARRD, and to a lesser extent, of the DENR.

Upon closer examination of the Department of Agriculture's AF R&D budget, it becomes evident that the majority of funding is directed towards rice and, to a much lesser extent, corn. High-value-added crops, livestock, and organic crops, which are nevertheless crucial for diversifying and increasing the incomes of small farmers in a context of climate change, are the least funded areas of AF R&D (See figure 16).

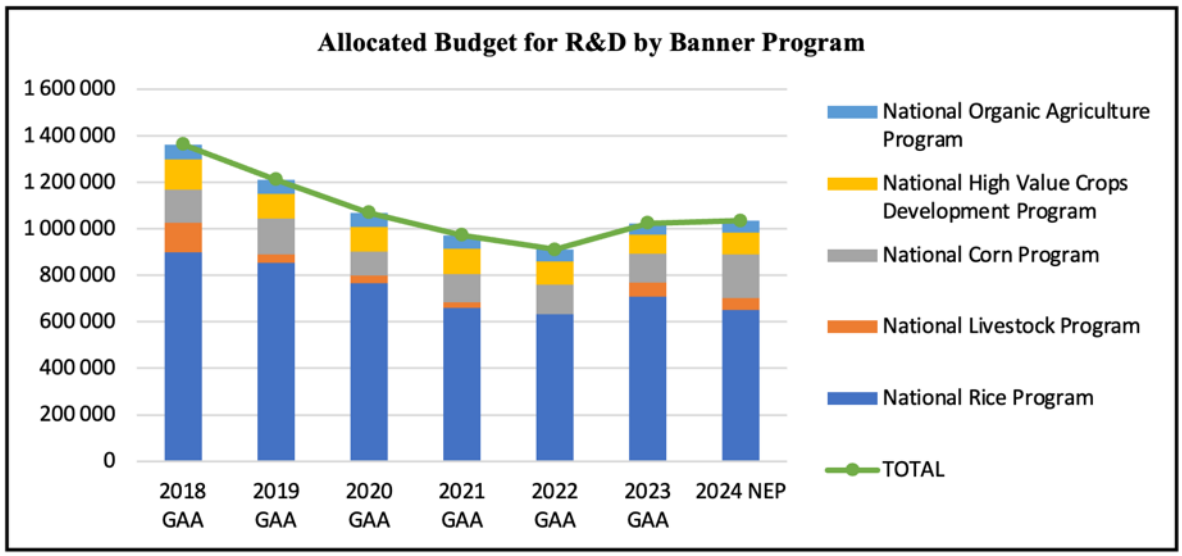


Figure 16: Allocated Budget for R&D by banner Programs. Source: DA Planning & Monitoring (2023)

We can also observe (figures 13, 14, 21) that in recent years in absolute and relative terms, especially since 2018, R&D spending has declined and this is reflected in DA R&D spending (Figure 16). Expenditures on extension has remained at a level proportional to overall government spending on agriculture (Figure 13).

Planned R&D budget

The agriculture and fishery sector is a major priority for the Philippines, as emphasized in President Ferdinand Romualdez Marcos Jr. The expanding trade deficit makes the country increasingly vulnerable to the international food market given fragile global food security system, series of health and geopolitical crises, and the long-term risk posed by climate change. Against this backdrop, the government is planning to increase its AFF R&D budgets. This is reflected in the DOST agenda, Harmonized National Research and Development Agenda 2022-2028 (HNRDA, 2022).

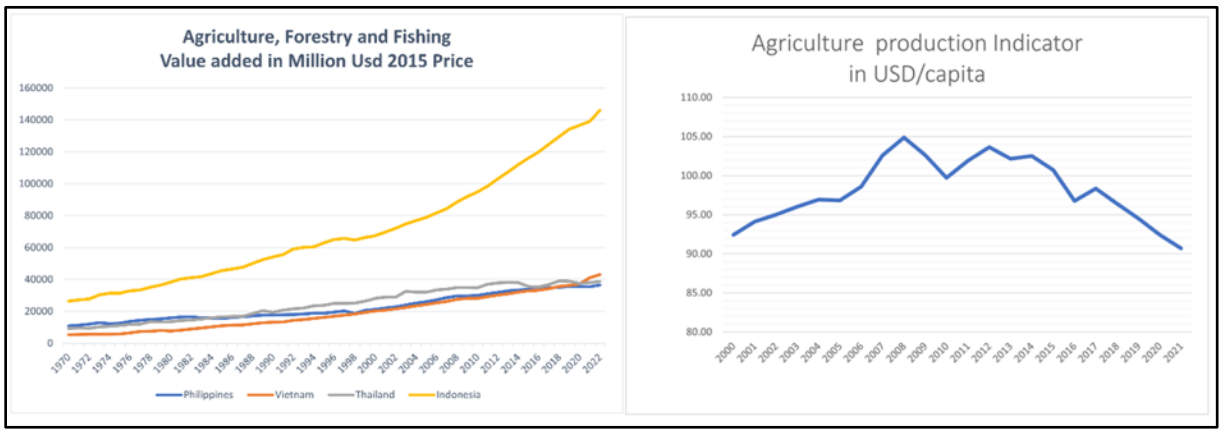


Figure 17: Agricultural growth in Philippines has been stagnant in recent decades (Sources: FAOSTAT).

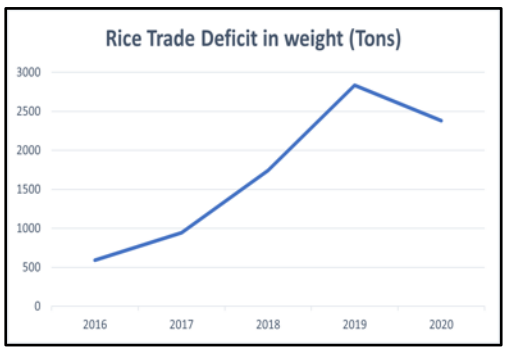


Figure 18: Rice trade deficit has been multiplied by 5 in 4 years (Source of data: UN COMTRADE).

SUMMARY	2022	2023	2024	2025	2026	2027	2028	TOTAL
A. CROPS R&D AGENDA	640.4	884.26	1068.49	1170.26	1173.5	1061.73	1,163.57	7,162.21
B. LIVESTOCK R&D AGENDA	238.93	373.88	364.84	322.17	374	376.5	344	2,394.32
C. AQUATIC R&D AGENDA	444.43	771.57	696.76	609.47	602.9	498.4	524.1	4,147.63
D. FORESTRY R&D AGENDA	339	379	421	424	483	518	391	2,955
E. NATURAL RESOURCES AND ENVIRONMENT R&D AGENDA	312.98	487.65	564.72	639.2	567.37	491.24	481.46	3,544.62
F. CLIMATE CHANGE	13	34	59.5	64.5	67.5	72.5	67.5	378.5

Table 9: HNRDA 2022-2028 Proposed Budget (in million Pesos), Source: DOST, 2022.

It is evident from table 9 and graph 16 that the focus remains on crops, the aquaculture, livestock and environment R&D budgets remain relatively stable, and research into climate change is emerging slowly (HNRDA, DOST, 2022). The budget proposed by DOST represents a significant increase in the budget for AF R&D in the coming years.

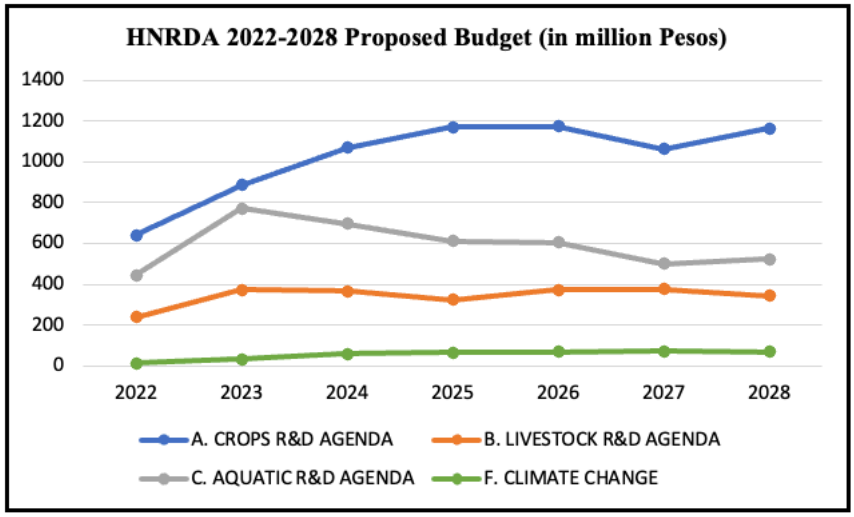


Figure 19: HNRDA 2022-2028 proposed budget (in million Pesos) (Source HNRDA)

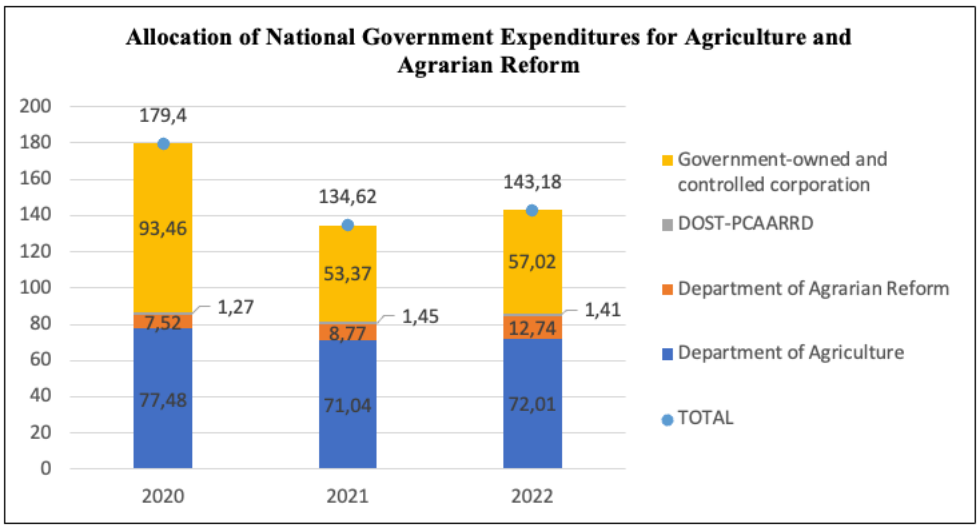


Figure 20: Allocation of National Government Expenditures for Agriculture and Agrarian reforms

Gross rate of value added % (source PSA)	2001-10	2011-18	2019	2020	2021
Agriculture	**3.5**	**2.1**	**1.2**	**-0.2**	**-0.3**
Crops	2.3	1.1	-2.0	1.5	2.2
Livestock & poultry	4.2	4.1	5.5	-4.7	-8.1
Fisheries & aquaculture	7.0	1.1	2.5	-1.3	0.2

Table 10: Growth rate of Agricultural GVA by subsector (2001-2021) (%) in 2018 (Source PSA).

3.2. Philippines AFF R&D budget is below international standards

The R&D budget in the agriculture and fisheries sector in the Philippines is below international standards. Significant yet achievable increases in R&D budget are needed to make the sector competitive, innovative, impactful and resilient to climate change impacts.

From 2018-2022, the R&D budget of the Department of Agriculture (DA) of the Philippines ranges from P3.12 billion (2021) to P3.93 billion (2018) out of the total annual budget of P85.6 billion (2021) and P103.07 billion (2018), respectively. By standard definition, R&D expenditures basically include current and capital and MOOE[10] expenditures to implement various types of research work may it be basic, applied and experimental or combinations thereof. If by any indication, a declining trend of the R&D budget for the DA Bureau of Agricultural Research (BAR)--the major research arm of the department, has been noted particularly from 2018 onwards (Figure 16 & 21). While most of the agencies and bureaus under the DA are also engaged in R&D, department's budget is largely focused on major staple especially rice. The role of the government spending on R&D remains crucial as it constitutes a major share in the overall R&D spending of the country. In a report by OECD (2022), the breakdown of the General Support Services Estimate (GSSE) in the Philippines reached about P90 B in 2018 but the R&D budget is small accounting to 3.5% only (Figure 13 and 14).

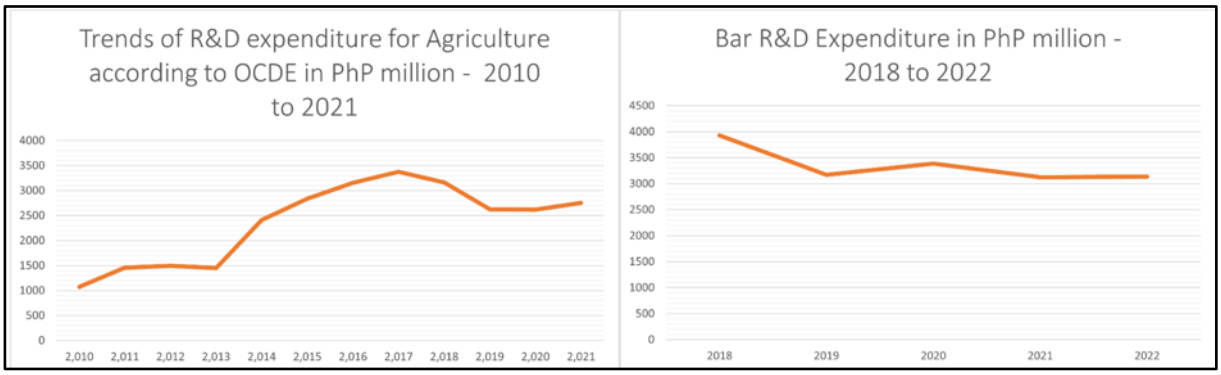


Figure 21: DA-BAR Expenditure (on right) and OECD R&D budget estimate (on left) for the Philippines Agriculture and fisheries sector at current prices. Sources of data: OECD (2022) and DA-BAR (2023)

Overall, while the Philippine government's spending on R&D in agriculture and fisheries sector is at $3.5 for every $100 it spends to support its agriculture, it is $6 in Vietnam, $10 in Brazil, $11 in China, and $21 among OECD countries (OECD, 2022) (Figure 23).

Additionally, the total public spending for R&D as a percentage of national production of the Agriculture and Fisheries sector (AgGDP) is another commonly used indicator to measure the country's research intensity. In the Philippines, this ratio is very low pegged at around 0.15 % (OCDE, 2022), while an earlier report puts it at 0.41 in 2017 (Stads 2021). In contrast, this ratio reaches between 1 to 2% in Malaysia, 2% in Brazil, and 3 to 4 % in most OECD countries. In effect, the Philippines faces a significant deficit of attainable investment for agriculture R&D, as measured by the difference between actual research intensity (public research expenditure/AgGDP) and potential attainable research intensity (Figure 17).

[10] Maintenance and Other Operating Expenses (MOOE) refers to the expenditures to support the operations of the research project or program, such as, but not limited to supplies and materials, transportation, travel, utilities, repair, etc..

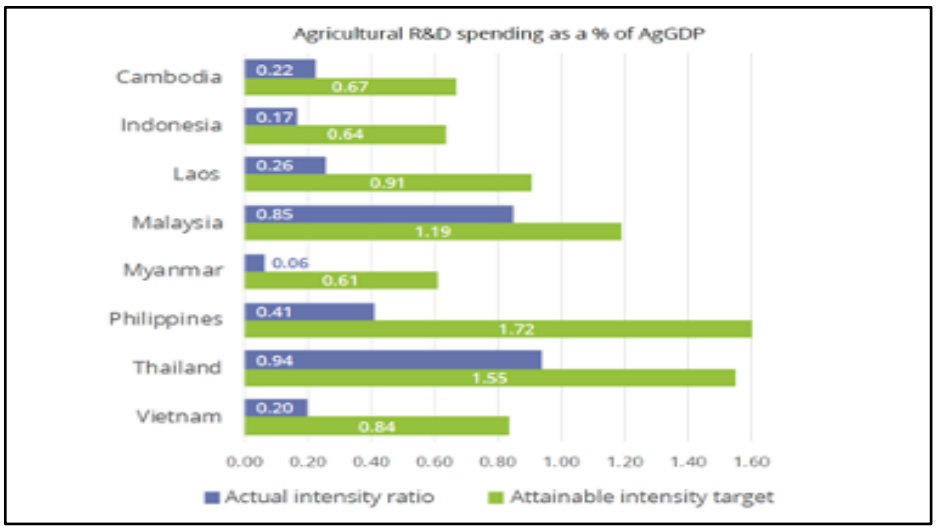


Figure 22: Agriculture research intensity ratios and attainable targets in 2017 for different countries of South-East-Asia. Sources of data: ASTI and Nin Pratt in Stads G.J. & al. (2020)

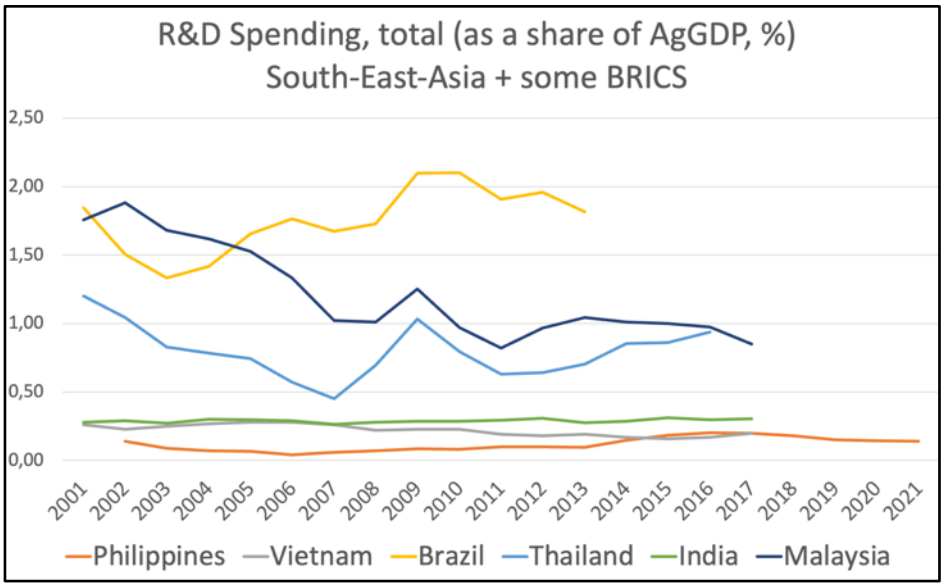


Figure 23: R&D budget spending in % of AgGDP for different countries around the world. Source of data: ASTI: https://www.asti.cgiar.org/data-graphics and OECD (2022)

There are ways in the Philippines for increasing the R&D budget without imposing significant strain on the national budget (Figure 14). Shifting producer support policies from market price support to expenditure support would be a more efficient use of public funds. A broader and deeper appreciation by all of the value of R&D and extension as public goods thereby meriting government spending would be strategic (Briones, 2022).

In addition to the usual administrative and procurement concerns, recent studies have highlighted the slow growth of the number of researchers and a huge fragmentation of research (Dikitanan & al 2022, and Stads G.J., 2021) as among the major issues of the agriculture research system in the Philippines. This means that any increase in the budget must also consider the absorptive capacity of the agriculture and fishery sector research system.

3.3. Why R&D is the best government investment for supporting AF resilience?

The R&D investment in the agriculture and fisheries sector in the Philippines pays off and promises huge potential for economy-wide impacts should systemic changes be achieved, with increased budget playing a crucial role in unlocking this potential.

There is ample evidence that public investment in agricultural R&D ushers in significant returns and has been a key element in yield increases and rural poverty reduction in the South (OECD 2022; Alston 2021; Piesse & Thirtle 2010). The R&D is making it possible to produce more food per hectare with the same or fewer inputs that cause pollution and greenhouse gas emissions. Based on a meta-analysis of $60 billion in R&D spending around the world, Alston (2021) was able to show that the cost-benefit ratio is on average 1 to 10, making R&D the best investment a government can make to support its agriculture sector.

In addition, investments in research in the Philippines yields significant results in terms of the rate of return. The R&D investments are generally more profitable than other investments, and for the primary sector such as agriculture, rates of return are around 60% (Cororaton, 1999). Specifically, regarding rice varietal R&D, a recent study by Dikitanan et al. (2022) estimates the economic returns to investments in rice varietal development in the Philippines and Bangladesh to be strongly positive in both countries. However, the net returns to partners' investments are decreasing at a faster rate in the Philippines (24%) than in Bangladesh (6%). Furthermore, the use of improved rice variety in the Philippines is decreasing over time, showing other issues along the value chain. On the other hand, the DOST-PCAARRD publishes a regular bulletin on the impact assessment of the R&D system, finding that research helps farmers to engage in profitable activities particularly on innovations related to key commodities like goat production (IRR of 35%) or food fish (IRR of 21%), among others.

3.4 Improvements to increase resilience to Climate change in AF sector

Climate solutions are increasing but would require more R&D investment to make it bigger, smarter, and more impactful.

As among a major response could be Climate-Smart Agriculture (CSA) that for years have gained national interest. The CSA makes the link between climate change and food security. This approach has already been adopted in several countries. Interestingly, the agriculture sector is both a victim of climate change and partly responsible for it. Hence, as a victim it must adapt, while as a responsible party, it must reduce its emissions as much as possible. The CSA is based on three principles: adaptation to climate change, mitigation of climate change, and food security. The CSA incorporates technical changes in the way agriculture is done, but it involves other elements, such as public policies and fundings needs. Technically, the CSA is based on ecological intensification, which consists of strengthening existing ecological mechanisms for the benefit of farmers, while ensuring the agricultural production that the country needs could be met. These approaches need to be locally specific, multi-disciplinary and would require substantial R&D efforts.

The presence of climate change has added additional layer to making the agriculture and fishery sector

of the Philippines competitive and resilient. Sombilla (2018) noted the importance of stronger climate change-related R&D particularly in the agriculture and fishery sectors in the Philippines. Of particular interest are science-based knowledge on climate change adaptation and mitigation approaches, best practices, and technologies that must be all aimed towards increasing productivity while enhancing lowland and upland ecosystems through land, soil and water conservation and mitigation (Sombilla 2018). Systematic, comprehensive and across the value-chain R&D, extension and innovation system is needed to enhance breeding and improved farm and productive practices, information and public awareness campaigns, and the adoption of effective regulatory measures and policies to correct human-and industry-induced malpractice.

3.5 Guidelines for calibrating AF R&D budgets

Sufficient, sustained, and regular R&D budget must be strategically allocated by aligning it with the existing national agriculture and fisheries modernization and industrialization plans and roadmaps (NAFMIP, AFMA, etc) along with the National Harmonized R&D Agenda.

Undoubtedly, achieving the necessary transformation in the agriculture and fishery sector requires innovation that can be made possible by significant R&D support. Despite the Philippines' longstanding support for the agriculture and fisheries sectors, policymakers must further appreciate that their decisions today regarding resource allocation to R&D will enable their envisioned agricultural productivity and sustainability. This becomes especially crucial in anticipating and addressing the escalating challenges posed by climate change.

In 2017, total R&D expenses in the Philippines, excluding extension and education according to international definitions, was 6.9 billion. To date, the best source of information on expenditure on AF R&D from DOST-PCAARRD employing the methodological framework from ASTI. They found that the research intensity, which is the ratio of A&F research expenditure to AgrGDP, was 0.41% in 2017 (Stads, 2020). So this corresponds to an AF R&D budget of PhP 6.9 billion. In 2018, the total DA R&DE budget was about PhP 3.9 billion (DA-BAR, 2023 & OECD, 2022), while the DOST budget was about PhP 2.5 billion, and a small portion coming from the university budget through PhD scholarships and DENR. To date, this research intensity ratio has been declining, with the total DA R&DE budget reaching 3.1 billion in 2021 (DA-BAR, 2023), indicating a drop in A&F research intensity to around 0.27%.

Under the National Harmonized R&D Agenda, the DOST analyzed the R&D needs and calculated the needed budgetary requirement to be at PhP 401 billion over 7 years for the Agriculture, Aquatic and Natural Resources sector, which includes R&D in forestry, natural resources and the environment (DOST, 2022). Specifically, for agriculture, fisheries and climate change, this plan calls for a budget of PhP 308 billion, or PhP 44 billion per year. On the other hand, the budget (GSSE) stipulated by NAFMIP is PhP 8 trillion over 10 years or PhP 800 billion per year. The PhP 44 billion budget required by the HRNDA for A&F R&D would amount to 0.055% of the NAFMIP budget. In other words, the government needs to allocate $5.5 to A&F R&D for every $100 it spends. This is approximately two dollars more than the business-as-usual approach, allowing the A&F R&D gap identified by ASTI to be addressed in alignment with Philippines' targets.

While the R&D budget for the agriculture and fishery sector will require substantial increases, this may be achieved through innovations that harness existing resources available in the current institutional and administrative set-up.

The research priorities set by DA-BAR and DOST require an ambitious R&D budget. All indicators suggest that the current investment in A&F R&D and innovation in the Philippines is inadequate. To achieve the country's food security objectives, enhance the well-being of the rural population, and proactively address the compounding challenges posed by climate change, a significant increase in the R&D budget for the agriculture and fisheries sector is imperative. To realize this, the following considerations are highlighted:

- The increase in the R&D budget of the A&F sector may be accompanied by a reorganization of the R&D agencies and reforms in accounting, auditing procedures and procurement system to increase their absorptive capacity so that these budgets can be used more effectively and efficiently. Simultaneously, measures should be taken to attract talented young researchers.

- The budget increase can be implemented gradually, aligning with the Philippine National Development Plans. A phased approach, clearly directed towards the required R&D budget increase over specified periods, would made the target more achievable.

- Addressing the fragmentation of A&F R&D in the Philippines requires ongoing efforts to harmonize and rationalize relevant policies, plans, programs and activities among all concerned agencies. This includes better understanding of the budgets allocations, enhanced allocation strategies to avoid duplication, and establishment of more platforms for sharing, learning and complementing R&D results. Coordination efforts between DOST-PCAARRD and DA-BAR should be continued, deepened, and expanded. International cooperation, particularly with ASTI, which allows the Philippines' efforts in A&F R&D to be compared with what is being done internationally, is essential to inform decisions at the time of budgetary choices.

- The Philippines devotes a considerable and growing budgetary effort in supporting its agriculture and fisheries sector, and rightly so, as it is a strategic and essential sector that is regularly exposed to multiple crises. A strategic budget reallocation could reconcile short-term and long-term interests, in particular by significantly increasing the share of AF R&D, which currently amounts to about 3 to 4 $ per 100 $ spent on supporting the sector. By ensuring that the share of R&D in A&F increases progressively to $4 and then to $5 for every $100 spent, today's decision-makers could ensure that the objectives of national plans for food security, climate change adaptation, and rural poverty reduction can be met. This approach also facilitates future stabilization of budgets supporting agriculture and fisheries.

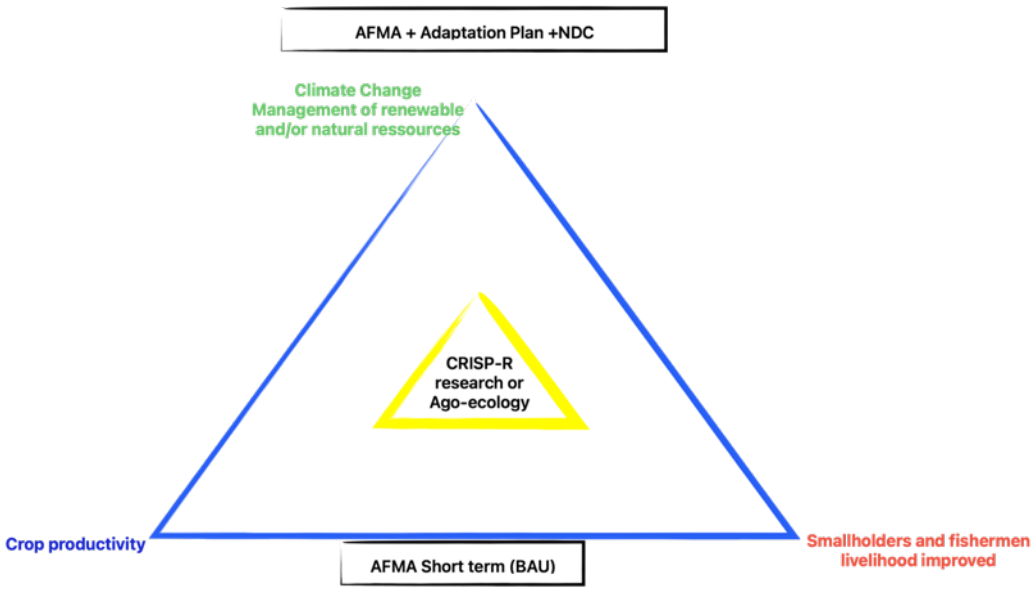


Figure 24: The R&D priority setting triangle

4. Concluding remarks

As the triangle shows (figure 24), climate change is significantly altering R&D priorities for agriculture. Traditionally, research tends to prioritize initiatives that quickly enhance productivity or improve the well-being of local populations, often focusing on short-term results. While this tendency is understandable, and such research is important, it is insufficient in the context of climate change. Climate change requires anticipating changes and considering the environment as a crucial actor, given that environmental changes directly impact people's lives.

In this context of climate change we also need to develop anticipatory science to guide agriculture plans and establish long-term research priorities that can be revised every five years. Research on natural resource management, biodiversity management, soil management and water management in these changing contexts can no longer be neglected. This also means investing in new types of research that are more multi-, inter- or even transdisciplinary and long-term. Such efforts inevitably entails additional costs, which justify a significant increase in R&D budgets.

We now need to focus on research at the heart of our triangle, the yellow triangle. Some are highly technological, such as Chris-R and the associated genome editing tools, while others require multi-or interdisciplinary approaches. Examples include agroecology and agroforestry, which bridge the gap between the social and biological sciences. This shift may require reorganization within some research laboratories or even research institutions.

The perennial underinvestment in R&DE hinders the country's overall goal of making the agriculture and fishery sector modernized, competitive, and resilient. The sector's stagnant growth, balanced deficit, and low contribution to poverty reduction has long requires the inducement of enough R&D budget, a need made more urgent by the challenges posed by climate change. At a bare minimum,

climate change-related R&D must increase in the Philippines' agriculture and fisheries sectors. Specifically, this research should generate new scientific knowledge for climate change adaptation and mitigation, including best practices and technologies to both increase productivity and improve lowland and upland ecosystems through the conservation and sustainable management of land, soil, and water.

A significant yet achievable increase in R&D budget is needed to make the sector competitive, innovative, impactful, and resilient to climate change impacts. Such increase should coincide with efforts to enhance the competence of research professionals and the corresponding institutions/agencies. Additionally, improving the continuum between research and extension/training is essential (Bantayan et al, 2023). Corrective measures must be implemented to enable the Philippines to allocate more resources to R&D, given the current allocation of only ~0.15% total public spending for R&D as a percentage of national production of the Agriculture and Fisheries sector (AgGDP). Achieving a modernized agriculture and fisheries sector requires the government to allocate at least $5 for R&D for every $100 it spends to support the agriculture and fisheries sector. Sufficient, sustained, and regular R&D budgeting must be strategically aligned with existing national agriculture and fisheries modernization and industrialization plans and roadmaps (NAFMIP, AFMA, NDC, NAP etc.) as well as the National Harmonized R&D Agenda. In the short term, the size of the R&D budget for the agriculture and fishery sectors, primarily administered through the Department of Agriculture, could be gradually increased based on the country's R&DE needs for its agriculture and fishery sector.

The R&D investment in the agriculture and fisheries sectors in the Philippines pays off and promises huge potential for economy-wide impacts should systemic changes be achieved, with increased budget playing a crucial role in unlocking this potential. While the R&D budget for the agriculture and fishery sector may require substantial increases, this may be achieved through innovations that harness existing resources available in the current institutional and administrative set-up. Climate solutions are advancing but would require more R&DE investment to make it more extensive, smarter, and more impactful.

While several successes in agricultural initiatives have been noted in the Philippines, they are few and far between and appears to be fragmented, requiring urgent systematic interventions to make them scalable and impactful, especially in light of challenges and uncertainties due to climate change. Now is the time to make these initiatives work, given the country’s perennial concerns on food security, which are further exacerbated by climate change.

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[1] https://www.germanwatch.org/en/cri

Annex 2-Global government support for agriculture and agrarian reform

AGENCY	2020	2021	2022
Department of Agriculture	77.48	71.04	72.01
Department of Agrarian Reform	7.52	8.77	12.74
DOST-PCAARRD	1.27	1.45	1.41
Government-owned and controlled corporation	93.46	53.37	57.02
TOTAL	**179.4**	**134.62**	**143.18**

Table 11: Allocation of National Government Expenditures for Agriculture and Agrarian Reform, 2020-2022, in billion pesos
Source: WorldBank (2023)

Annex 3-DA R&DE Budgets 2018-2024

Particulars	2018 GAA	2019 GAA	2020 GAA	2021 GAA	2022 GAA	2023 GAA	2024 NEP
OPERATIONS	46 710 816	39 881 496	55 024 463	61 820 981	61 375 418	60 356 412	58 376 101
R&D	3 162 010	2 627 657	2 619 017	2 754 286	2 570 830	2 834 834	2 972 611
growth rate		*-16,90%*	*-0,33%*	*5,16%*	*-6,66%*	*10,27%*	*4,86%*
percentage share in Operations budget	*6,77%*	*6,59%*	*4,76%*	*4,46%*	*4,19%*	*4,70%*	*5,09%*

Table 12: DA R&D budget with DA operation budget (in Thousand Pesos)

ESETS	5 603 129	5 446 734	5 976 301	5 084 324	5 935 963	4 200 383	6 300 249
growth rate		*-2,79%*	*9,72%*	*-14,93%*	*16,57%*	*-29,24%*	*49,99%*
percentage share in Operations budget	*12%*	*13,66%*	*10,86%*	*8,22%*	*9,67%*	*6,96%*	*10,79%*

Table 13: DA budget for Extension Support, Education and Training Services (ESETS) (in Thousand Pesos)

We can see that the DA budget for extension is roughly double that for DA R&D.

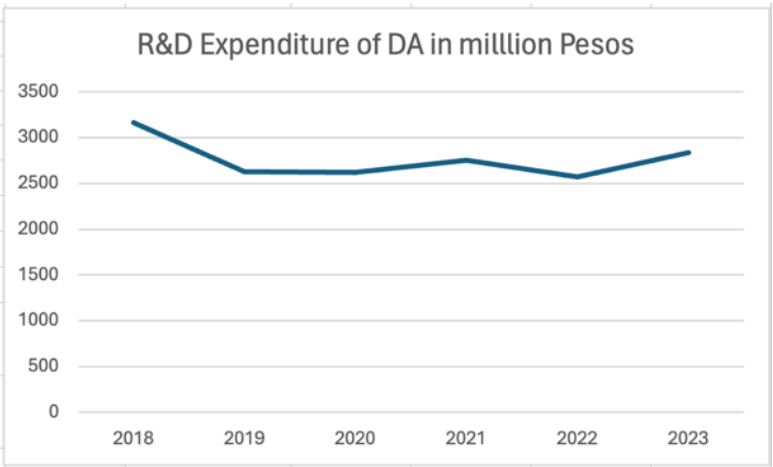

Figure 25: Stagnant DA R&D Expenditure over years (2018-2023)

The department's R&D budget decreased between 2018 and 2022, with the exception of fiscal 2021, which recorded an increase of 5.16%. Nevertheless, for fiscal 2023, the R&D budget increased significantly by 10.27%. According to the DA, this budget increase will be maintained in 2024, with a rise of 4.86%. However, these recent increases do not make up for previous decreases, and the budget remains lower than in 2018.

The Ministry's budget for Extension Support, Education and Training Services (ESETS) has seen decreases and increases between 2018 and 2024. It is set to increase significantly, in 2024 by almost 50% compared with 2023, when it was at its lowest. The proportion of the DA operating budget allocated to ESETS is 10.3% compared with R&D (5.2%).

Banner Programs	2018 GAA	2019 GAA	2020 GAA	2021 GAA	2022 GAA	2023 GAA	2024 NEP
National Rice Program	897 912	853 369	766 287	658 788	632 487	708 527	651 292
National Livestock Program	129 352	37 554	34 463	25 191	1 000	60 000	50 000
National Corn Program	140 750	154 509	100 783	120 004	127 495	123 362	190 185
National High Value Crops Development Program	130 124	105 356	107 156	109 107	100 107	82 440	92 508
National Organic Agriculture Program	65 639	60 716	60 941	59 824	50 000	50 000	51 217

Table 14: Budget for R&D by Banner Program (Amount in Thousand Pesos)- 2018-2023.

Over the 2018-2024 period, among the banner programs, the rice program benefited from the highest R&D allocation, followed by the corn program (with an average of PhP 738.38 million and PhP 136.72 million, respectively).

Over the 2018-2024 period, the rice program benefited from the highest R&D allocation, followed to a much lesser extent by the corn program (with an average of PhP738.38 million and PhP136.72 million, respectively).

The downward trend in the R&D budget is also reflected in the allocation of all the banner's programs except corn. The R&D budget for the livestock program has been sharply reduced due to the reprioritization of research activities towards production support services, in particular for the insemination of animals on livestock farms.

Banner Programs	2018 GAA	2019 GAA	2020 GAA	2021 GAA	2022 GAA	2023 GAA	2024 NEP
National Rice Program	1 819 720	2 243 933	987 242	977 224	1 356 891	1 263 078	3 082 157
National Livestock Program	396 775	318 474	374 483	303 783	611 269	529 041	704 851
National Corn Program	395 110	483 949	381 635	303 713	286 583	304 946	310 333
National High Value Crops Development Program	436 037	392 641	366 728	361 226	367 962	351 056	402 162
National Organic Agriculture Program	198 458	199 897	180 387	174 739	157 056	200 000	204 868
National Urban and Peri-Urban Agriculture Program	-	-	-	-	-	73 405	104 067
Halal Food Industry Development Program	-	-	-	-	-	21 063	17 699

Table 15: Budget for ESETS by Banner Program (Amount in Thousand Pesos), 2018-2023.

The ESETS budget by banner programs is erratic, which pose problems in the field. The rice program again benefited from the largest ESETS allocation and increase. The livestock program also increased, while all others programs stagnated or decreased. Based on the 2024 NEP, the ESETS budget for all programs under the banner will increase, with the exception of the Halal program, which has

decreased by almost 16%. Notably, the rice program will increase by 144%, from Php1.26 billion to Php3.08 billion, to support the Masagana program on clustering, in particular, the scaling-up of rice technologies such as agroecological rice farms and rice diversification.

Annex 4-Number of researchers by sectors

Classification by Field of Specialty	Sector of Performance				
	Government	Public HEI	Private HEI	Private Non-Profit Institutions	TOTAL
Natural Sciences	688	1 842	354	33	2 917
Engineering and Technology	989	1 674	596	15	3 274
Agricultural Sciences	1 366	1 697	47	7	3 117
Medical and Health Science	695	1 260	1 194	82	3 231
Social Sciences	295	2 923	1 152	119	4 489
Humanities	8	816	312	3	1 139
Others Not classified	214	861	153	6	1 234

Table 16: Profile of Researchers by Field of Specialty and Sector of Performance, 2019

Classification by Field of Specialty	Sector of Performance				
	Government	Public HEI	Private HEI	Private Non-Profit Institutions	Total
Natural Sciences	690	1 903	352	21	2 966
Engineering and Technology	1 002	2 066	689	17	3 774
Agricultural Sciences	1 445	1 686	55	10	3 196
Medical and Health Science	718	1 468	1 319	75	3 580
Social Sciences	310	3 008	1 335	102	4 755
Humanities	12	855	334	3	1 204
Others Not classified	223	849	139	4	1 215

Table 17: Profile of Researchers by Field of Specialty and by Sector of Performance, 2020

R&D in the agricultural sector requires specialists with varied profiles, in order to achieve multidisciplinary approaches. However, these data do not inform us about the composition of these teams, and we assume that most of the researchers have an agricultural science profile in the agricultural sector. What is striking in these data is the importance of the HEIs. Among researchers with an agricultural science profile, over 40% are from the government and just over 50% are from HEIs. This table does not include researchers working in the private sector outside HEIs.

Annex 5 - List of acronyms

AED - agro-enterprise development

AF - agriculture and fisheries

AFC - agricultural and fishery council

AFMA - Agriculture and Fisheries Modernization Act

AFMP - Agriculture and Fisheries Modernization Plan

AO - administrative order

ASEAN - Association of Southeast Asian Nations

ASF - African swine fever

BAFE - Bureau of Agricultural and Fisheries Engineering

BAFPS - Bureau of Agriculture and Fisheries Product Standards

BAR - Bureau of Agricultural Research

BAS - Bureau of Agricultural Statistics

BFAR - Bureau of Fisheries and Aquatic Resources

BFT - Barangay food terminal

BSWM - Bureau of Soils and Water Management

CARP - Comprehensive Agrarian Reform Program

CERDAF- Council for Extension, Research, and Development in Agriculture and Fisheries

CHED - Commission on Higher Education

CSO - civil society organization

DA - Department of Agriculture

DA-AMIA - Department of Agriculture-Adaptation and Mitigation Initiatives in Agriculture

DAP - Development Academy of the Philippines

DAR - Department of Agrarian Reform

DA-RFO 2- DA-regional field office 2

DBM - Department of Budget and Management

DOST - Department of Science and Technology

EO - Executive order

FAO - Food and Agriculture Organization

FDI - foreign direct investment

FIES - Family Income and Expenditure Survey

FMR - farm-to-market road

FNRI - Food and Nutrition Research Institute

GDP - gross domestic product

GHG - greenhouse gas

GM - genetically modified

GSSE - General Services Support Estimate

GVA - gross value added

ha - hectare

HEI - Higher education institution

HNRDA - harmonized national R&D agenda

I-O - Input-output

ICT - Information and communications technology

IFPRI - International Food Policy Research Institute

IRR - Implementing Rules and Regulations

IRRI - International Rice Research Institute

ISI - Import substitution industrialization

IUU - Illegal, unreported, and unregulated

JICA - Japan International Cooperation Agency

LDC - Local development council

LGU - Local government unit

M&E - Monitoring and evaluation

MT - Metric ton

NACF - National Agricultural Cooperative Federation

NAFC - National Agriculture and Fishery Council

NAFIAT - Nationwide Agri-Fisheries Investment Audit Team

NAFMIP- National Agriculture and Fisheries Modernization and Industrialization Plan

NEDA - National Economic and Development Authority

NFA - National Food Authority

NFD - net food disposable

NFRDI - DA-National Fisheries Research and Development Institute

NGO - nongovernment organization

NIA - National Irrigation Administration

NIS - national irrigation systems

NPAAAD -Network of Protected Areas for Agricultural and Agro-Industrial Development

OECD - Organisation for Economic Co-operation and Development

PAFEA - Philippine Agriculture and Fisheries Extension Agency

PAFES - Province-led Agriculture and Fisheries Extension System

PCAF - Philippine Council for Agriculture and Fisheries

PCAARRD - Philippine Council for Agriculture, Aquatic and Natural Resources Research & Development

PhD - Doctor of Philosophy

PhilFIDA - Philippine Fiber Industry Development Authority

PhilFSIS - Philippine Food Security Information System

PhilRice - Philippine Rice Research Institute

PHP - Philippine peso

PIAF - Provincial Institute of Agriculture and Fisheries

PIDS - Philippine Institute for Development Studies

PRDP - Philippine Rural Development Project

PRIR - Philippine Rice Industry Roadmap

PRRI - Philippine Rubber Research Institute

PSA - Philippine Statistics Authority

R&D - Research and development

R4DE - Research for development and extension

RDEAP - Research, Development, and Extension Agenda Program

RDI - Research and development institute

RRDEN - Regional Research and Development Extension Network

SBF - Sugarcane block farming

SCT - Single commodity transfer

SDG - Sustainable Development Goal

SEARCA - Southeast Asian Regional Center for
Graduate Study and Research in Agriculture

SFF - Small farmers and fisherfolk

SOE - State-owned enterprise

SRA - Sugar Regulatory Administration

SUCs - State universities and colleges

TESDA - Technical Education and Skills Development Authority

TFP - Total factor productivity

tmt - thousand metric tons

TSE - Total Support Estimate

UP - University of the Philippines

USAID - United States Agency for International Development

USD - United States dollar

VCD - value chain development

WTO - World Trade Organization

Annex 6 – Terms or Reference

Component 1: comprehensive policy review and appraisal of the agriculture R&D landscape in the Philippines.

TORS:

This component will comprise the following generic tasks which have been mostly covered by the Briones report "How Modern is Philippine Agriculture and Fisheries?". Thus, the added value of the TA component 1 is to extract the salient points of this report as well as other existing reports in order to specifically focus on R&D expenditure increase to climate change adaptation and resilience for each of the following points. Along these points the key activities will be to analyse policies, identify of policy gaps, and recommend reform agenda for climate-resilient/climate smart R&D for agriculture. This will include:

1.1. Overview and contributions of the Philippine R&D policy to its agriculture commodities (crops, livestock, poultry, fisheries), comprising: Cereal (Palay, corn), Fruits (Bananas, pineapple, mango, other fruits), Non-food & industrial (Abaca, coconut, coffee, tobacco, sugarcane, cacao, others), Vegetables & root crops (Ampalaya, cassava, eggplant, mong beans, onions, sweet potatoes, potatoes, tomatoes, others), Farming system (Monocrop, diversified, clustering approaches), Agro-based value chains (Upstream, farm production, midstream, downstream), Swine/Hog, Carabao, Goat, Chicken, Duck, Chicken eggs, Duck eggs, Marine capture, Inland capture, Aquaculture, Freshwater, brackishwater.

1.2. Review and Analysis of the R&D demand: who are the clients (regions, type of workforce, gender disaggregation, value chain segment players), and what relevance of the R&D on their production, incomes, and capacity to adapt and mitigate climate change, what are the feedback mechanism to suppliers of R&D on addressing R&D needs/wants, both actual and perceived, what is the extent of R&D outreach of R&D in agro-based value chains.

1.3. Review and Analysis of the R&D extension and agriculture services: bridge of supply and demand: Nature and extent as well as funding allocation of extension services/agriculture service delivery system as provided by LGUs considering that extension services have been devolved, Effectiveness and efficiency of extension services by LGUs in disseminating climate change related R&D (information, climate-smart technology and practices,) and as feedback mechanism (from consumers of R&D to suppliers of R&D; relation of DA with LGUs; have LGUs been effective link of the R&Ds provided by DA/DOST/state colleges and universities and the consumers of the R&D), Impact of Mandanas ruling that starting 2022 would increase the funding of LGUs.

Experts: Philippe Guizol UR F&S - Dr John Pulhin and Prof Rico Ancog

Part 2 - Value Chain Analysis by AF commodities : focus on R&D needs

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Introduction of Part 2 - Value Chain Analysis by AF commodities

Value chain analysis is a method used to assess various agricultural and fisheries commodities in the Philippines, with the goal of understanding the challenges related to commodity development, improvement, and value-addition. By identifying these challenges, the analysis helps to pinpoint opportunities for improvement throughout the value chain, ultimately revealing weak points that can be addressed to add value to commodities and their potential derivative products. This strategic input can lead to increased efficiency, productivity, and profitability across the sector. Value chain analysis encompasses a full range of value-adding activities, providing a comprehensive view of the processes from production to the final consumer, allowing stakeholders to develop more targeted interventions (Ponte et al., 2014).

In this section, the synthesis of the value chains of various agricultural and fisheries commodities was developed in order to assess the different research and development needs of these sectors. The goal is to propose future activities and priorities. Additionally, this part of the report aims to complement the policy analysis of the Philippine agriculture and fisheries sectors and the review of the research, development, and extension services landscape in the Philippines, all within the context of climate change.

This report presents the value chain analysis of fifteen (15) commodities, including rice, corn, tomato, onion, mango, banana, pineapple, coconut, sugarcane, carabao, chicken egg, pork, tilapia, tuna and seaweed. According to the Philippine Statistics Authority (PSA), among the fifteen commodities, rice or *palay,* corn, banana, pineapple, coconut, and sugarcane are considered major agricultural crops, among these commodities.

Methodology

The value chain analyses were derived using recent and reliable data from sources such as the Philippine Statistical Authority (PSA), the Department of Agriculture (DA) and its various, the Department of Environment and Natural Resources (DENR), the Food and Agriculture Organization (FAO), and the Organization for Economic Cooperation and Development (OECD), among others. This section of the report primarily relies on secondary data, without the collection and processing of primary data.

Each commodity's value chain analysis was prepared following a general outline:

1. Introduction
2. General data (including production data, consumption data, export data and import data, prices)
3. Socio-economic aspects
4. Environmental aspects and climate change
5. Challenges and opportunities
6. Policies and programs
7. R&D opportunities

The concluding remarks provide a distillation of the research and development opportunities for the selected agriculture and fisheries commodities.

1. Rice

Introduction

Rice (Palay) is the staple food of the Philippines, playing a central role in both the diet of Filipinos and the country's agricultural sector. The Philippines is one of the world's largest consumers and producers of rice globally, although it also imports rice to meet domestic demand.

General data

Types of rice grown: Popular varieties include IR64, NSIC Rc160, and traditional varieties like Dinorado and Sinandomeng.

Botanical description: Rice (Oryza sativa) is a staple food in Asia, belonging to the Poaceae family. Varieties differ in grain length and texture, with white, red, brown, and black rice offering distinct nutritional profiles and culinary uses[1].

Production data

- Area and Volume: Rice is cultivated on approximately 4.8 million hectares, producing around 18.8 million metric tons annually. From 2010 to 2023, total production increased by around 4.287 million metric tons (Figure 1).

- Regions: Major rice-producing regions include Central Luzon, Cagayan Valley, Western Visayas, and Ilocos Region.

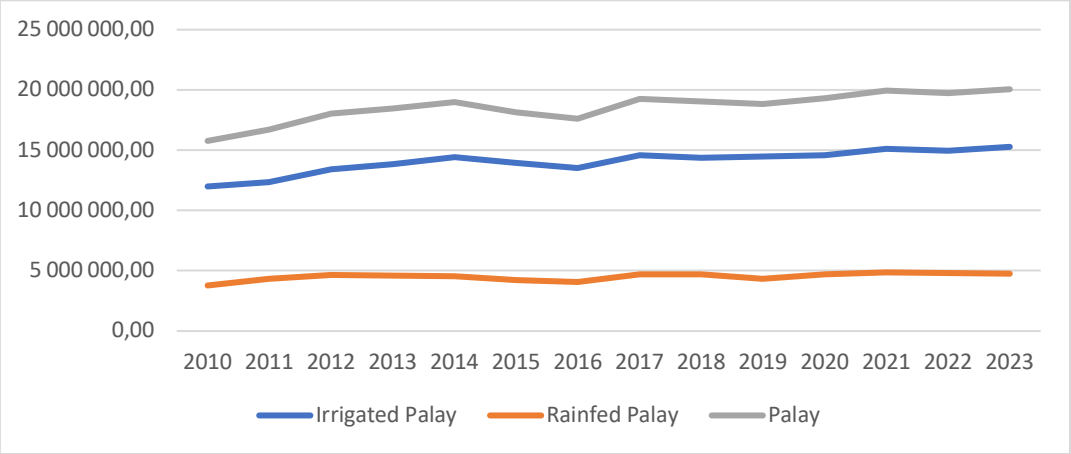

Figure 1: Rice annual production in metric tons, 2010-2023 (Source: PSA[2]).

Consumption data

- Domestic Market: Rice is a staple food for all Filipinos, with per capita consumption estimated at 118 kilograms per year.

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[1] DOST-PCAARRD. (202 C.E.). Rice Industry Profile. PCAARRD's Industry Strategic Science and Technology Programs. Retrieved May 31, 2024, from https://ispweb.pcaarrd.dost.gov.ph/isp-commodities/rice/

[2] Philippines Statistics Authority (PSA). 2022. Palay and Corn: Volume of Production in Metric Tons by Ecosystem/Croptype, by Quarter, by Semester, by Region and by Province, 1987-2024. https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__CS/0012E4EVCP0.px/chart/chartViewLine/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313

- Imports: Despite significant local production, the Philippines imports rice mainly from Vietnam and Thailand to meet consumption needs.

Export data[3]

- Export volume: The Philippines is one of the world's largest rice exporters, with an export volume of around 1.8k tons ($1.5m) in 2022.

- Main destination countries: The main destination countries for Philippine rice are Bangladesh, United Arab Emirates, Qatar, Saudi Arabia, and Jordan.

- Recent trends: From 2017-2022, Vietnam is the fastest growing exporter (+76%) while United States is the fastest declining (-20%) (see figure below).

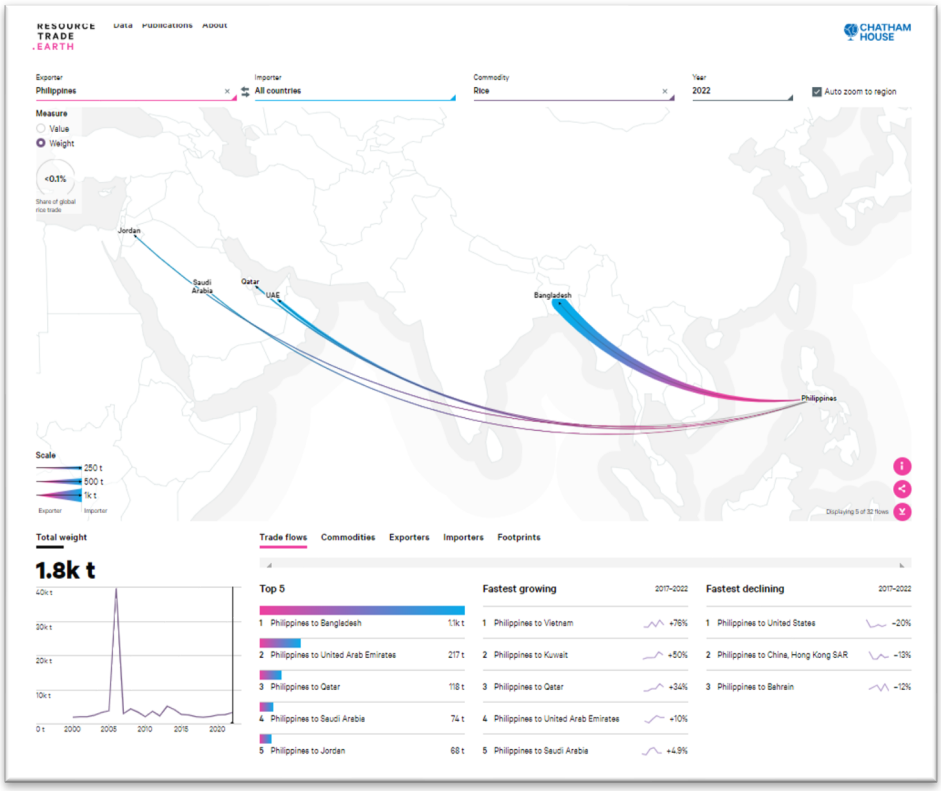

Figure 2: Rice export from the Philippines (Source: https://resourcetrade.earth).

Import data[3]

- Imported volume: The Philippines imports 1.2m tons ($1.3bn) in 2022.

- Main supplier countries: The main supplier countries of imported rice in the Philippines are Vietnam, Myanmar, Thailand, Pakistan, and India.

- Recent trends: From 2017-2022, Myanmar is the fastest growing importer (+64%) while Thailand is the fastest declining (-8.6%).

[3] Chatham House, The Royal Institute of International Affairs, 2020. Resource Trade. Earth. https://resourcetrade.earth

Prices

- Average domestic price: The retail prices of regular rice per kilo is Php 42.80, while the price of well-milled rice is Php 47.41 per kilo as of 2023[4].

- Average export price: The average producer price of regular rice is USD 320.1 per ton as of 2022[5].

Socio-Economic Aspects

- Employment: The rice industry provides employment to about 2.5 million farmers and numerous others in related sectors.

- Income: Rice farming is a primary source of income for millions of rural households. Based on the Philippine Rice Industry Road Map 2030 a Filipino farmer's net profit is roughly PHP 5 per kg if return to farm management is considered while PHP 8 per kg if return to land, labor, and capital is considered.

- Rural Development: The industry supports rural development by providing livelihoods, improving infrastructure, and enhancing local economies.

Costs (P/kg)	Philippines	Thailand	Vietnam
Seed	0.58	1.12	0.44
Fertilizer	1.94	1.56	1.36
Pesticide	0.36	0.90	0.87
Hired Labor	3.76	0.66	0.46
Operator, Family, & Exchange Labor	0.66	0.65	0.81
Animal, Machine, Fuel & Oil	1.73	1.66	0.81
Irrigation	0.45	0.14	0.08
Land Rent	2.11	1.89	1.49
Interest on Capital	0.43	0.07	0.08
Others	0.40	0.20	0.13
Total Cost/kg	**12.41**	**8.85**	**6.53**
Paid-out Cost/kg	**9.21**	**6.24**	**4.15**
Farmgate Price (14% MC)	**17.19**	**14.09**	**9.64**
Net Profit	**4.78**	**5.24**	**3.11**
Net Above Paid-out Cost	**7.98**	**7.85**	**5.49**

Source: Moya et al., 2016

Table 1: Cost and return of rice production (Source: Philippine Rice Industry Road Map 2030[8]).

Environmental Aspects and Climate Change

Environmental Impacts

- Land Use: Extensive rice farming can lead to habitat loss and soil degradation.

- Water Consumption: Rice cultivation is highly water-intensive, requiring substantial irrigation, which can strain water resources.

- Greenhouse Gas Emissions: Flooded rice paddies emit methane, a potent greenhouse gas, contributing to climate change.

[4] State of the Philippines Rice Sector. https://www.philrice.gov.ph/ricelytics/

[5] https://www.fao.org/faostat/en/#data/PP

- Chemical Use: Heavy use of fertilizers and pesticides in rice farming can lead to soil and water pollution.

Impacts of Climate Change

- Climate change is resulting in more frequent occurrences of extreme weather events, which in turn are causing a decrease in crop production, a decline in food quality, and the possibility of crop losses and damage to infrastructure (CGIAR, 2023).

Adaptation to Climate Change

- Improved Varieties: Breeding and disseminating high-yielding, climate-resilient rice varieties.
- Water Management: Implementing efficient irrigation systems and water-saving techniques such as Alternate Wetting and Drying (AWD).
- Integrated Pest Management (IPM): Reducing dependency on chemical pesticides through IPM practices.
- Diversification: Encouraging diversification with other crops and income sources to enhance resilience and reduce risks.

Challenges and Opportunities

Current challenges

- Unregulated conversion of agricultural land: Increasing transformation of agricultural land to non-agricultural uses, especially in urban areas, is hampering rice production.
- Climate Change: Rising temperatures, altered rainfall patterns, and increased frequency of extreme weather events threaten rice production. Flooding, drought, and salinity intrusion are major concerns.
- Pests and Diseases: Outbreaks of pests like the rice black bug and diseases such as bacterial leaf blight are becoming more frequent.
- Market Volatility: Fluctuations in global rice prices can affect the income stability of farmers.
- Infrastructure: Inadequate infrastructure for irrigation, storage, and transportation hampers productivity and increases post-harvest losses.

Opportunities

- The Philippines, the eighth-largest rice producer globally, has over four million hectares of arable land and an annual rice harvest of 18,032,400 metric tons. Despite this, around 20% of its local consumption is supplied by imported rice[6].

[6] Agcaoili et al. (2023). Initiatives towards inclusive trading practices of rice value chain in Pila, Laguna, Philippines. https://doi.org/10.1051/e3sconf/202344402033

- The government's current measures are focused on enhancing agricultural productivity at the farm level, with the goal of achieving a yield of 5.50 metric tons per hectare, by improving access to irrigation, inputs, and technical expertise[7].

Policies and Programs

The main policies and programs that are implemented to achieve food security and help farmers be globally competitive amidst liberation is the "Rice Tariffication Law" (Republic Act no. 11203)[8]. Appropriate funds are allocated to provide farm machinery and equipment, seed development, credit program, and extension services[9].

According to the 2030 Philippine Rice Industry Roadmap (PRIR), improved competitiveness, enhanced resiliency to disasters and climate risks, and ensured access to safe and nutritious rice are the main targets for the country. Furthermore, the following are the required key legislative agenda to achieve the 2030 goals:

- Legislate the Rice Industry Development Act to ensure funding of the PRIR 2030
- Revisit the Seed Industry Development Act
- Support the Comprehensive Land Use Plan
- Harmonize the Philippine Grain Standardization Program
- Institutionalize a rice buffer stock mechanism
- Converge initiatives among concerned government agencies on the management of water resources

R&D Opportunities

1. Addressing the issue of shrinking agricultural lands: Identifying hotspots areas of unregulated agricultural land conversions for residential and commercial developments.

2. Climate-Resilient Varieties: Developing rice varieties that are tolerant to drought, flood, salinity, and heat.

3. Sustainable Farming Practices: Researching and promoting practices that reduce environmental impacts, such as System of Rice Intensification (SRI) and organic farming methods.

4. Post-Harvest Technologies: Innovations in drying, milling, and storage to minimize losses and improve the quality of rice.

Conclusion

The rice industry is crucial to both the diet of Filipinos and the overall economy of the Philippines' agricultural sector. Despite the significant volume of domestic production, the country continues to import rice to meet its consumption needs. The high dependence on rice highlights the importance of improving rice production, efficiency, and sustainability.

The rice farming industry in the Philippines provides vital employment and income for millions of people, contributing to rural development. However, it faces significant challenges, including reduction

[7] Mamiit RJ et al. (2021) Productivity Hot Spots and Cold Spots: Setting Geographic Priorities for Achieving Food Production Targets. *Front. Sustain. Food Syst.* 5:727484. doi: 10.3389/fsufs.2021.727484

[8] https://www.officialgazette.gov.ph/2019/02/14/republic-act-no-11203/

[9] https://ati.da.gov.ph/archives/ati-main/?q=PROGRAMS/RCEF

of agricultural land, the impacts of climate change, pest and disease outbreaks, market instability, and inadequate infrastructure. Moreover, unsustainable farming practices contribute to environmental issues such as habitat destruction, strain on water resources, greenhouse gas emissions, and pollution. Addressing these challenges is essential to achieving a rice-sufficient nation while maintaining ecological balance.

Research and development efforts should prioritize key areas that can significantly enhance the productivity, sustainability, and resilience of the country's rice industry. These include policy research to balance agricultural land use with developmental needs, the adoption of climate-resilient rice varieties, the promotion of sustainable farming practices, and advancements in agricultural technology and innovation.

2. Corn

Introduction

Corn is the second most important crop in the Philippines after rice, serving as a staple food and a crucial feed for livestock. The country produces both white corn (for human consumption) and yellow corn (primarily for animal feed)[10].

General data

Types of rice grown: White corn is mainly consumed by humans, while yellow corn is used for livestock feed. Other colors usually dark such as red, purple, and brown which are of native genetics origin, are minimal in supply and used more for their nutritive value in food.

Botanical description: Maize, also known as corn (*Zea mays L.*), was domesticated over 9,000 years ago in southern Mexico/Mesoamerica. It belongs to the Maydeae tribe of the grass family Poaceae and is a highly versatile multi-purpose crop in comparison to wheat and rice. Primarily utilized as a livestock feed crop, maize also has various industrial and energy applications[11] [12].

Production data

- Area and Volume: Corn is cultivated on about 2.5 million hectares of land, yielding approximately 8.3 million metric tons annually[13]. The country's average corn farm area is 1.30 hectares[14].

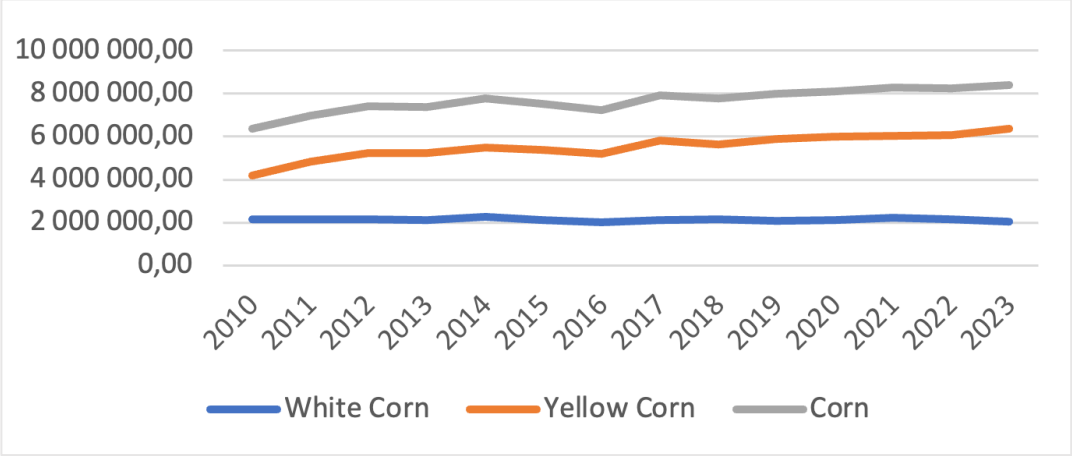

Figure 3: Corn annual production in metric tons, 2010-2023 (Source: PSA[15]).

[10] Philippine Council for Agriculture and Fisheries (PCAF). (2022, June 24). Philippine Yellow Corn Industry Roadmap 2021-2040 - Philippine Council for Agriculture and Fisheries. Philippine Council for Agriculture and Fisheries. https://pcaf.da.gov.ph/index.php/cir-corn/

[11] ICAR-Indian Institute of Maize Research. (2022). Maize Biology. https://iimr.icar.gov.in/?page_id=1785

[12] Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K., & Prasanna, B. (2022). Global maize production, consumption and trade: trends and R&D implications. Food Security, 14(5), 1295–1319. https://doi.org/10.1007/s12571-022-01288-7

[13] Foreign Agricultural Service. (2024). Philippines Corn Area, Yield and Production. https://ipad.fas.usda.gov/countrysummary/Default.aspx?id=RP&crop=Corn

[14]Salazar et al. (2021). Issues Paper on Corn Industry in the Philippines. https://www.phcc.gov.ph/wp-content/uploads/2021/01/PCC-Issues-Paper-2021-01-Issues-Paper-on-Corn-Industry-in-the-Philippines.pdf

[15] Philippines Statistics Authority (PSA). 2022. Palay and Corn: Volume of Production in Metric Tons by Ecosystem/Croptype, by Quarter, by Semester, by Region and by Province, 1987-2024. https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__CS/0012E4EVCP0.px/chart/chartViewLine/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313

- Regions: Major white corn-producing regions include Region 12 (SOCCSKSARGEN), ARMM, and Region 10 (Northern Mindanao). While the yellow corn producing region include the regions of Cagayan Valley (Region 2), SOCCSKSARGEN, (Region 12), and Northern Mindanao (Region 10)[14].

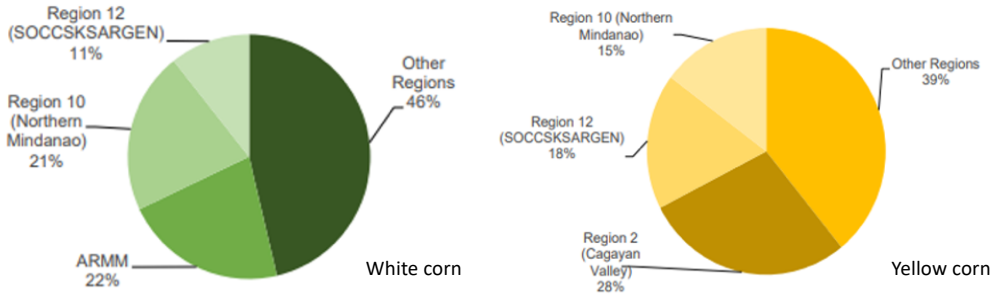

Figure 4: Corn-producing regions in the country (Source: Salazazt et al., 2021[14]).

- Corn producing country in Southeast Asia: Despite the fact that the productivity of yellow corn in the Philippines is already comparable to its neighboring Asian countries, Indonesia remains the most productive corn producer in Southeast Asia.

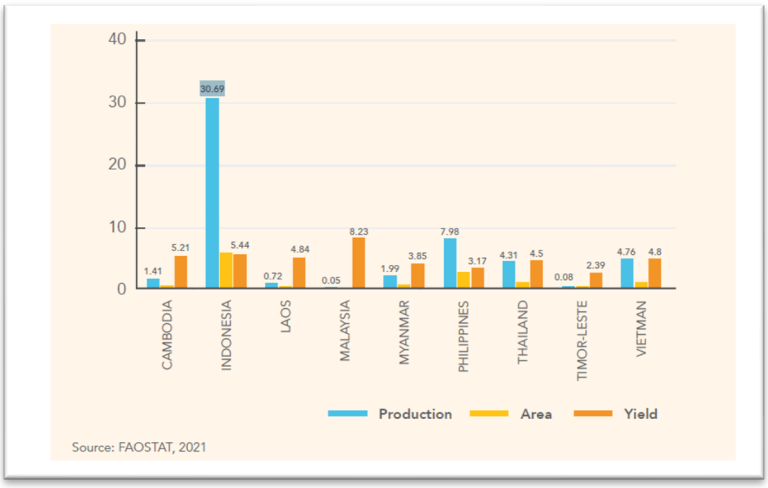

Figure 5: Corn-producing countries in Southeast Asia (Source: Philippine Yellow Corn Industry Roadmap 2021-2040[10]).

Consumption data

- Domestic Market: White corn is a staple food, particularly in the Visayas and Mindanao regions. Yellow corn is a key ingredient in the livestock and poultry industries.

- Corn consumption in the country was 14.70 kg per year between 2015-2016, with a significant increase as compared to previous years.

- Industrial Use: Corn is processed into corn oil, corn starch, and other food products.

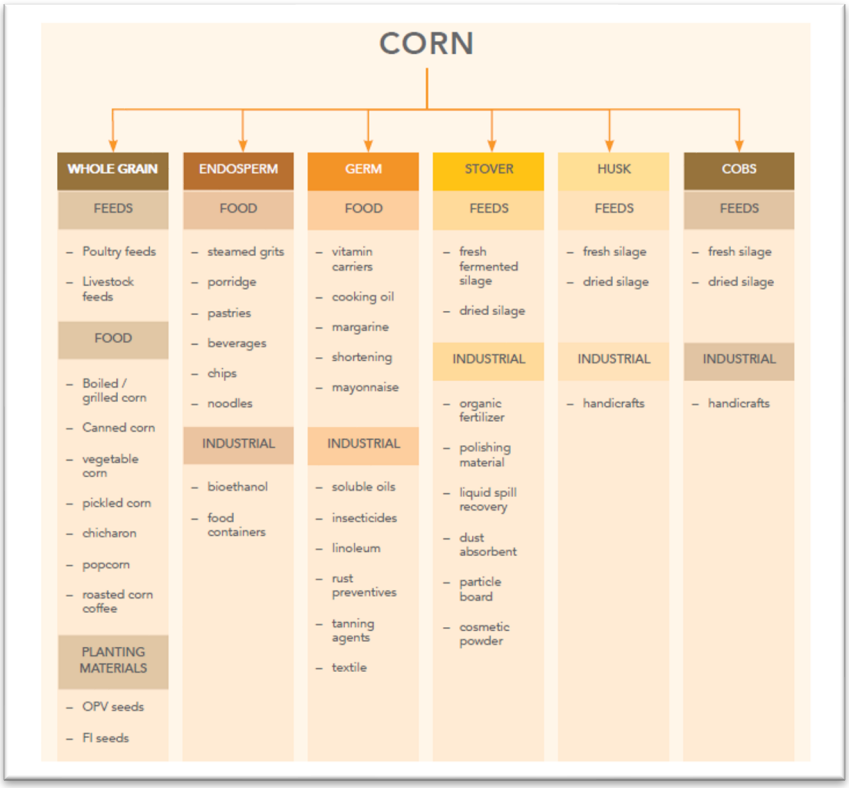

Figure 6: Comprehensive utilization of corn: Applications in food, feeds, planting materials, and industrial uses (Source: Philippine Yellow Corn Industry Roadmap 2021-2040[10]).

Export data[16]

- Export volume: The Philippines is one of the world's largest corn exporters, with an export volume of around 3.2k tons ($9m) in 2022.
- Main destination countries: The main destination countries for Philippine corn are Vietnam, Thailand, United States, Malaysia, and Qatar.
- Recent trends: From 2017-2022, Vietnam is the fastest growing exporter (+42%) while Chile is the fastest declining (-56%) (see figure below).

Import data[16]

- Imported volume: The Philippines imports 1m tons ($382m) in 2022.
- Main supplier countries: The main supplier countries of imported corn in the Philippines are Myanmar, China, Brazil, Indonesia, and Vietnam.
- Recent trends: From 2017-2022, Myanmar is the fastest growing importer (+149%) while Thailand is the fastest declining (-47%).

[16] Chatham House, The Royal Institute of International Affairs, 2020. Resource Trade. Earth. https://resourcetrade.earth

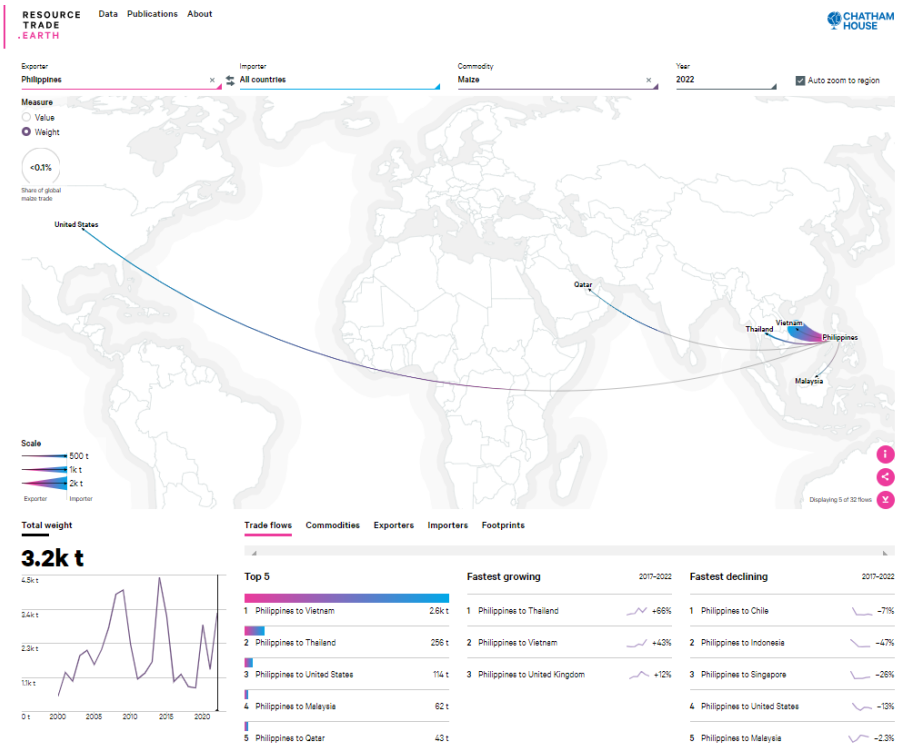

Figure 7: Corn export from the Philippines (Source: https://resourcetrade.earth).

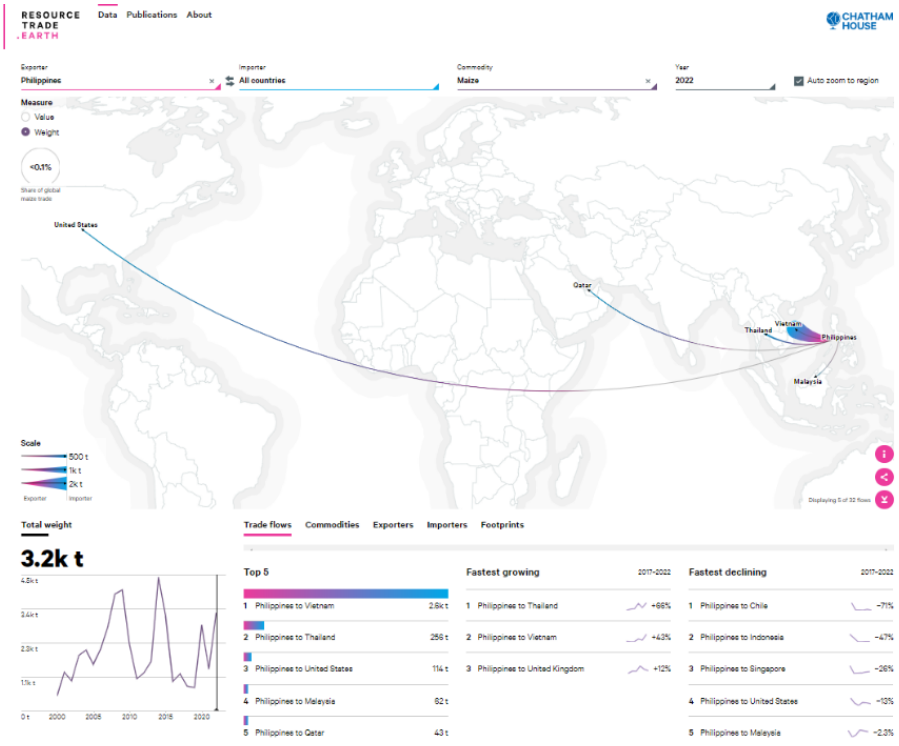

Figure 8: Corn export from the Philippines (Source: https://resourcetrade.earth).

Prices

- Average Domestic Price: The average whole sale price of yellow corn is PHP 20/kg and retail price is PHP 24.37/ kg while the whole sale price of white corn is PHP 17.47/kg, retail price is PHP 25.80/kg for January 2021[17].

[17] Philippine Statistics Authority. (2021). Updates on Philippine Palay, Rice, and Corn Prices. In Philippine

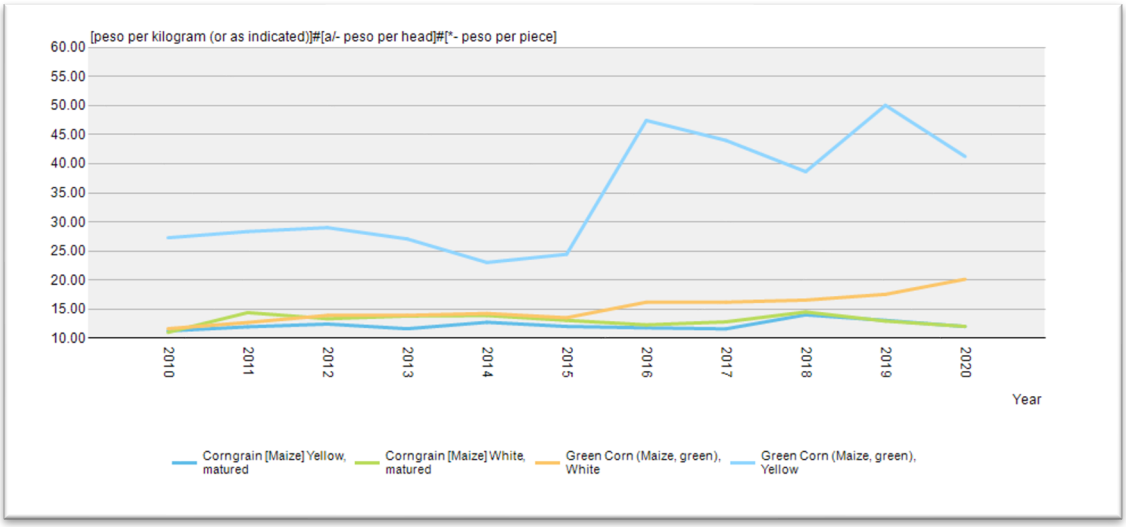

Figure 9: Corn farmgate prices by region and by province[18].

- Average Export Price: The producer price of corn in the Philippines is 321.7 USD per ton in 2022[19].

Socio-Economic Aspects

- Employment: The corn sector supports millions of Filipino livelihoods, from smallholder farmers to workers in related sectors, with around 850,000 farmers depending on corn for their income, in addition to benefiting input suppliers, traders, transport services, and processing industries[10].

- Income: Producing 1 kilogram of yellow corn incurs a cost of PHP 10.43, with a yield of 5,466.69 kilograms per hectare. In 2019, farmers enjoyed an average net income of PHP 18,889.14 for each hectare per cropping season, which translated to a return on costs of 33.1%[10].

- Rural Development: The industry contributes to rural development by improving local economies and infrastructure.

Environmental Aspects and Climate Change

Environmental Impacts

- Land Use: Corn farming often involves monoculture practices, which can lead to soil degradation and reduced biodiversity.

- Water Consumption: Corn farming is relatively water-intensive, raising concerns about water resource management.

- Pesticide and Fertilizer Use: Intensive corn cultivation requires substantial pesticide and fertilizer inputs, contributing to soil and water pollution.

Statistics Authority. Retrieved May 29, 2024, from https://psa.gov.ph/system/files/main-publication/Special%2520Release%2520on%2520Weekly%2520Updates%2520on%2520Prices%2520of%2520Cereals_Wk4Jan2021%2520v2_signed_23.pdf

[18] PSA OpenSTAT (2020). Cereals: Farmgate Prices by Region and by Province. PX-Web - Select variable and values (psa.gov.ph)

[19] FAOSTAT (2022). Producer Prices. https://www.fao.org/faostat/en/#data/PP

Impacts of Climate Change

- Climate-induced extreme weather patterns pose serious threats to the corn industry. Based on the data, the industry loses PhP 3.9 billion of production due to El Niño, typhoons, and flooding[10].

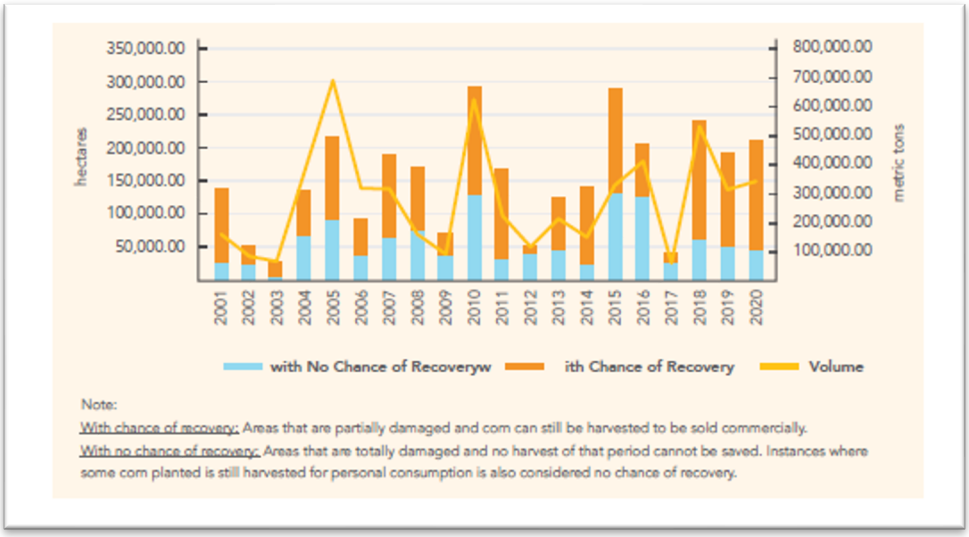

Figure 10: Corn production losses from natural disasters (Source: https://resourcetrade.earth).

- Fluctuations and extreme weather patterns have an impact on crop produce and grain quality.
- Climate change can increase the vulnerability of corn production to pests and diseases.

Adaptation to Climate Change

- Improved Varieties: Breeding and disseminating corn varieties that are resistant to pests, diseases, and climate stresses.
- Water Management: Adopting efficient irrigation techniques and water conservation practices.
- Integrated Pest Management (IPM): Implementing IPM strategies to reduce reliance on chemical pesticides.
- Diversification: Encouraging crop diversification to enhance resilience and reduce risks associated with monoculture.

Challenges and Opportunities

Current challenges

- Climate Change: Corn production is vulnerable to climate change, with increasing temperatures, shifting rainfall patterns, and extreme weather events affecting yields. Pests and diseases such as corn borer and downy mildew are also influenced by changing climates.
- Market Volatility: Fluctuating prices in the global market impact the stability of farmers' incomes.
- Infrastructure: Inadequate infrastructure for storage and transportation can lead to post-harvest losses and reduced marketability of the crop.

Opportunities[10]

- The locally produced corn is competitive against imports, and further enhancing them may strengthen the sustainability of the supply chain in the country.

- The increasing demand for corn both at the local and global levels promotes the adoption of intervention to increase productivity and competitiveness.

Policies and Programs

- Government Policies: There are a set of relevant policies that permit the efficient movement of products across the field distinct segments of the value chain of corn. Meanwhile, there is also effort to develop a climate-resilient corn industry emerging threat of extreme climate disturbances.

- Support Programs: Various programs have been implemented to offer seeds, fertilizers, farm machinery, and equipment, along with irrigation services. Additionally, these programs include capacity-building through training and seminars, all aimed at assisting in yield increase while ensuring sustainable farming practices.

R&D Opportunities

1. Development of Climate-Resilient Varieties: Investing in research to develop and promote corn varieties that can withstand climate change impacts.

2. Sustainable Agricultural Practices: Promoting conservation agriculture, organic farming, and other sustainable practices to enhance environmental health.

3. Enhanced Post-Harvest Handling: Developing technologies and practices to improve post-harvest handling, storage, and transportation.

4. Extension Services: Strengthening extension services to disseminate research findings and provide practical support to farmers.

5. Infrastructure Development: Improving infrastructure for better access to markets and reduced post-harvest losses.

6. Market Development: Enhancing market access through improved trade policies and marketing strategies.

7. Capacity Building: Training farmers and stakeholders in best practices for corn cultivation, pest management, and climate adaptation.

Conclusion

Corn is a crucial part of the agricultural landscape in the Philippines. It is the second most valuable crop after rice and plays a significant role in ensuring food security, economic stability, and rural development. As a highly versatile multi-purpose crop, it is used for various purposes including food, livestock feed, industrial applications, and energy production, thereby supporting millions of local livelihoods.

The growing demand for corn, driven by the increasing demand from the livestock sector, is challenged by several aspects, including environmental sustainability, market volatility, limited technology, inadequate infrastructure, and threats posed by climate change. On the other hand, there are numerous opportunities for the industry. The sector can improve its productivity, resilience, and sustainability by implementing strategic policies, support programs, and research and development efforts.

This can be achieved by investing in climate-resilient varieties, promoting sustainable agricultural practices, improving infrastructure, enhancing market access, and providing capacity building. These steps are essential for creating a food-sufficient, sustainable, and resilient corn industry with empowered and competitive corn farmers.

References

Philippine Council for Agriculture and Fisheries (PCAF). (2022, June 24). Philippine Yellow Corn Industry Roadmap 2021-2040 - Philippine Council for Agriculture and Fisheries. Philippine Council for Agriculture and Fisheries. https://pcaf.da.gov.ph/index.php/cir-corn/

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3. Tomato

Introduction

Tomato (Lycopersiconesculentum) is a popular fruit vegetable extensively cultivated as a secondary crop in the Philippines. It is presently identified as a high valued crop in the country.

General data

The table below provides a comparison of tomato production in the Philippines between the second quarters (April to June) of 2022 and 2023, showing that the tomato production during this period in 2023 was approximately 70.33 thousand metric tons.

Crop	Production (in metric tons)				Year-on-Year Change (%)		Percent Share
	January–March		April–June				
	2022	2023	2022	2023p	Jan–Mar	Apr–Junp	Apr–Jun 2023p
Tomato	89,996.07	92,707.89	71,587.67	70,327.82	3.0	-1.8	NA

Notes: p – preliminary
Percent share of varieties to the total crop production
NA - Not Applicable
Details may not add up to total due to rounding
Source: Philippine Statistics Authority, Crops Production Survey (CrPS)

Table 2: Volume for tomato production, January-March 2022 and April-June 2022-2023 (Source: PSA, 2023).

Contextual Understanding

- Potential Reasons for Decrease: The decrease in production could be attributed to various factors such as adverse weather conditions, changes in farming practices, pest infestations, or other agricultural challenges faced during 2023.

- Production Trends: This data point represents a minor reduction in tomato production for specific quarters and years, indicating the need for further analysis to understand and address the underlying causes. Understanding production trends is essential for policymakers and stakeholders in the agriculture sector to develop strategies to improving future production. This requires historical data to enable trend analysis, which is a valuable input for appropriate policy actions.

Region	Production (in metric tons) January–March		April–June		Year-on-Year Change (%)		Percent Share
	2022	2023	2022	2023p	Jan–Mar	Apr–Junp	Apr–Jun 2023p
PHILIPPINES	**89,996.07**	**92,707.89**	**71,587.67**	**70,327.82**	**3.0**	**-1.8**	**100.0**
Cordillera Administrative Region (CAR)	1,209.49	1,114.79	778.68	808.13	-7.8	3.8	1.1
Region I (Ilocos Region)	35,834.88	37,544.15	24,407.74	23,774.10	4.8	-2.6	33.8
Region II (Cagayan Valley)	1,925.30	1,904.87	7,313.79	7,306.04	-1.1	-0.1	10.4
Region III (Central Luzon)	24,094.92	25,003.95	9,004.09	8,792.57	3.8	-2.3	12.5
Region IV-A (CALABARZON)	7,388.77	7,723.07	6,162.09	5,430.46	4.5	-11.9	7.7
MIMAROPA Region	703.75	591.56	2,379.55	2,087.39	-15.9	-12.3	3.0
Region V (Bicol Region)	769.11	746.23	2,823.78	2,786.99	-3.0	-1.3	4.0
Region VI (Western Visayas)	8,189.48	8,856.21	2,438.73	2,752.06	8.1	12.8	3.9
Region VII (Central Visayas)	597.72	723.08	2,560.33	2,856.79	21.0	11.6	4.1
Region VIII (Eastern Visayas)	45.38	45.35	239.32	263.90	-0.1	10.3	0.4
Region IX (Zamboanga Peninsula)	553.68	638.34	3,258.19	3,695.84	15.3	13.4	5.3
Region X (Northern Mindanao)	6,048.61	5,030.38	7,238.91	6,818.36	-16.8	-5.8	9.7
Region XI (Davao Region)	1,385.54	1,497.38	2,118.61	2,200.02	8.1	3.8	3.1
Region XII (SOCCSKSARGEN)	1,122.60	1,157.41	582.87	480.55	3.1	-17.6	0.7
Region XIII (Caraga)	41.90	47.27	184.78	177.68	12.8	-3.8	0.3
Bangsamoro Autonomous Region in Muslim Mindanao (BARMM)	84.95	83.86	96.21	96.93	-1.3	0.7	0.1

Notes: p - preliminary
Details may not add up to total due to rounding
BARMM excludes the Eight Area Clusters
Source: Philippine Statistics Authority, Crops Production Survey (CrPS)

Table 3: Volume of production of tomato by region, January-March 2022 and April-June 2022-2023 (Source: PSA, 2023).

The data provided outlines the production of tomatoes in the Philippines, focusing on regional contributions and year-on-year changes for the periods January to March and April to June of 2022 and 2023. Following are the detailed analysis of the figures:

Regional Distribution of Tomato Production (April- June 2023)

1. Ilocos Region: The top producer with 23,774.10 metric tons, accounting for 33.8% of the total production.
2. Central Luzon: Second in production with 8,792.57 metric tons (12.5%).
3. Cagayan Valley: Produced 7,306.04 metric tons (10.4%).
4. Northern Mindanao: Contributed 6,818.36 metric tons (9.7%).
5. CALABARZON : Yielded 5,430.46 metric tons (7.7%).

Year-on-Year Production Comparison

- Total Production: The total production decreased slightly from 71,587.67 metric tons in April-June 2022 to 70,327.82 metric tons in the same period in 2023, representing a -1.8% change.

- January-March: The production increased from 89,996.07 metric tons in 2022 to 92,707.89 metric tons in 2023, showing a 3.0% rise.

Regional Performance Highlights

1. Ilocos Region: Despite a slight decrease of -2.6% from the previous year, it remains the largest producer.
2. Central Luzon: Recorded a minor decrease of -2.3%.
3. Cagayan Valley: Maintained a relatively stable production with a -0.1% change.
4. Northern Mindanao: Saw a decrease of -5.8%.
5. CALABARZON: Experienced a significant decline of -11.9%.
6. Zamboanga Peninsula: Notable increase of 13.4%.
7. Central Visayas: Substantial growth of 11.6%.

Insights and Observations

- Production Shifts: While some regions like Ilocos and Central Luzon saw minor decreases, regions such as Central Visayas and Zamboanga Peninsula showed significant growth, indicating possible improvements in agricultural practices or favorable climatic conditions.

- Top Producers Consistency: The top producing regions remain consistent, with Ilocos Region leading by a substantial margin.

- Growth Regions: Regions like Central Visayas and Zamboanga Peninsula could be seen as emerging key players due to their significant year-on-year production increases.

The overall tomato production in the Philippines has seen a minor decrease during the April-June period of 2023 compared to the previous year. However, some regions have shown promising growth, suggesting potential areas for focused agricultural development and investment. The Ilocos Region continues to dominate tomato production, contributing significantly to the national output (see Figure 11).

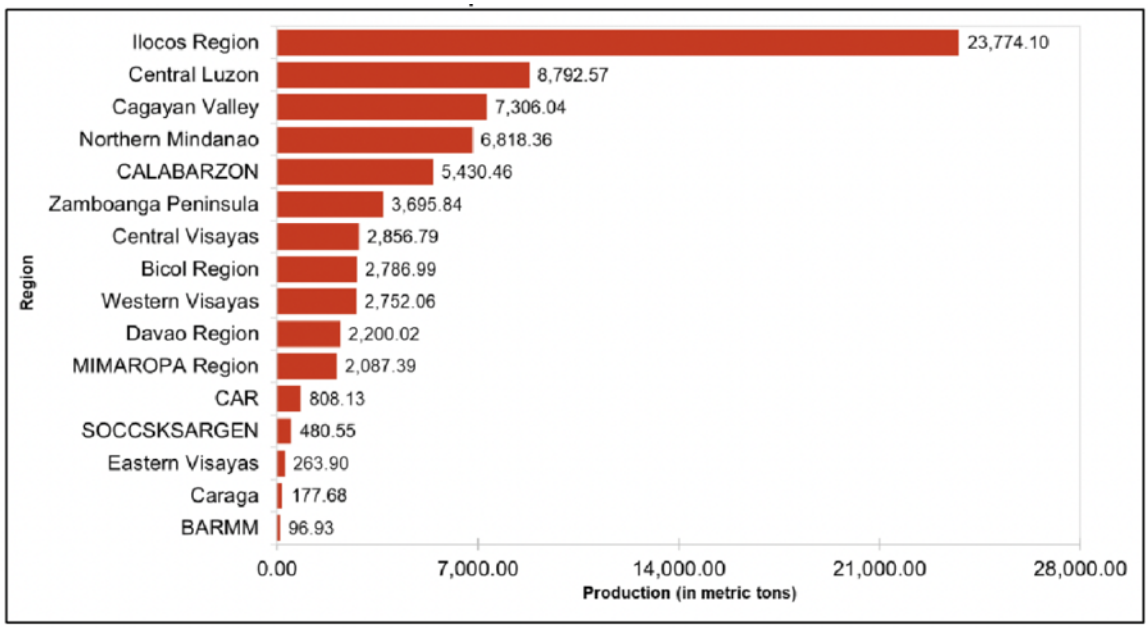

Figure 11: Distribution of tomato production by region, April-June 2023 (Source: PSA, 2023).

Figure 12 provides information about the area of land dedicated to tomato cultivation in the Philippines for the first half of the years 2022 and 2023. The figure shows the following specific information:

1. Area Planted for Tomato (January to June 2023): The total area planted with tomatoes from January to June 2023 was 10.81 thousand hectares.

2. Annual Decrease: This area represents a decrease of 1.8% compared to the same period in 2022.

3. Area Planted for Tomato (January to June 2022): During this period in 2022, the area planted with tomatoes was slightly larger, at 11.01 thousand hectares.

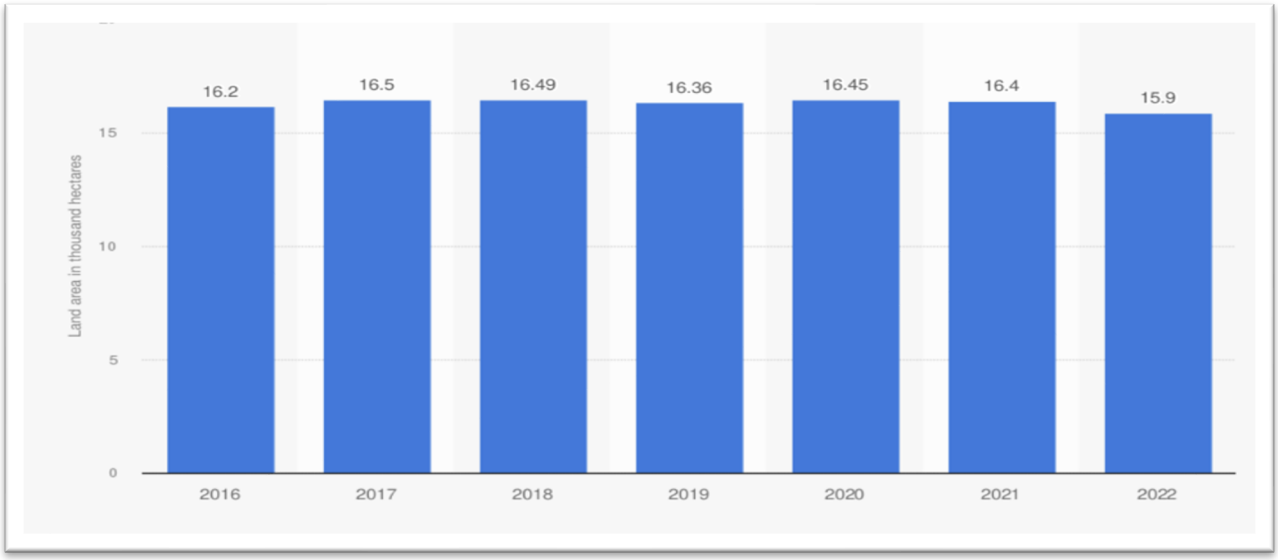

Figure 12: Total land area used for tomato cultivation, 2016 to 2022 in 1,000 hectares (Source: PSA, 2023).

Implications

- Reduction in cultivated area: There was a reduction in the amount of land used for tomato cultivation by 0.2 thousand hectares from the first half of 2022 to the same period in 2023.

- Impact on production: This decrease in the area planted could be one of the factors contributing to the slight reduction in tomato production during the same period, as less land available for cultivation typically leads to lower total output.

Contextual Understanding

- Reasons for decrease: The reduction in the cultivated area might be due to several reasons, such as farmers shifting to other crops, land reallocation, economic factors, or unfavorable agricultural conditions.

- Distribution by Region: This data point doesn't directly discuss the regional distribution of tomato production, but it provides a national overview of the land use for tomato cultivation.

Overall, the decrease in the area planted for tomatoes reflects a slight contraction in the resources allocated to tomato farming in the Philippines, which could influence the overall production trends observed.

From 2016 to 2022, the land area used for tomato cultivation in the Philippines experienced minor fluctuations with an overall downward trend. This decrease in cultivated area could contribute to the fluctuating production volumes of tomatoes in the country over the past decade. Addressing the factors leading to the reduction in land area could be crucial for stabilizing and potentially increasing tomato production in the future.

Key Observations

1. Overall Decline: There is a slight overall decline in the land area used for tomato cultivation from 2016 (16.2 thousand hectares) to 2022 (15.9 thousand hectares).

2. Fluctuations: The data indicates minor fluctuations in the area used for tomato cultivation, with a peak in 2017 at 16.5 thousand hectares and a general downward trend thereafter.

Analysis

- Peak in 2017: The largest area dedicated to tomato cultivation was in 2017 with 16.5 thousand hectares.
- Steady Decrease: Following 2017, there is a gradual decrease in the land area until 2022.
- Missing Data: The absence of data for 2020 and 2021 leaves a gap in the trend analysis, but the available data suggests a declining trend.

Implications

- Impact on Production: The reduction in land area dedicated to tomato cultivation could correlate with the fluctuations and potential declines in tomato production volumes observed over the years.
- Agricultural Shifts: The decreasing trend might indicate shifts in agricultural practices, possibly due to changes in market demand, crop profitability, or other socio-economic factors affecting farmers' decisions.
- Need for Support: To reverse or stabilize this trend, there might be a need for agricultural support, improved farming techniques, and incentives to encourage tomato cultivation.

Consumption

Tomato consumption in the Philippines is highly shaped by its import and export activities, reflecting the country’s agricultural trade dynamics and market behavior. Here's a detailed analysis of the tomato trade in the Philippines for the year 2022.

Export Analysis

- Export Value: In 2022, the Philippines exported tomatoes worth $1.72k, making it the 137th largest exporter of tomatoes globally.
- Export Ranking: Tomatoes were the 1061st most exported product from the Philippines.
- Main Destinations: The primary export destinations for Filipino tomatoes were the United Arab Emirates ($1.6k), Bahamas ($67), and Maldives ($48) (OEC, n.d.).

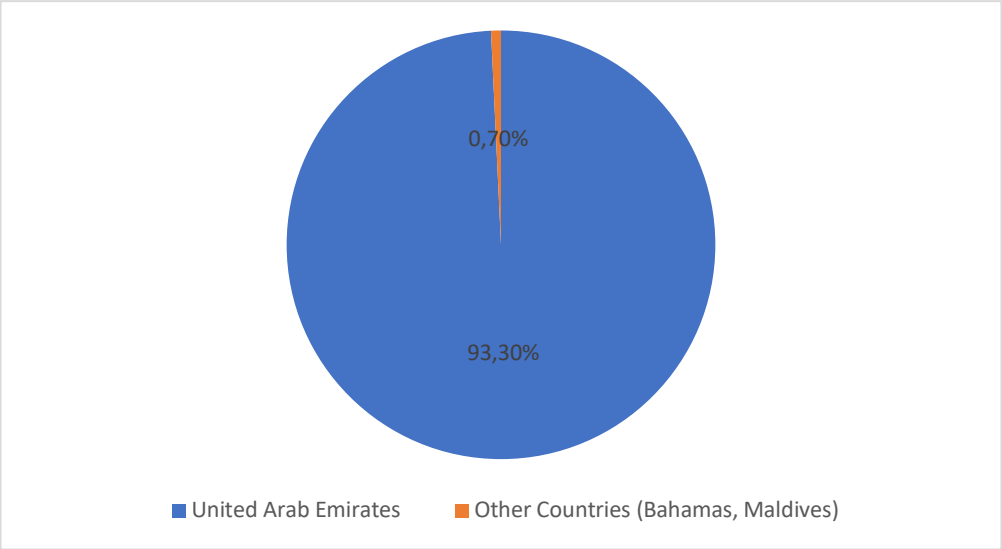

Figure 13: Export destinations of Philippines tomatoes.

Import Analysis

- Import Value: In the same year, the Philippines imported tomatoes valued at $44.7k, positioning it as the 144th largest importer of tomatoes worldwide.
- Import Ranking: Tomatoes ranked as the 1168th most imported product into the Philippines.
- Primary Sources: The main countries exporting tomatoes to the Philippines were China ($39.7k), France ($2.59k), Brazil ($1.08k), Singapore ($791), and South Korea ($355) (OEC, n.d.).

The disparity between export and import values indicates a substantial reliance on imports to meet domestic demand for tomatoes. Despite being a tomato-producing country, the Philippines imports significantly more tomatoes than it exports. This suggests that local production does not fully satisfy the domestic consumption needs.

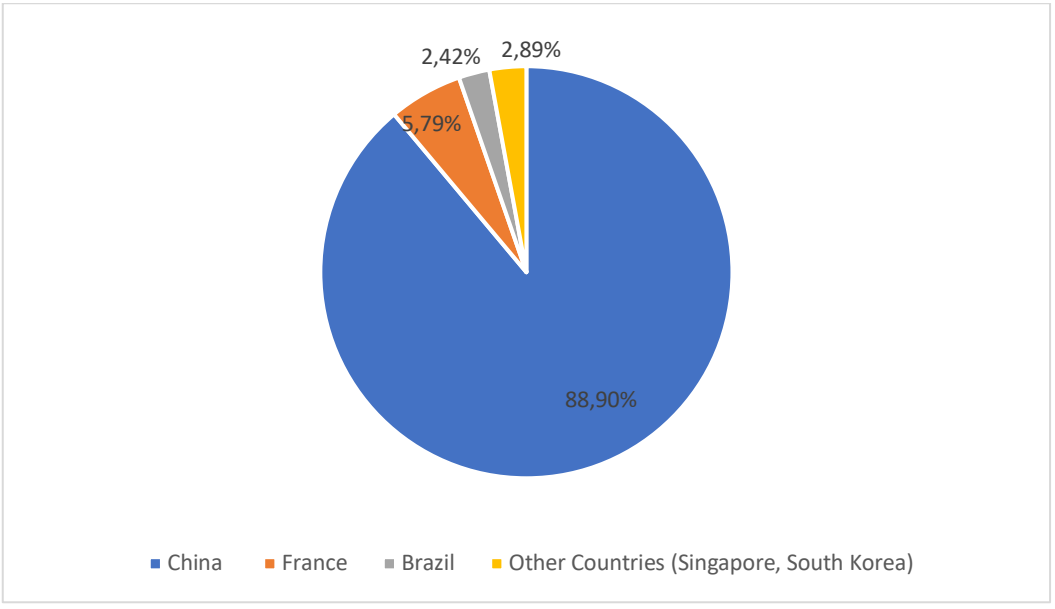

Figure 14: Import origins of tomatoes.

Key Insights

1. Domestic Demand: The high import value relative to exports highlights a strong domestic demand for tomatoes, which local production struggles to meet.

2. Import Dependence: The reliance on imports, primarily from China, underscores the need for the Philippines to either boost local production or continue depending on imports to satisfy consumption requirements.

3. Export Market: The limited export figures indicate that the Philippines has a relatively small presence in the global tomato export market, focusing more on fulfilling domestic needs.

Tomato consumption in the Philippines is heavily influenced by import activities, with the country relying significantly on imported tomatoes to meet its demand. The limited export of tomatoes reflects a focus on satisfying local consumption over participating in the global market. To reduce import reliance, the Philippines might consider strategies to enhance local production, thereby achieving a more balanced trade scenario and potentially increasing its export capacity in the future.

Socio-Economic Aspects

Tomato production in the Philippines has shown a significant increase in value over the past five years, reflecting its growing economic importance. Here's an analysis of the value of tomato production from 2018 to 2022 and its socioeconomic implications.

1. Steady Increase: There has been a consistent increase in the value of tomato production from 2018 to 2022, with a significant rise from 3,860.52 million PhP in 2018 to 7,439.65 million PhP in 2022.

2. Economic Growth: The value more than doubled over the five-year period, indicating strong growth in the tomato sector.

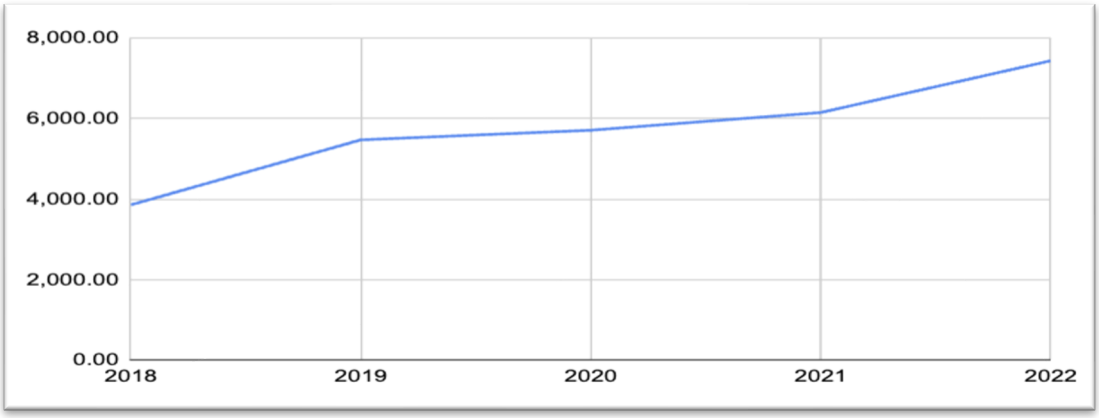

Figure 15: Value of tomato production at current prices, 2018-2022 in Million PhP (Source: PSA, 2023).

The substantial increase in the value of tomato production in the Philippines from 2018 to 2022 highlights the sector's growing economic significance. This growth has positive socioeconomic effects, including higher incomes for farmers, increased employment, and regional development. However, sustainable practices and supportive policies are necessary to ensure long-term benefits and address potential challenges. The rising value of tomato production thus plays a crucial role in enhancing the socioeconomic landscape of the Philippines.

Particulars	
Gross Returns (PhP/ha)	246,767
Total Costs (PhP/ha)	233,052
Net Returns (PhP/ha)	13,715
Net Profit-Cost Ratio	0.06
Cost per Kilogram (PhP)	17.08
Yield per Hectare (kg/ha)	13.649
Farmgate Price (PhP/kg)	18.08
Return on Investments (ROI, %)	6

Figure 16: Summary of one hectare average cost and returns, 2019 (Source: DA, 2021).

Gross Returns and Costs

In 2019, the gross returns for tomato farming in the Philippines stood at PHP 246,767 per hectare. However, the total costs associated with tomato farming were substantial, amounting to PHP 233,052 per hectare. These costs cover a wide range of expenses including seeds, fertilizers, pesticides, labor, and irrigation. The high costs relative to the gross returns indicate that tomato farmers operate on very narrow profit margins, which poses significant financial challenges.

Net Returns and Profitability

After accounting for the total costs, the net returns from tomato farming were only PHP 13,715 per hectare. This modest profit is further reflected in the net profit-cost ratio of 0.06, which means that for every peso spent on tomato farming, farmers earn just six centavos in profit. Additionally, the return on investment (ROI) was a mere 6%, indicating that the financial gains from tomato farming are quite limited. These figures highlight the low profitability of tomato farming, raising concerns about the financial viability of this agricultural activity.

Cost and Price Per Kilogram

The average cost to produce one kilogram of tomatoes was PHP 17.08. Given the average yield of 13,649 kilograms per hectare, this production cost is significant. The farmgate price, or the price at which farmers sell their tomatoes, was PHP 18.08 per kilogram. The narrow margin of just one peso between the production cost and the selling price highlights the financial constraints faced by tomato farmers. This slim margin means that even slight increases in production costs or decreases in market prices can severely impact farmers' profits.

Yield Per Hectare

Tomato farmers achieved an average yield of 13,649 kilograms per hectare. While this yield demonstrates the productive potential of tomato farming, it is not sufficient to ensure high profitability given the high production costs. The financial burden of these costs significantly diminishes the benefits of the yield, underscoring the need for strategies to reduce expenses and improve profit margins.

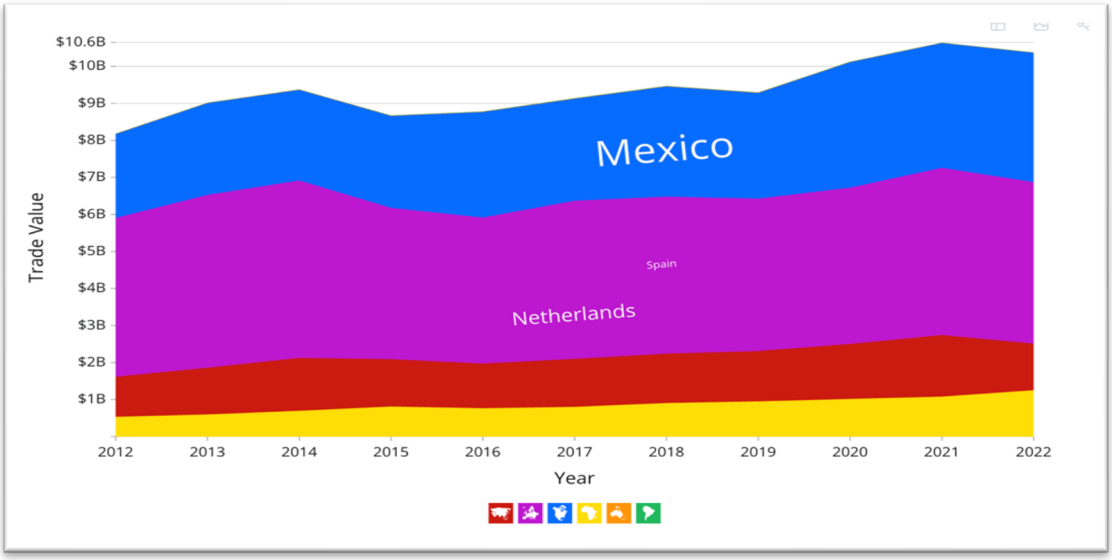

Figure 17: Trade value of tomatoes by exporters (Source: OEC, n.d.).

In 2022, the Philippines faced stiff competition from major tomato-exporting countries. Mexico led with $2.74 billion in exports, followed by the Netherlands with $1.68 billion, and Spain with $1.18 billion. These countries not only have established markets but also benefit from advanced agricultural practices and substantial investment in their agricultural sectors. For the Philippines to compete effectively, it needs to address the gaps in its agricultural framework and seek to emulate the successful strategies of these leading exporters.

Environmental Aspects and Climate Change

The area planted and harvested for tomatoes Philippines has shown a significant upward trend from 2018 to 2022. The data, expressed in thousand hectares, indicates a substantial increase in the land dedicated to tomato farming, from 3,860.52 thousand hectares in 2018 to 7,439.65 thousand hectares in 2022. This growth reflects a significant increase in agricultural activity, driven by the rising demand for tomatoes and possibly efforts to boost local production and reduce reliance on imports. However, such an expansion also brings about various environmental implications what warrant careful consideration.

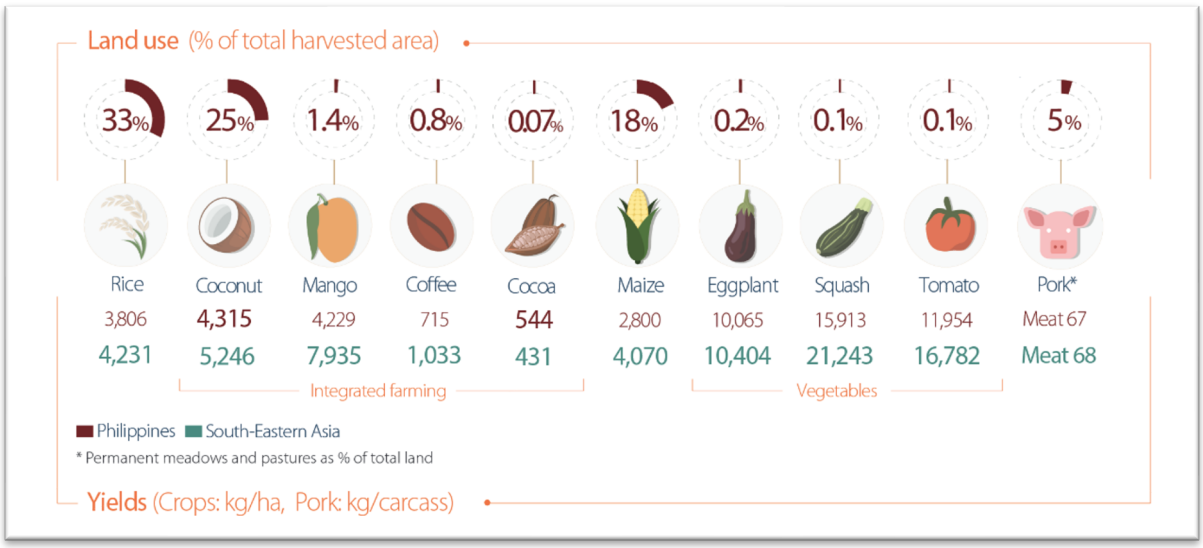

Figure 18: Land use of selected crops in the Philippines, 2017 (Source: Office of Agricultural and Fisheries Information Service, 2018).

In 2017, tomatoes accounted for only 0.1% of the total harvested area in the Philippines compared to other crops. This minimal percentage suggests that while tomatoes are an important crop, their environmental footprint in terms of land use is relatively small. However, given the current increase in planted areas, it is crucial to monitor and manage this growth to prevent adverse environmental effects. Sustainable farming practices, such as crop rotation and organic farming, can help maintain soil health and biodiversity. Implementing these practices will be essential as the country navigates the balance between expanding tomato production and preserving environmental integrity.

Challenges and Opportunities

Challenges

Tomato production in the Philippines is confronted with significant current and future challenges, particularly concerning the pervasive issue of bacterial wilt infection. This disease poses a major threat to tomato crops, leading to substantial yield losses and economic setbacks for farmers. The infection rate of bacterial wilt in tomatoes varies significantly depending on the cultivation environment, with open field conditions proving to be particularly susceptible.

In open fields, tomatoes experience a notably higher infection rate of 67.5%, whereas this rate drops to 28.17% when tomatoes are grown under protective structures. This stark difference is primarily due to the exposure to adverse environmental conditions in open fields, such as heavy rainfall. Rain not only creates favorable conditions for the growth of bacterial wilt but also facilitates the spread of pathogens through surface water runoff. Consequently, managing bacterial wilt in open fields is considerably more challenging due to the direct impact of weather patterns on disease proliferation.

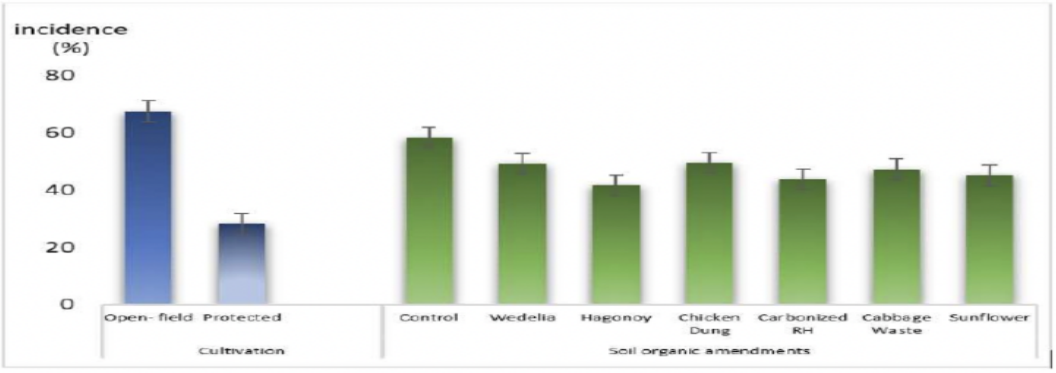

Figure 19: Percent bacterial wilt incidence of tomato grown in the open field and protective structures as influenced by different soil organic amendments (Source: Gorme et al. 2017).

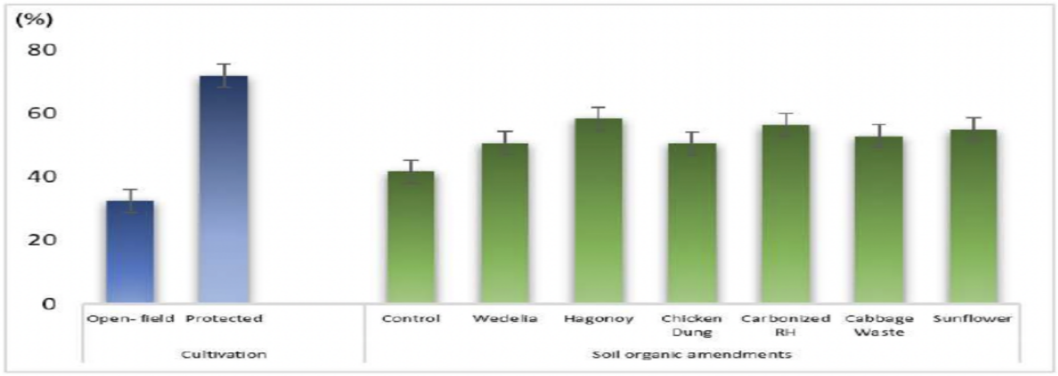

Figure 20: Percent survival of tomato grown in the open field and protective structures as influenced by different soil organic amendments (Source: Gorme et al. 2017).

Adaptation strategies

- Protective Structures: Protective structures, such as greenhouses or high tunnels, offer a significant advantage by mitigating these environmental risks. By regulating moisture levels and creating a controlled environment, these structures make conditions less favorable for soil-borne pathogens like those causing bacterial wilt. The survival rate of tomato plants under protective structures is 71.8%, more than double the 32.5% survival rate of those grown in open fields. This demonstrates the critical role of protective structures in enhancing plant health and yield by providing a physical barrier against adverse weather conditions and pathogen spread.

- Soil Amendments: Soil amendments, which involve adding organic or inorganic materials to improve soil quality, have shown to improve the survival rates of tomato plants in both open fields and under protective structures. These amendments can enhance soil structure, fertility, and water retention, thereby supporting healthier plant growth and resilience against diseases. However, the benefits of these amendments are more pronounced when used in conjunction with protective structures, highlighting the importance of integrated pest and disease management strategies.

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4. Onion

Introduction

Onion or *Allium cepa* is a staple ingredient for many Filipino dishes. PSA data shows that the average onion consumption in the country was 2.34 kg/year. The onion industry is relatively simple as compared to other commodities—production is localized in only few regions and the supply chain is relatively short. Only four regions namely Central Luzon, Ilocos Region, Cagayan Valley, and MIMAROPA account for the majority of onion production in the Philippines. Three types of onion are produced in the country: red onions (red creole and red Pinoy), white/yellow onions (granex), and shallot.

General data

Production

Area and Yield

- About 35,000 farmers grow onion in about 18,391 hectares (ha) in a few regions of the country, 0.5 hectares per family.

- From 2011 to 2020, the average annual growth in production is 10.72% (128,837 mt to 229,539 mt) while the average annual growth in area planted is 4.91% (14,641 to 18,391 ha).

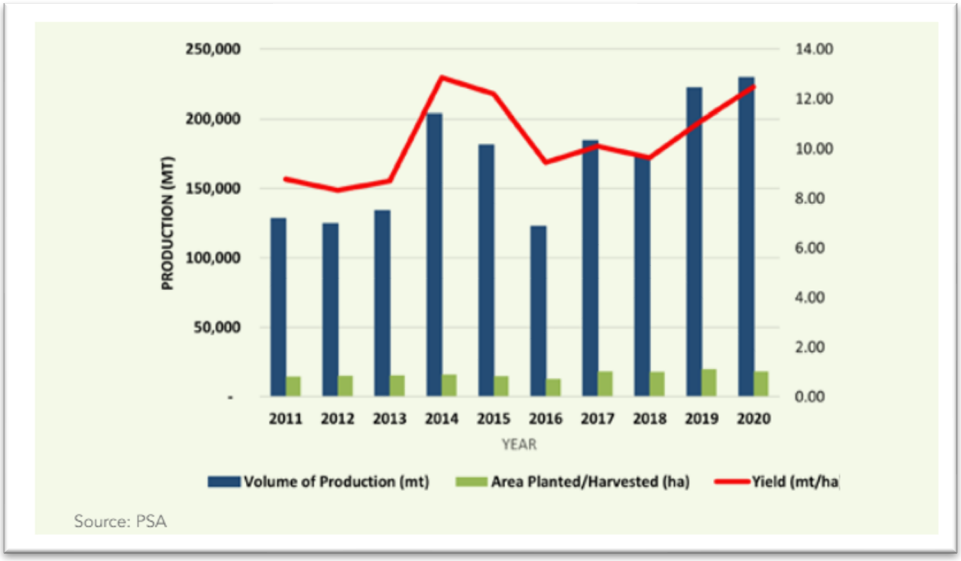


Figure 21: Total volume of production, area planted, and yield, 2011-2020 (Source: Philippine Onion Industry Roadmap 2021-2025).

- Onion-producing ASEAN countries such as Indonesia, Myanmar, and Vietnam outperformed the Philippines in terms of volume of harvest from 2011-2019.

- In 2020, the total onion production is 229,539 metric tons (mt). Red and Yellow Onion comprised 83% (190,974.88 mt) while 17% were shallots (38,564.36 mt).

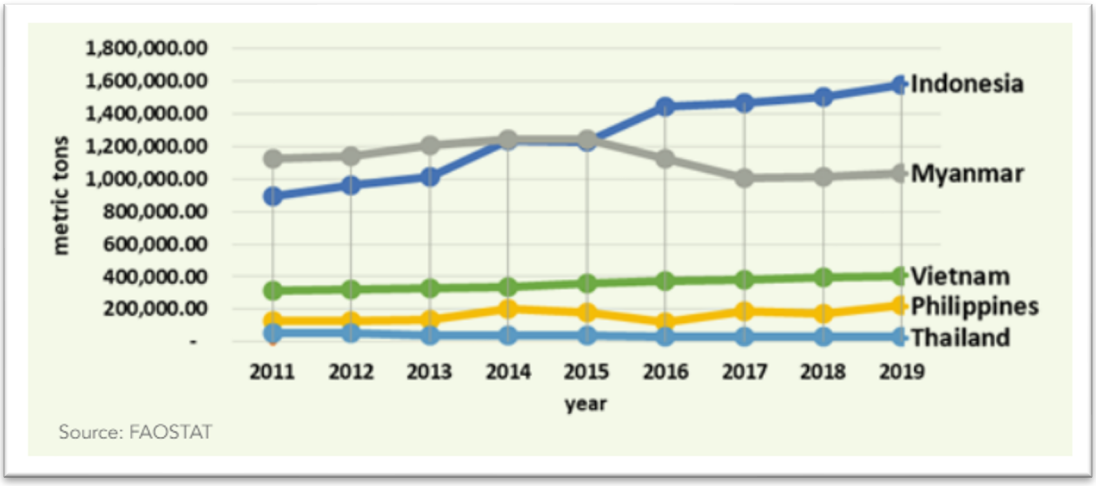


Figure 22: Harvest volume (mt) of onion-producing ASEAN countries, 2011-2019 (Source: Philippine Onion Industry Roadmap 2021-2025).

Figure 23: Volume of production by type, 2011-2020 (Source: Philippine Onion Industry Roadmap 2021-2025).

- In the second quarter of 2023, PSA recorded 84.90 thousand metric tons of onion production, which was 3.4 percent higher than the previous year's same quarter output of 82.08 thousand metric tons.

Crop	Production (in metric tons) January–March		April–June		Year-on-Year Change (%)		Percent Share
	2022	2023	2022	2023p	Jan–Mar	Apr–Junp	Apr–Jun 2023p
Mung bean/Mongo	9,172.24	9,021.39	23,173.69	22,738.97	-1.6	-1.9	NA
Potato	19,012.90	18,178.67	15,117.32	15,431.62	-4.4	2.1	NA
Cabbage	27,068.81	28,472.54	24,439.58	23,328.28	5.2	-4.5	NA
Eggplant	79,152.31	78,136.65	106,865.41	102,982.01	-1.3	-3.6	NA
Tomato	89,996.07	92,707.89	71,587.67	70,327.82	3.0	-1.8	NA
Ampalaya Fruit	18,785.10	18,938.98	32,050.91	33,073.43	0.8	3.2	NA
Onion	147,147.62	156,533.85	82,075.98	84,903.99	6.4	3.4	
Bermuda (Red Creole and Yellow Granex)	119,648.47	125,181.20	80,775.97	83,728.29	4.6	3.7	98.6
Native	27,499.15	31,352.65	1,300.01	1,175.70	14.0	-9.6	1.4
Sweet Potato	114,389.78	105,847.27	163,938.19	151,649.13	-7.5	-7.5	NA
Cassava	465,248.48	489,407.41	698,627.96	709,912.10	5.2	1.6	NA

Notes: p – preliminary
Percent share of varieties to the total crop production
NA - Not Applicable
Details may not add up to total due to rounding
Source: Philippine Statistics Authority, Crops Production Survey (CrPS)

Table 4: Volume of production of selected vegetables and root crops, Philippines January-March 2022-2023 and April-June 2022-2023 from Major Vegetables and Root Crops Quarterly Bulletin, April-June 2023 (Source: PSA).

- Cost and Return Analysis of Onion Per Hectare

Item	Total Cost (PhP/ha)
I. Variable Costs	
A. Labor Costs (250/MD)	
Clearing/weeding (20MD)	5,000
Bed preparation (20MD)	5,000
Placing plastic mulch (4MD X 2)	2,000
Planting and fertilizer application (basal application) (10MD)	2,500
Irrigation (24MD)	6,000
Hilling up/side dressing (10MD)	2,500
Spraying/Pest Control (7MD)	1,750
Foliar application (5 MD)	1,250
Harvesting (20MD)	5,000
Sorting and Drying (10MD)	2,500
Subtotal	**33,500**
B. Seeds	
10 cans X 3,000	30,000
C. Fertilizer	
40 bags processed manure (50PhP/bag)	2,000
10 bags (14-14-14)	14,000
2 bags (46-0-0)	2,800
4 bags Dolomite	1,800
Botanical extracts (citronella+marigold etc.)	500
Fungicides (Nordox)	1,500
Fungicide (Ridomil)	500
Foliar Fertilizer (Guano extract) 2 L	700
Rice hull (10Php/bag) -100bags	1,000
Red bags 1900 X 8	15,200
Plastic Mulch - 8rolls (1600/roll)	12,800
Subtotal	**82,800**
Total Variable Cost	**116,300**
Miscellaneous (15% total variable cost)	17,445
II. Fixed Cost	
A. Land Rental	**8,000**
TOTAL COST	**141,745**
Total yield/ha -20,000kg (25PhP/kg)	
GROSS INCOME	**500,000**
NET INCOME	**358,255**
ROI	**257.75%**

Table 5: Cost and return analysis of onion per hectare from onion production guide (Source: Department of Agriculture - Bureau of Plant Industry).

Major Growing Regions

- The Philippines' major onion-producing regions are Ilocos, Cagayan Valley, Central Luzon, and MIMAROPA, based from PSA data for the year 2020. About 64% of the country's total production for 2020 was from Central Luzon alone.

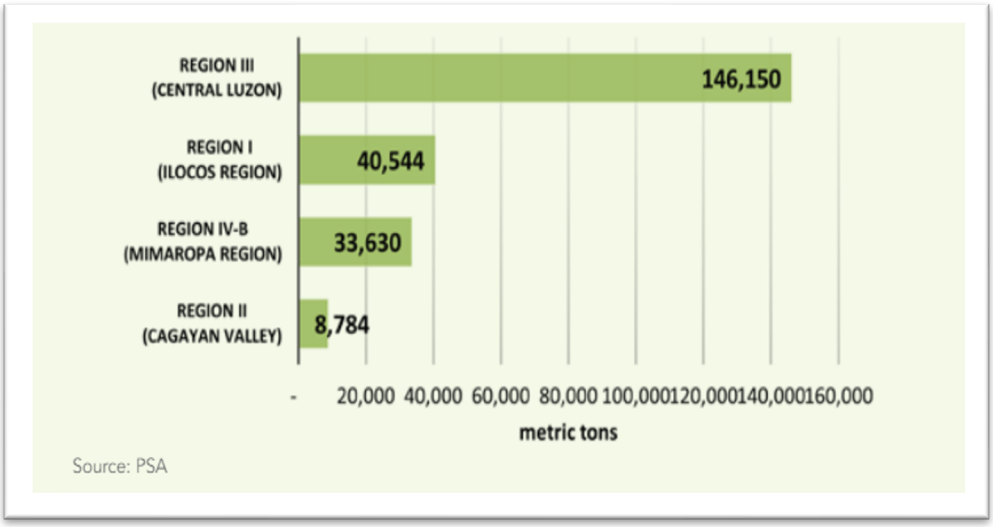


Figure 24: Top producing regions by volume, 2020 (Source: Philippine Onion Industry Roadmap 2021-2025).

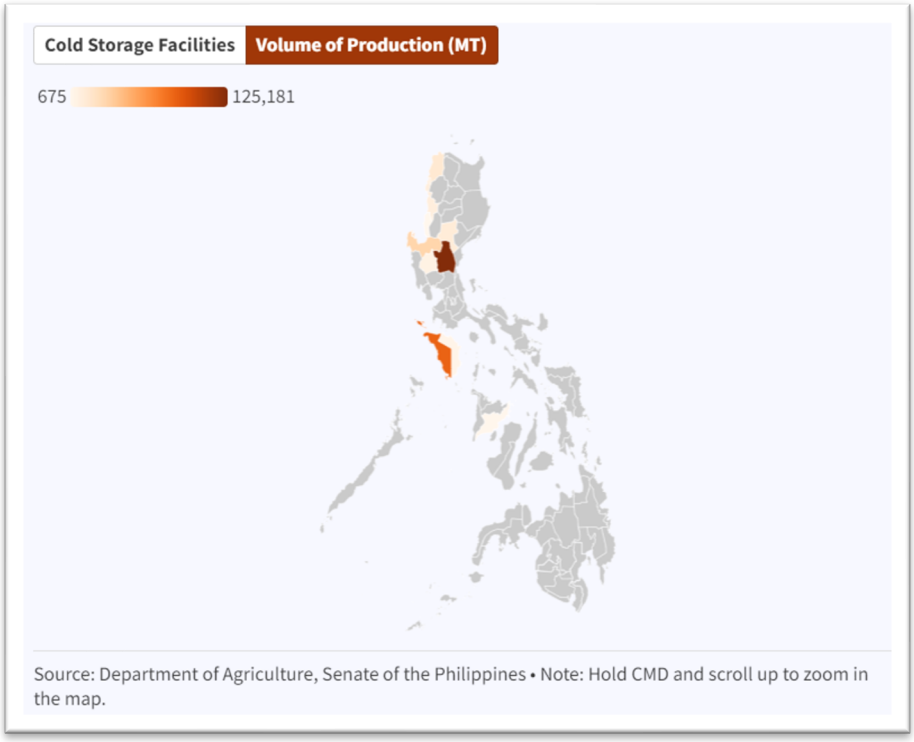


Figure 25: Volume of production of onion-producing provinces (Source: Rappler).

- The annual volume of production of onions (mature bulb) by the top 4 onion-producing regions from 2010 to 2023 shows that Central Luzon has been the leading onion producer for the past 13 years.

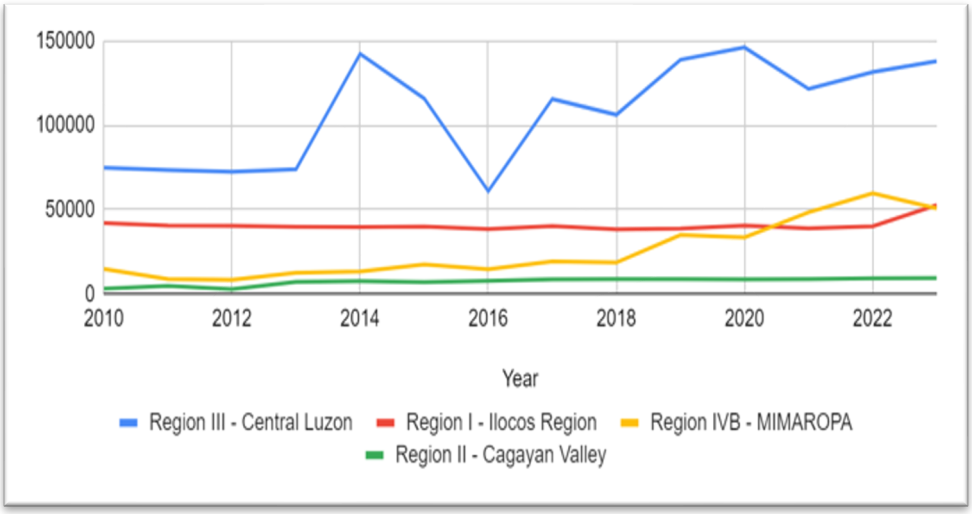


Figure 26: Annual volume of production of onion (mature bulb), by top onion-producing regions, 2010-2023 (Source: PSA).

- In 2022, the top onion-producing provinces in the Philippines were Nueva Ecija (96.8% of Central Luzon's production), Occidental Mindoro, Ilocos Sur, Ilocos Norte, Nueva Vizcaya, Tarlac, Pangasinan, Oriental Mindoro, La Union, and Iloilo.

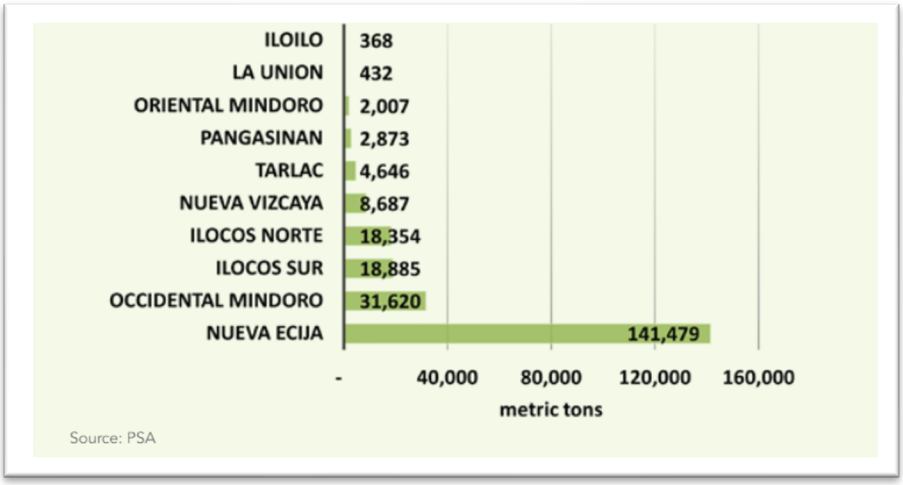


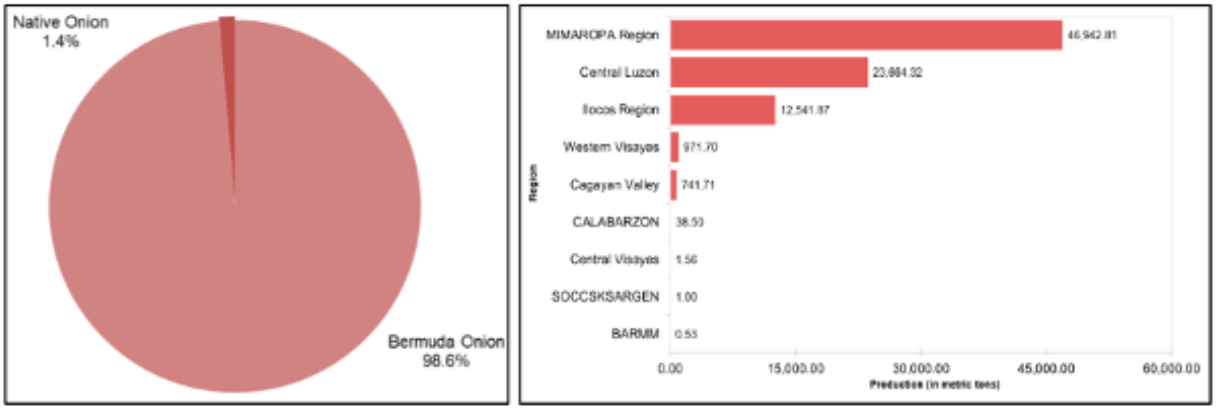
Figure 27: Top producing provinces by volume, 2020 (Source: Philippine Onion Industry Roadmap 2021-2025).

- Majority of the production and areas planted for onions are in Luzon, however, growing onions in Visayas and Mindanao are now being considered to augment production and to respond to expected increase in local and international demand.

Varieties

- There are three types of bulb onion grown in Luzon, namely: red onions (red creole and red Pinoy), white/yellow onions (granex), and shallot/multiplier, which is locally called Sibuyas Tagalog.

- During the second quarter of 2023, majority of the onions produced are bermuda onions and MIMAROPA Region was the top-producing region.



p - preliminary
Source: Philippine Statistics Authority, April to June 2023 Crops Production Survey (CrPS)

Figure 28: Distribution of onion production by type, Philippines April-June 2023 (left); Distribution of onion production by region April-June 2023 from Major Vegetables and Root Crops Quarterly Bulletin, April-June 2023 (Source: PSA).

Consumption

Domestic Use

- Onions are a staple in Filipino cuisine, used extensively in cooking for their flavor and aroma. They are consumed fresh, cooked, or processed into various products such as dried onions and onion powder. They are commonly used to flavor dips, salads, soups, spreads, stir-fry and other dishes. It is popular as a gourmet vegetable in both the domestic and export markets.

- Onion consumption in the country was 2.34 kg per year, with Cagayan Valley and Central Luzon having the highest per capita consumption in 2015 at 3.40kg and 3.24kg, respectively. Metro Manila is the largest domestic market for onions.

	1999-2000	2008-2009	2012	2015-2016
PHILIPPINES	1.92	1.92	2.37	2.34
National Capital Region (NCR)	2.03	2.34	3.00	2.75
Cordillera Administrative Region (CAR)	2.08	1.77	2.44	2.91
Region I (Ilocos Region)	1.77	1.56	2.21	2.45
Region II (Cagayan Valley)	2.24	2.44	3.22	3.40
Region III (Central Luzon)	2.13	2.55	3.22	3.24
Region IV-A (CALABARZON)	1.92	2.24	2.97	2.84
Region IV-B MIMAROPA Region	1.82	1.82	1.96	2.26
Region V (Bicol Region)	1.92	2.03	2.28	2.52
Region VI (Western Visayas)	1.66	1.51	2.14	2.64
Region VII (Central Visayas)	1.51	1.20	1.50	1.95
Region VIII (Eastern Visayas)	1.09	1.30	1.42	1.77
Region IX (Zamboanga Peninsula)	1.14	1.61	1.41	1.53
Region X (Northern Mindanao)	1.61	1.46	1.63	1.67
Region XI (Davao Region)	1.82	1.61	1.91	2.17
Region XII (SOCCSKSARGEN)	2.03	2.08	2.49	2.20
Region XIII (Caraga)	1.46	1.51	1.51	1.83
BARMM	1.40	1.35	1.56	1.60

Table 6: Regional consumption (kg/capita) based on PSA's FD (Source: Philippine Onion Industry Roadmap 2021-2025).

Import

- There has been a fluctuating trend of imports from 2011 to 2020. A higher volume of bulb onions is imported than of shallots.

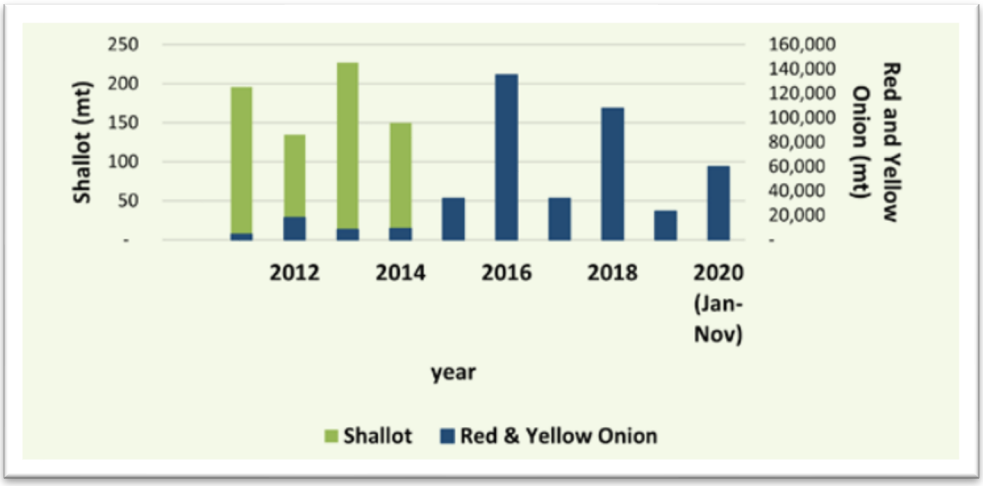


Figure 29: Volume of onion imports, 2011-2020 (Source: Philippine Onion Industry Roadmap 2021-2025).

Export

- The Philippines mainly exports shallots, which has been declining over the years due to competition with other countries. From 2011-2020, highest volume of exportation was in 2014 at 14,010 mt valued at US$ 6.541 M or 10.91% of local production, but there is an observed steady decrease until 2020.

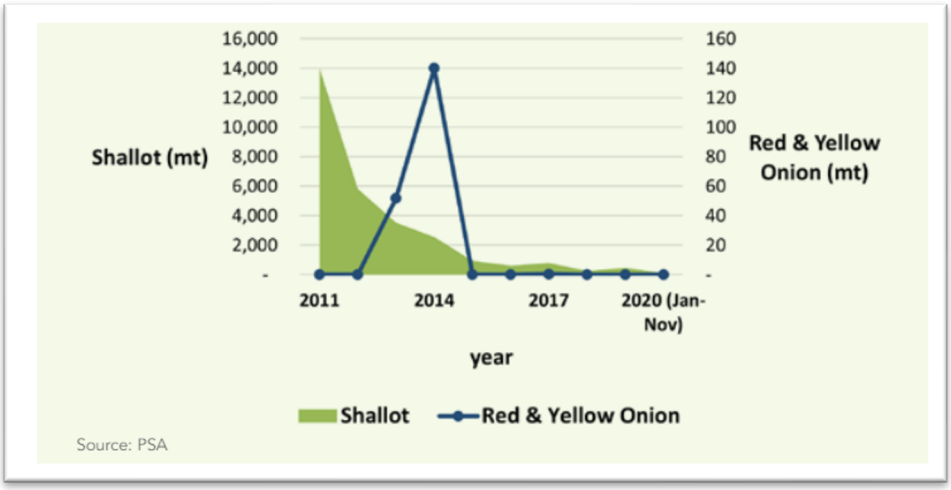


Figure 30: Volume of onion exports, 2011-2020 (Source: Philippine Onion Industry Roadmap 2021-2025).

- Based on the trade matrix data from PSA in 2020, the primary destination of the country's export is Singapore.

Year	Volume (mt)	Value (US$)	Destination
2011	14,010	6,541,524	Indonesia, Malaysia, Singapore, and USA
2012	5,825	2,641,878	Indonesia, Malaysia, Singapore, Hongkong, and Korea
2013	3,519	1,542,431	Indonesia, Malaysia, Singapore, Thailand, and USA
2014	2,551	1,405,719	Indonesia, Malaysia, and Singapore
2015	922	608,743	Indonesia, Malaysia, and Singapore
2016	601	535,543	Indonesia, Malaysia, Singapore, Taiwan, and Vietnam
2017	776	732,596	Singapore, Malaysia, Vietnam
2018	252	325,855	Singapore and Malaysia
2019	459	574,644	Singapore and Malaysia
2020 (Jan-Nov)	121	175,275	Singapore

Table 7: Exportation of shallot, 2011-2020 (Source: Philippine Onion Industry Roadmap 2021-2025).

Socio-Economic Aspects

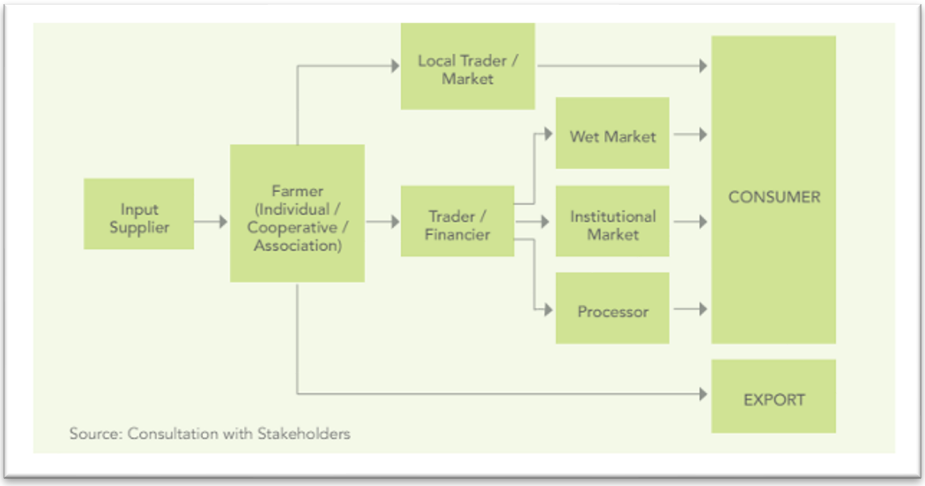
- Employment: Onion farming provides livelihood and employment to about 35,000 onion farmers in the country. Additionally, the industry also creates a source of income for other key players within the supply chain, with additional jobs created in processing and distribution.

- Income: Onion cultivation is a significant source of income for many smallholder farmers, though profitability can be influenced by market prices, production costs, and environmental factors. Farmer's income after deducting the cost of production from the farm gate price is PHP 40.37 and a high Return to Cost (RTC) of 292.04%.

- Community Impact: Onion farming supports rural economies and contributes to community development through income generation and infrastructure improvement. As one of the world's leading onion growers, onion production provides money to farmers, stimulates rural economies, and helps local companies participate in the onion value chain.

- Key Industry Players: Consultation with onion farmer associations reveals that key industry players in the onion value chain include input suppliers, farmers, financers, traders, and consumers. From

the farms, the onion produce goes to local traders or to traders/financers who distributes the onions to markets. Seventy five percent of locally produced onions are sold in wet markets, while



35% head directly to supermarkets, fast food chains, hotels, restaurants, and processors.

Figure 31: Key industry players for onion (Source: Philippine Onion Industry Roadmap 2021-2025)

- Cultural Significance: Farming practices are essential in the lives and cultures of Filipino onion farmers in the Philippines. The interplay between cultural practices, traditional agricultural methods, and social dynamics is crucial in shaping the vibrant fabric that defines the onion farming community. In Nueva Ecijja, cultural practices play a significant role within the onion farming community.

Environmental Aspects and Climate Change

Onions are in the top ten list of vegetables with lowest carbon footprint, and some of the most land and water-efficient crops in comparison to other vegetables. In the Philippines, farmers exhibit strong adherence and dedication to using traditional agricultural practices, such as organic farming, as a testament to their commitment to sustainable agriculture.

Land Use

- Onions are produced best in open, friable, well drained/loam soils with good water holding capacity. They are also adapted to a wide range of soils with proper preparation, good drainage, fertilization and irrigation.

- Onions are land-efficient and have a relatively small impact on wildlife, biodiversity, and loss of habitable land. Farming onions cause some soil erosion, but can be combated with proper soil management techniques.

- Intensive onion farming can lead to soil degradation and nutrient depletion if not managed sustainably.

Water Use

- Onions are highly sensitive to water stress. They require a moderate amount of water, 350–550 mm of water for optimum yield, because of their shallow root systems, making efficient water management important for sustainability.

- Onions have different water requirements depending on its growth stages.

Growth stage	Establishment	Vegetative growth	Bulb initiation	Bulb development	Maturation
Stage duration (days)	30	30	30	45	15
Water requirements (mm)	30.6	156.6	145.2	110.4	00

Figure 32: Onion growth stage and water requirements (Source: Sansan et al., 2024).

- Agriculture is one of the leading causes of water pollution. However, onions have been found to be effective at absorbing heavy metals and toxins from water, and could be an environmentally friendly way to reduce water pollution.

Pesticide and Fertilizer Use

- Heavy use of agrochemicals can lead to soil and water pollution. Pesticide usage produces carbon emissions across its lifecycle—through manufacturing, transportation, and application to crops, as well as contaminating soil and causing potential harm to wildlife and ecosystems.

- Onions require a high source of nitrogen, which can cause nature loss and even be damaging to human health.

Current and Future Challenges Linked to Climate Change

- Temperature and Rainfall Changes : Onion production is sensitive to changes in temperature and rainfall patterns, with extreme weather events such as droughts and heavy rains adversely affecting yields and bulb quality. Drought hinders vegetative growth, lowers yields and bulb quality, reduces photosynthetic activity, and alters the onion plant's metabolism. Climate change impacts have resulted in limited productivity and incomes for onion farmers. (See Figure 34)

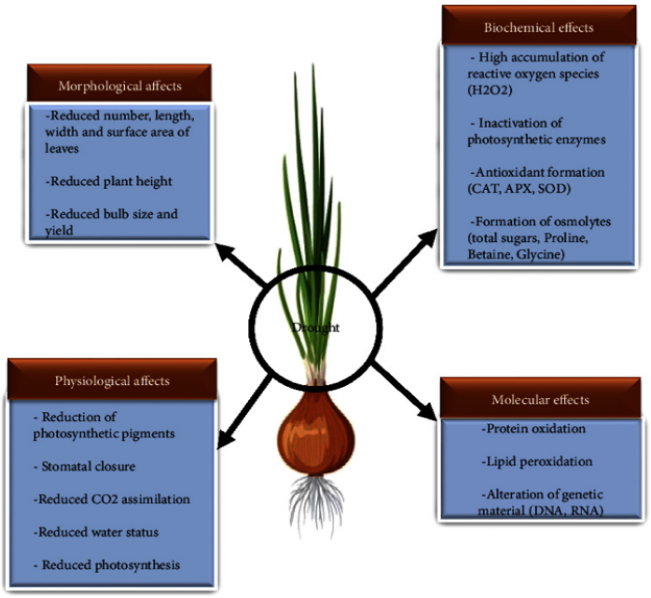


Figure 33: Impact of drought on different onion parameters (Source: Sansan et al., 2024).

- Pests and Diseases : Climate change can exacerbate pest and disease pressures, threatening crop health and productivity. Common pests and diseases in onions include thrips, armyworms, cutworms, white rot, bacterial blight, fusarium silt, iris yellow spot, pink root, downy mildew, and purple blotch.

- Soil Health: Increased erosion and changes in soil composition due to climate change can affect the productivity and sustainability of onion fields.

R&D Opportunities

1. Climate-Resilient Varieties: Development of onion varieties that can withstand extreme weather conditions, pests, and diseases. Climate-resilient crops and crop varieties have been recommended as a way for farmers to cope with or adapt to climate change.

2. Sustainable Farming Practices: Research into sustainable and regenerative farming practices to improve soil health, reduce water use, and minimize environmental impact.

3. Efficient Water Management: Innovations in irrigation and water management to enhance water use efficiency and reduce dependency on rainfall.

4. Post-Harvest Technology: Improved post-harvest handling, storage, and processing technologies to reduce losses and add value to onion products.

Necessary Adaptation Strategies

1. Diversification: Encouraging crop diversification and rotation to enhance soil health and reduce risks associated with monoculture.

2. Infrastructure Improvement: Strengthening agricultural infrastructure to withstand extreme weather events and improve resilience.

3. Water Conservation Techniques: Implementing water-saving technologies and practices, such as drip irrigation and rainwater harvesting.

4. Soil Conservation Practices: Promoting soil conservation methods like contour plowing, cover cropping, and organic amendments to improve soil structure and fertility.

R&D Priorities

1. Breeding and Genetics: Focus on breeding programs to develop high-yield, disease-resistant, and climate-resilient onion varieties through advanced genetic research.

2. Sustainable Agriculture Practices: Research into sustainable agriculture practices that enhance soil health, improve water use efficiency, and reduce environmental impact.

3. Water Management Innovations: Development of efficient irrigation systems and water management strategies to optimize water use and ensure availability.

4. Pest and Disease Management: Enhancing pest and disease management through integrated pest management practices, biological control methods, and resistant varieties.

5. Climate Adaptation Strategies: Investing in climate adaptation strategies, including crop diversification, improved infrastructure, and disaster risk reduction measures.

6. Extension Services and Farmer Education: Strengthening extension services to provide farmers with the knowledge and tools needed to adopt new technologies and practices, improve productivity, and enhance resilience to climate change.

By addressing these research and development priorities, the Philippines can bolster the sustainability and resilience of its onion industry, ensuring long-term economic benefits and environmental health.

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5. Mango

Introduction

The mango industry in the Philippines plays a significant role in the country's agricultural sector, contributing to both domestic consumption and export markets.

General data

Overview

The mango industry has been experiencing a decline in key performance indicators, including production volume, productive area, yield per unit area, and yield per tree.

Year	Production		Area		Yield per unit area		Yield per tree	
	Metric ton (MT)	Growth Rate	hectare	Growth Rate	In MT/ ha	Growth Rate	Kg/tree	Growth rate
2000-2009	925,247	-0.7%	163,106	3.9%	5.7	-4.5%	No data available	No data available
2010-2020	793,296	-0.93%	187,530	-0.14%	4.2	-0.80%	86.1	-2.1%
2016-2020	747,987	-2.3%	186,630	-0.14%	4.0	-0.94%	78.4	-2.2%

Table 8: Summary of mango performance indicators, 2010-2020 (Source: Philippine Mango Industry Roadmap 2021-2025).

The mango export industry in the Philippines is also facing challenges. Despite being the third most highly exported fruit crop in the country, with a gross value added of PHP 35.520 billion and a 1.95% contribution to the major industry in 2020, it is not performing as well as in previous decades.

Challenges exist throughout the value chain. Product registration faces difficulties due to regulations, particularly affecting input supply. Producers are significantly impacted by pests like the cecid fly and diseases such as anthracnose, which render mango trees unproductive. Additionally, high production costs have led some farmers to shift away from mango cultivation.

Production

Since 2010, the mango industry in the Philippines has struggled with unstable fruit production (Figure 35) (PSA, 2024). Overall, mango production has declined, with an average growth rate of -0.93% from 2010 to 2020. The last five years (2016-2020) have been particularly challenging, with the country producing an average of 747,987.2 metric tons of mango annually, 19% lower than in the early 2000s (2000-2009) (DA, 2021). Yet, the sufficiency ratio of mango production remains above 100 percent, indicating that the Philippines is mostly self-sufficient in mango production (Figure 36).

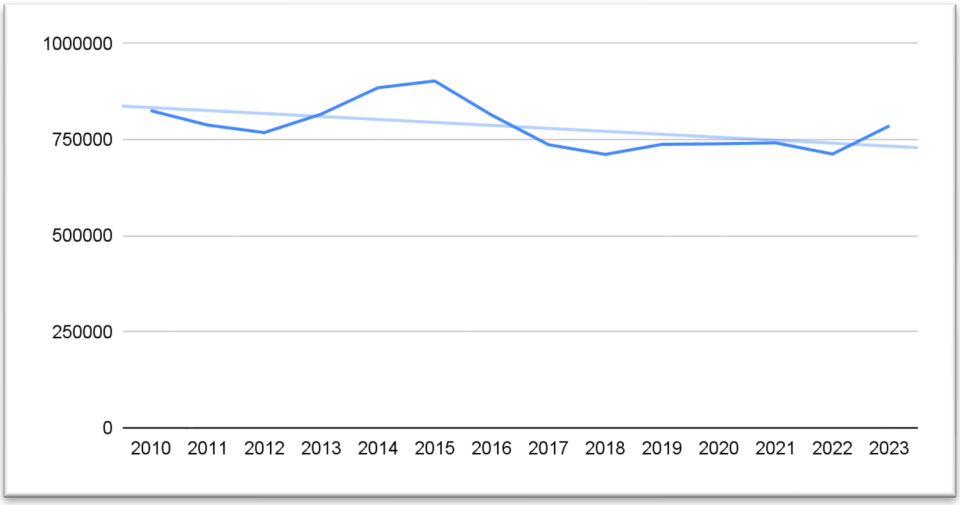

Figure 34: Volume of production of mangoes in the Philippines, 2010-2023.

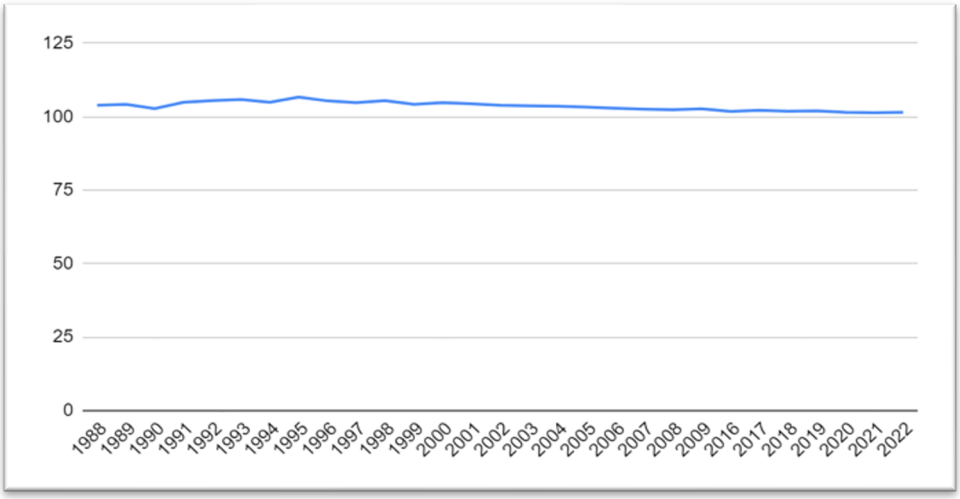

Figure 35: Mango production self-sufficiency ratio, 1988-2022.

Area and Yield

Area Harvested

The area allotted for mango plantations in the Philippines has remained relatively stable from 2007-2020, with a slight average decline of 0.14% from 2010-2020. The regions with the highest areas harvested are Central Luzon, the Ilocos Region, and the Davao Region.

Figure 36: Area of production, 2000-2020 (Source: Philippine Mango Industry Roadmap 2021-2025).

Region	AREA HARVESTED (hectare)				
	2016	2017	2018	2019	2020
CAR	791	789	783	776	776
Ilocos Region	21,855	21,487	21,475	22,478	22,469
Cagayan Valley	10,419	10,250	10,243	10,237	10,304
Central Luzon	33,576	33,571	33,500	33,649	33,566
CALABARZON	13,950	13,783	13,782	13,582	13,583
MIMAROPA	3,573	3,556	3,554	3,502	3,469
Bicol Region	2,836	2,837	2,837	2,841	2,810
Western Visayas	10,105	10,273	10,283	10,538	10,537
Central Visayas	11,978	11,977	11,976	11,978	11,979
Eastern Visayas	717	715	705	753	760
Zamboanga Peninsula	16,905	15,343	15,338	14,950	14,956
Northern Mindanao	8,720	8,719	8,722	8,730	8,827
Davao Region	18,315	18,639	18,572	18,563	18,768
SOCCSKSARGEN	17,143	17,146	17,125	17,079	17,024
Caraga	2,625	2,625	2,623	2,623	2,626
BARMM	14,328	14,330	14,341	14,344	14,345
PHILIPPINES	187,834	186,038	185,858	186,621	186,798

Table 9: Area harvested with mango per region, 2016-2020 (Source: Philippine Mango Industry Roadmap 2021-2025).

Number of Trees Harvested

In 2020, nearly 9.6 million productive mango trees were harvested, with 75% being Carabao mango trees. The number of bearing trees increased steadily from 2010-2014, followed by a sharp increase in 2015. However, the industry is unable to maintain this level in the subsequent years.

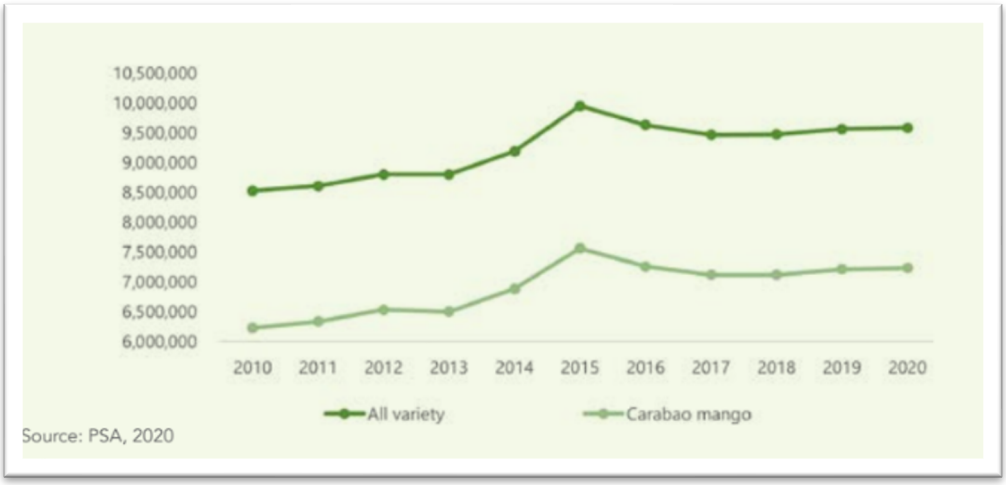

Figure 37: Number of trees harvested with mango, 2010-2020.

Regions with High Number of Trees

Central Luzon has the highest number of mango trees among all regions, followed by SOCCSKSARGEN and Cagayan Valley. Ilocos Region has an average of 771 thousand harvested trees.

Tree to Area Ratio

Each hectare of mango plantation in the Philippines has an average of 49 productive trees, with Carabao mango having an average of 47 trees per hectare. These figures are lower than common planting distances, indicating that mango plantations are not meeting their full potential in planting density and production.

Region	NUMBER OF TREES HARVESTED				
	2016	2017	2018	2019	2020
CAR	35,932	36,582	35,647	33,300	32,920
Ilocos Region	794,506	772,450	758,002	757,193	783,097
Cagayan Valley	968,283	963,869	940,055	940,126	938,561
Central Luzon	1,858,952	1,859,574	1,859,265	1,856,930	1,858,757
CALABARZON	985,204	983,367	928,509	906,909	908,349
MIMAROPA	208,320	198,877	198,156	198,006	197,457
Bicol Region	64,039	64,211	64,618	64,764	66,084
Western Visayas	410,576	411,281	431,036	431,868	434,751
Central Visayas	572,115	573,243	573,563	573,148	573,174
Eastern Visayas	18,492	18,774	18,843	18,571	18,854
Zamboanga Peninsula	1,006,835	1,009,739	897,962	904,342	954,565
Northern Mindanao	468,596	472,851	473,830	485,077	495,838
Davao Region	720,298	455,241	456,084	457,351	457,328
SOCCSKSARGEN	1,002,266	974,594	989,453	993,743	989,292
Caraga	203,365	204,125	204,449	204,254	204,257
BARMM	630,636	632,086	633,631	646,840	646,964
PHILIPPINES	9,948,415	9,630,864	9,463,103	9,472,422	9,560,248

Source: PSA, 2020

Table 10: Number of mango trees harvested per region, 2016-2020

Yield

The mango industry in the Philippines has experienced a decline in yield from 2016 to 2020, with an average decline of -0.94%. The average yield per hectare from 2010-2020 is 4.2 MT/ha, with the highest and lowest yields experienced in 2015 and 2018, respectively.

Major Producing Regions

Based on PSA data, the top 5 major producing regions were: Ilocos Region, Zamboanga Peninsula, Central Visayas, SOCCSKSARGEN, and Central Luzon.

Region	Average Annual Production (in metric tons)
Region I (Ilocos Region)	92,837.59
Region IX (Zamboanga Peninsula)	37,571.75
Region VII (Central Visayas)	31,753.79
Region XII (SOCCSKSARGEN)	24,216.42
Region III (Central Luzon)	23,948.24

Table 11: Major producing regions based on average annual production, 2010-2023.

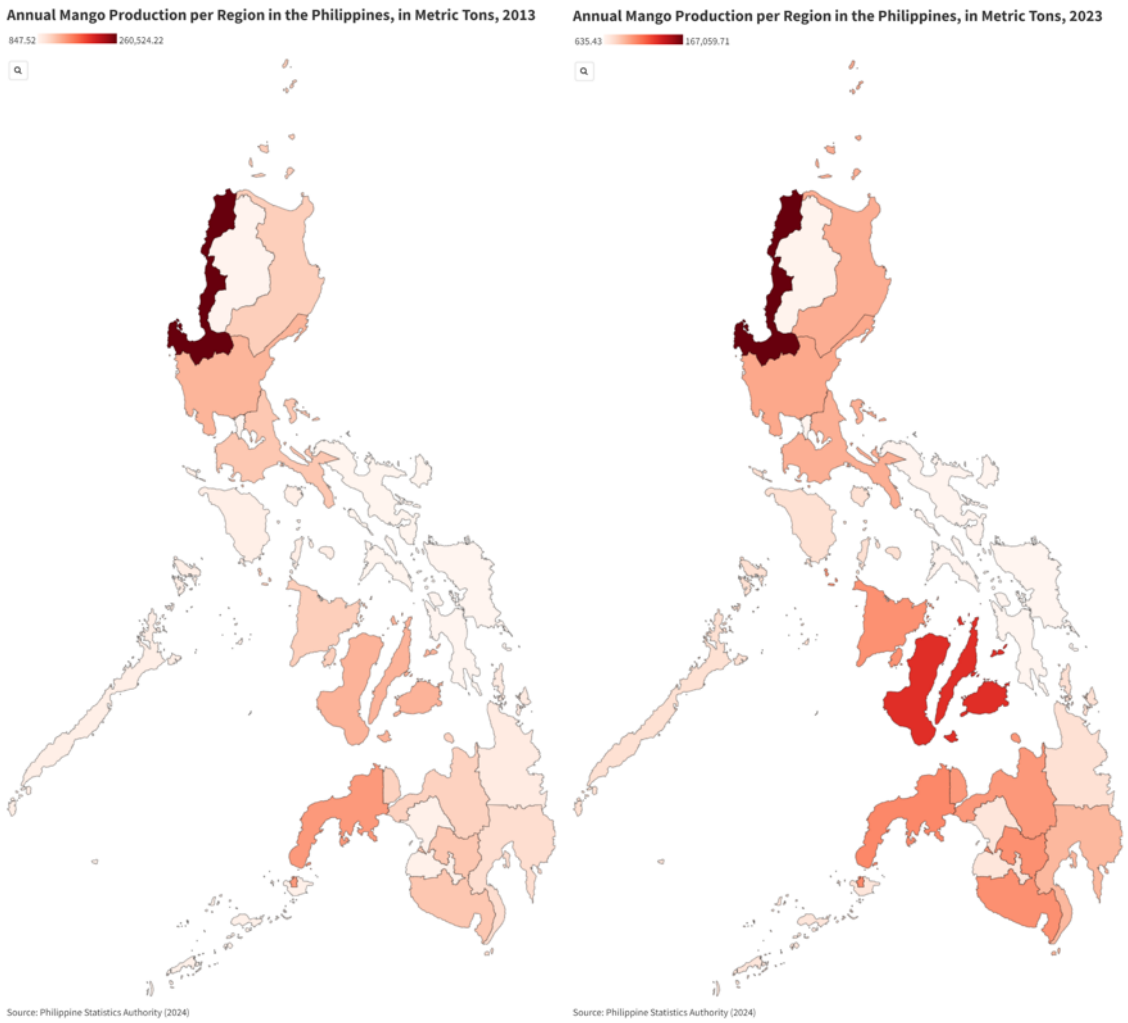

Figure 38: Philippine mango production per province in the Philippines, 2013-2023.

Varieties

There are three main types of mango in the Philippines: Carabao mango, Pico, and Katchamita (also known as Indian Mango). Carabao mangoes are elongated and kidney-shaped with thin yellow pulp, offering a very tender taste and slight aroma. Pico mangoes have a distinctive beak at the top and have fibrous light orange-yellow flesh. Katchamita mangoes, on the other hand, are small and rounded with green skin and yellowish flesh. Among these, Carabao mango is the most widely cultivated, renowned as the world's sweetest mango, and consequently, it has high demand both domestically and internationally (Figure 40). Additionally, other popular mango varieties in the Philippines include Apple mango, Pahutan, Paho, and Señorita. Exclusively grown in Batangas and Pangasinan are the Cambodiana and Hawaii varieties, while Duldul, Florida, Spanish, Mestiza, and Zambales are specific to Davao City and Davao del Sur.

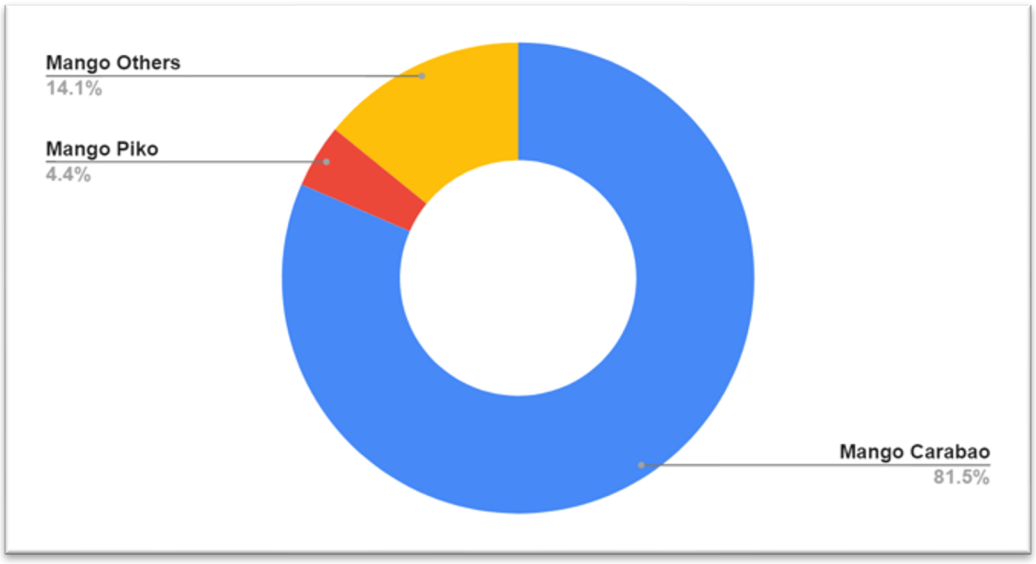

Figure 39: Distribution of volume of production per mango variety, 2010-2023 (Source: PSA, 2024).

Consumption

Domestic Use

- Average Consumption: An average Filipino consumes 7.07 kg of locally produced mangoes per year, both fresh and processed. This consumption is equivalent to 719, 241 MT, accounting for 92% of the country's average gross supply.

- Decline in Consumption: There has been a noticeable decline in per capita consumption over the past 10 years, from 7.3 kg/year in 2012 to 5.91 kg/year in 2022.

- Wastage and Utilization: On average, 46,103 MT of mangoes are either wasted or used as feed, accounting for 6% of total production. This wastage is 194% higher than the average volume of mangoes exported.

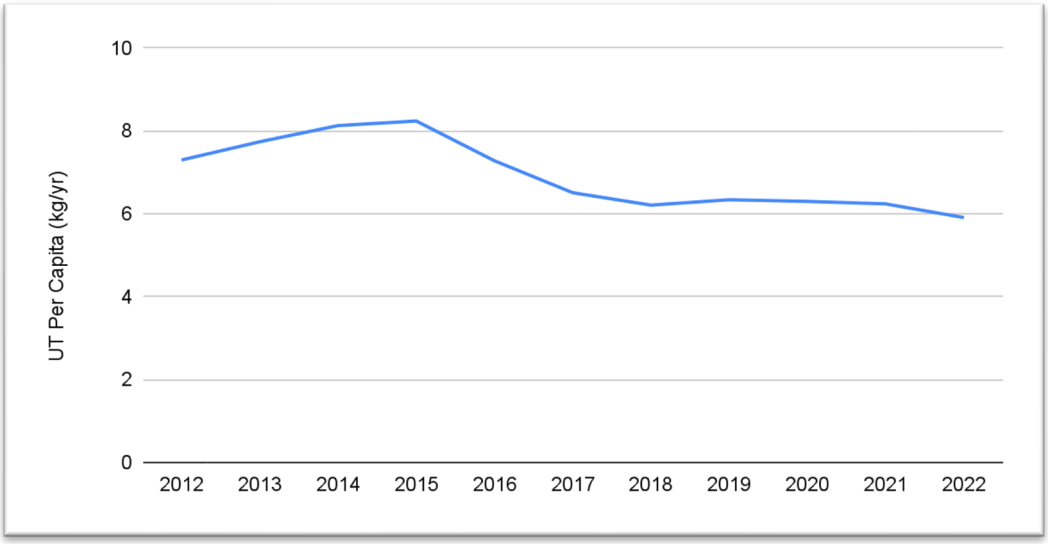

Figure 40: Mango utilization per capita, kilograms per year, 2010-2012.

- Production and Supply: Mango production increased by an average of 0.13% per year from 2017 to 2019. Production was 737.0 thousand MT in 2017, dropped to 711.7 thousand MT in 2018, and recovered to 737.9 thousand MT in 2019, averaging 728.9 thousand MT for the period.

- Food Availability: The volume of mango available for food averaged 671.4 thousand MT from 2017 to 2019. This volume decreased from 677.7 thousand MT in 2017 to 656.2 thousand MT in 2018, then increased to 680.3 thousand MT in 2019, equivalent to 6.34 kg per person. The annual per capita net food disposable averaged 6.35 kg over the past three years.

Year	Exports (MT)	Feeds and Waste (MT)	Total Net Food Disposable (MT)	UT Per Capita (kg/yr)
2012	18440	44998.2	704971.8	7.3
2013	7886	48509.52	759982.48	7.74
2014	21112	51835.56	812090.44	8.13
2015	12981	53385.48	836372.52	8.24
2016	14343	47982.74	751729.66	7.28
2017	16116.14	43254.98	677661.31	6.51
2018	13562.17	41885.86	656211.86	6.21
2019	14211.79	43423.59	680302.96	6.34
2020	10658.06	43715.5	684876.22	6.3
2021	10101.94	43897.36	687725.31	6.24
2022	10716.62	42110.19	659726.36	5.91
AVERAGE	**14,722.67**	**46,103.69**	**722,291.22**	**7.07**

Table 12: Utilization of mango from 2010 to 2019.

Export and Import

- Exports: Only 2% of the average gross supply is utilized for export. From 2017 to 2019, the highest export volume was in 2017 at 16.1 thousand MT, the lowest in 2018 at 13.6 thousand MT, and in 2019 it was 14.2 thousand MT, averaging 14.6 thousand MT for the three years.

Figure 41: Export of mango by volume and value, 2016-2020.

- Imports: From 2016 to 2020, the Philippines experienced a fluctuating trend in mango imports. In 2016, the country imported 94.76 MT of mangoes. Imports peaked at 6,136 MT in 2018. In 2019, imports drastically decreased to 933.34 MT. The most imported mango product is preserved mango from Cambodia. Other imported products include mango dice and slice/dehydrated mango from Cambodia, Vietnam, and Thailand.

Figure 42: Importation of mango by volume, 2016-2020.

Value Chain

Figure 44 presents the Philippine mango global value chain including the inputs and the different processes involved from production to marketing. Inputs in mango production includes the seeds planting materials, fertilizers, agrochemicals, farm equipment and irrigation equipment for irrigated areas.

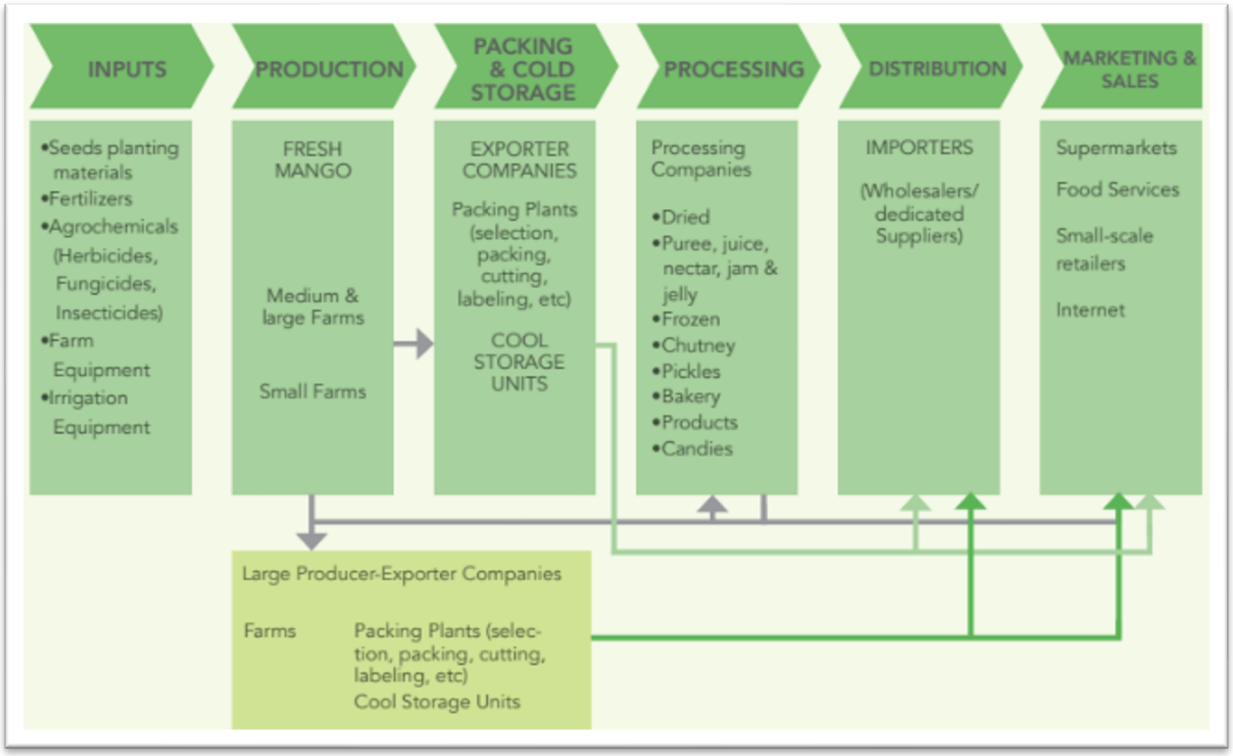

Figure 43: Philippine mango global value chain.

Production

Fresh mangoes in the Philippines are primarily cultivated by small-scale farmers, who constitute the majority of mango producers. While medium and large-scale farms also contribute significantly to the overall production, the backbone of the industry is believed to lie in the hands of countless smallholders across the country. This structure is typical of many Philippine agricultural sectors, where a vast number of small farms collectively produce a substantial portion of the country's agricultural output.

Packaging and Storage

The packaging and storage of mangoes in the Philippines varies depending on the intended market, whether local or export, and the stage of ripeness of the fruit.

- Local Market: For retail, mangoes for the local market are commonly packed in bulk or in small plastic bags. Some are also sold individually, wrapped in newspaper or banana leaves to protect the fruit. For wholesale, larger quantities are packed in wooden crates or cardboard boxes for transportation to markets.
- Export Market: Mangoes destined for export undergo rigorous quality control and are packed in specialized containers to ensure optimal conditions during transport. Common packaging materials include: corrugated cardboard boxes, plastic crates, and foam padding.

Processing Stage

Processing involves manufacturing fresh mangoes into products like dried mangoes, puree, and Individual Quick Frozen (IQF) mangoes. This requires significant capital for equipment and infrastructure.

Distribution

The distribution segment Includes activities related to receiving mangoes in the end market and delivering them to sales outlets. Exporters often sell directly to end clients, bypassing intermediaries, though brokers and intermediaries are still used. For processed mangoes, exporters may sell directly to large food retailers or manufacturers, or through distributors.

Marketing and Sales

Marketing and sales is handled by various actors, including supermarkets, food services, and small-scale retail outlets. Supermarkets are a key market channel for both fresh and processed mangoes.

Prices

Farmgate Prices (2010-2020):

- National average farmgate price of green carabao mango increased by 6.82% annually.
- Davao Del Sur had the highest annual price growth at 9.49%, followed by Pangasinan (8.74%) and Negros Oriental (8.60%).
- As of July 2021, Negros Oriental had the highest average price at PHP 71.67 per kilo, while Cotabato had the lowest at PHP 30.12 per kilo.
- From 2019 to 2020, Cotabato saw a 34.02% increase, whereas Batangas experienced a 12.01% decrease.

Rank	Province	AGR (2010-2020)	2019	2020	2021*	(2020/2019) % +/-
1	Pangasinan	8.74	51.75	58.39	69.24	12.83
2	Zamboanga del Norte	6.42	40.11	42.08	53.89	4.91
3	Cebu	6.76	41.68	49.73	48.52	19.31
4	Cotabato	2.93	26.07	34.94	30.12	34.02
5	Davao del Sur	9.49	45.55	51.29	46.31	12.60
6	Batangas	7.68	45.56	40.09	60.54	-12.01
7	Ilocos Norte	7.07	41.47	48.80	41.76	17.68
8	Misamis Occidental	2.20	31.77	37.35	42.64	17.56
9	Iloilo	7.62	63.01	74.30	67.84	17.92
10	Negros Oriental	8.60	65.34	74.19	71.67	13.54

Source: PSA, 2020
*2021 price is as the average from January to July 2021
AGR –average growth rate per year in percent (%)

Table 13: Top producing province and the farmgate price in peso per kilogram of mango, 2010-2021.

Wholesale Prices (2010-2019):

- NCR ripe mango price increased from PHP 46.80/kg in 2010 to PHP 92.96/kg in 2019, with an average annual growth of 7.92%.
- Pangasinan ripe mango prices grew at an average of 11.21% per year.

- Cebu and Lanao del Norte saw average annual growth of wholesale prices for green mango at 11.37% and 8.13%, respectively.

Selected Areas	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
NCR (ripe)	46.80	46.14	46.83	47.61	51.06	53.28	70.19	72.10	N/A	92.96
Pangasinan (green)	29.99	N/A	32.78	33.97	35.41	28.77	41.46	58.86	75.40	77.19
Pampanga (ripe)	N/A	57.28	62.94	64.67	62.22	70.74	73.72	71.62	100.52	102.69
Cebu (green)	49.47	49.54	47.60	47.81	49.68	56.41	71.01	99.67	114.00	106.84
Lanao del Norte (ripe)	39.43	45.60	42.85	42.10	42.86	40.25	58.56	85.48	62.53	79.44

Table 14: Wholesale price of ripe and green mango in selected area, 2010 to 2019 (Source: PSA, 2020).

Retail Prices (2010-2020):

- Retail prices for ripe carabao mango increased annually by 11.21% in Batangas, 9.02% in Cebu, and 8.95% in Misamis Occidental.

- From January to July 2021, Negros Oriental had the highest retail price at PHP 144.94/kg, while Zamboanga del Norte had the lowest at PHP 106.61/kg.

- From 2019 to 2020, notable price increases were seen in Cebu (24.71%) and Ilocos Norte (18.27%),

Rank	Province	AGR (2010-2020)	2019	2020	2021*	(2020/2019) % +/-
1	Pangasinan	6.36	91.40	89.22	134.20	-2.39
2	Zamboanga del Norte	5.47	84.76	72.08	106.61	-14.96
3	Cebu	9.02	107.50	134.06	133.52	24.71
4	Cotabato	7.55	95.36	91.60	118.71	-3.94
5	Davao del Sur	7.73	85.94	85.64	114.02	-0.35
6	Batangas	11.21	146.39	162.70	110.54	11.14
7	Ilocos Norte	6.76	78.04	92.30	134.20	18.27
8	Misamis Occidental	8.95	102.21	103.06	110.36	0.83
9	Iloilo	7.69	119.33	131.94	123.21	10.57
10	Negros Oriental	8.77	128.75	127.38	144.94	-1.06

Source: PSA, 2020
Note: *Average of January to July 2021

while Zamboanga del Norte saw a 14.9% decrease.

Table 15: Average growth rate per year of the retail price (PhP/kg) of ripe carabao mango in top producing mango provinces in the Philippines, 2010-2021.

Monthly and Yearly Retail Prices (2020-2021):

- The highest monthly retail price was recorded in September 2021 at PHP 195.07/kg in Pangasinan.
- The lowest monthly retail price was recorded in July 2020 at PHP 55.00/kg in Ilocos Norte.
- The highest average yearly retail price in Batangas at PHP 159.07/kg; lowest in Ilocos Norte at PHP 84.22/kg.

Rank	Provinces	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1	Pangasinan	110.00	118.63	137.59	90.04	71.81	69.03	123.03	156.67	195.07	189.90	169.46	176.63	133.99
2	Zamboanga del Norte	81.77	106.96	103.95	66.00	63.55	76.76	74.31	78.67	109.94	125.71	115.83	121.00	93.70
3	Cebu	133.43	135.20	124.48	136.90	146.16	129.67	127.38	124.56	129.33	133.25	152.00	154.00	135.53
4	Cotabato	84.00	95.37	103.14	98.29	81.54	70.00	80.00	100.00	111.96	103.27	100.00	110.17	95.65
5	Davao del Sur	85.54	95.83	90.15	80.46	71.83	80.00	76.36	81.67	106.15	92.62	78.25	100.73	85.80
6	Batangas	166.25	158.64	154.00	127.60	124.38	124.37	149.19	162.05	180.90	183.74	185.97	191.69	159.07
7	Ilocos Norte	N/A	87.62	142.27	96.96	65.20	58.26	55.00			N/A			84.22
8	Misamis Occidental	114.13	118.49	110.15	100.83	88.15	80.63	77.79	89.76	130.73	116.56	124.08	108.00	104.94
9	Iloilo	155.00	171.67	148.46	129.67	118.68	109.38	107.14	115.33	141.29	145.26	132.50	159.00	136.12
10	Negros Oriental	130.00	127.75	129.11	112.00	114.00	112.00	111.11	104.00	130.00	154.00	151.75	141.40	126.43

Source: PSA, 2020
Note: Pangasinan is a regional-level data in the absence of a provincial data
N/A- no available data

Table 16: Average monthly retail prices (PhP/kg) of ripe carabao mango in the top ten producing provinces in 2020.

Exported Price of Carabao Fresh Mango (2011-2019):

- Switzerland had the highest FOB price in 2019 at USD 3.20/kg; Malaysia had the lowest at USD 0.53/kg.
- Average FOB price from 2011 to 2019 was highest in Japan at USD 2.10/kg and lowest in Malaysia at USD 0.77/kg.
- Switzerland saw the highest annual growth in FOB price at 22.78%, followed by Hong Kong (13.28%) and Saudi Arabia (5.99%).
- Singapore and Malaysia saw annual decreases in FOB prices by 2.33% and 6.41%, respectively.

Country of Destination	2011	2012	2013	2014	2015	2016	2017	2018	2019	AGR (2011-2019)	Average Price (USD) Per Year
Hongkong	0.42	0.39	0.97	0.56	0.85	0.67	0.90	1.09	1.24	13.28	0.79
Republic of Korea	1.63	1.68	2.04	2.06	2.08	2.03	2.54	2.29	1.96	3.56	2.03
Japan	1.86	1.76	2.22	2.38	1.77	2.98	1.92	1.86	2.19	1.24	2.10
Singapore	1.74	1.98	1.50	1.70	1.39	1.46	1.82	1.88	1.20	-2.33	1.63
Malaysia	1.21	0.60	0.67	1.13	0.91	0.64	0.62	0.60	0.53	-6.41	0.77
Switzerland	1.61	0.40	0.79	0.52	1.23	2.36	2.40	2.81	3.20	22.78	1.70
Saudi Arabia	1.30	1.03	0.96	0.97	1.18	1.25	1.51	1.26	2.00	5.99	1.27
Bahrain	2.03	1.84	1.63	1.98	2.19	2.12	1.98	1.99	2.14	1.49	1.99

Source: PSA, 2020

Table 17: Average FOB price (USD/kg) of exported fresh mango in selected countries, 2011-2019.

Socio-Economic Aspects

- Employment: Mango farming and processing employ thousands of Filipinos, from smallholder farmers to workers in processing facilities.
- Income: Mango farming is a significant source of income for many rural households, although profitability can be affected by market prices, production costs, and environmental factors.
- Community Impact: Mango cultivation supports rural economies and contributes to the development of local communities through income generation and infrastructure development.

Environmental Aspects and Climate Change

Environmental Impacts

- Land Use: Large-scale mango orchards can lead to soil degradation and loss of biodiversity if not managed sustainably.
- Water Use: Mango trees require a considerable amount of water, making efficient water management crucial to ensure sustainability.
- Pesticide and Fertilizer Use: Intensive use of agrochemicals can lead to soil and water pollution, affecting local ecosystems and human health. Cubelo and Cubelo (2021) identified that pesticide application is the main pest management strategy in all surveyed mango farms and by all sprayer-contractors. This practice is deeply entrenched due to farmers' aversion to production risks from pests, impacting yield and profit. Pesticide use is extensive, involving a combination of insecticides from 8 chemical families and 13 active ingredients, not all registered for mango use.

Current and Future Challenges Linked to Climate Change

Mango trees thrive in a variety of frost-free environments. They yield the best results in regions with a distinct, relatively cool dry season combined with high heat accumulation during the flowering and fruit development stages. However, rain or excess moisture (including high humidity, heavy dew, and fog) during these periods can promote fungal diseases, leading to flower and fruit drop (Bally, 2006). The crop suitability map and the area planted with mango are illustrated in Figure 45. The top-producing regions' climates were well-suited for the cultivation of mangoes.

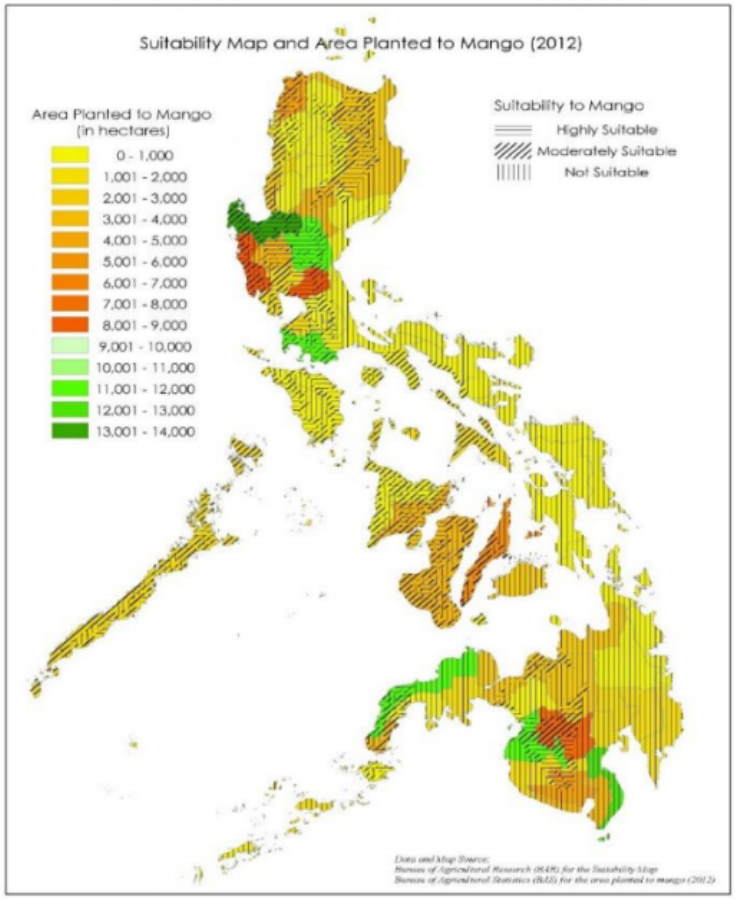

Figure 44: Mango suitability map and planted area.

Pests and Diseases

The mango industry in the Philippines is facing challenges with declining yield and quality, largely due to pests and diseases. This issue is particularly critical for international markets, which demand higher quality standards compared to the domestic market. The major problems identified by growers are cecid fly infestation during production and anthracnose disease in postharvest. To address these issues, the Department of Agriculture is working with State Universities and Colleges (SUCs) and experts on research studies for managing and controlling these pests and diseases.

The cecid fly, also known as "*kurikong*" or "*nora nora*," is a small delicate fly that attacks both the fruits and leaves of mango trees. Infestation begins as early as 32 days after flower induction (DAFI) and can recur up to 75 DAFI. Management strategies include pruning, weed removal, fruit disposal, insecticide spraying, and practices like Insecticide Resistance Management (IRM) to prevent resistance development. Prevention methods include bagging fruits or applying insecticides.

Anthracnose, a major postharvest disease, causes brown spots on leaves, blossom blight, and fruit rot. Field management practices such as maintaining good light and air circulation, burning trash, bagging fruits, fertilizing, and applying fungicides are recommended to mitigate the impact of these diseases.

Adaptation Strategies

The mango industry in the Philippines faces significant challenges, including cecid fly infestation, high production costs, food safety requirements for international markets, postharvest losses, and the conversion of mango orchards into vegetable-based plantations. Addressing these issues requires strategic, innovative, and long-term research and development efforts to enhance the industry's competitiveness in both local and export markets.

Policies and Programs

Priority Programs

- Cecid Fly Control and Management Action Plan. Upgrade production systems to reduce the vulnerability of the mango industry to pest outbreaks and promote food safety, farm workers' health, and environmental protection.

- Tree Rehabilitation. Rehabilitation of mango trees through pruning and fertilization to increase productivity and yield by at least 50%.

- National Mango Association Strengthening. Strengthen the National Mango Association to ensure proper representation of the mango sector in policy-making activities.

- Access to Financing. The Agriculture and Credit Policy Council will create a specific loan window for mango farmers, offering a maximum loan of P150,000 per hectare.

- Farm Clustering, Consolidation, and Modernization. Implement farm clustering and consolidation to achieve economies of scale for more cost-efficient production, harvest, processing, and market operations.

Policies, Legislation, and Ordinances

- Review of the Comprehensive Agrarian Reform Program. Attract foreign direct investors and enable technology transfer to modernize farming, increase productivity, and competitiveness.

- National Mango Act. Enact a law to ensure sustained support for the mango industry.

- Local Ordinances. Encourage mango farm owners to utilize their farms and impose strict standards on harvesting mangoes at the right age of maturity.

- Exporters Incentives. Provide economic assistance to secure foreign markets, including export subsidies, direct payments, low-cost loans, tax exemptions on export profits, and government-financed international advertising.

R&D Opportunities

1. Climate-Resilient Varieties: Development of mango varieties that can withstand extreme weather conditions, pests, and diseases.

2. Sustainable Farming Practices: Research into sustainable and regenerative farming practices to improve soil health, reduce water use, and minimize environmental impact.

3. Efficient Water Management: Innovations in irrigation and water management to enhance water use efficiency and reduce dependency on rainfall.

4. Post-Harvest Technology: Improved post-harvest handling, storage, and processing technologies to reduce losses and add value to mango products.

5. Pest and Disease Management: Addressing the major challenges posed by pests like the cecid fly and diseases such as anthracnose. Research on integrated pest management (IPM) practices and sustainable pest control methods is crucial.

6. Planting Density Optimization: Increasing the planting density of mango trees to utilize the full potential of the plantation area, as current tree-to-area ratios are lower than optimal.

7. Market and Export Strategies: Developing strategies to enhance the competitiveness of Philippine mangoes in international markets, addressing quality standards, and exploring new market opportunities.

8. Socio-Economic Impact: Understanding and mitigating the socio-economic impacts of mango farming, including effects on employment, income generation, and community development.

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6. Banana

Introduction

The banana (*Musa* spp.) is one of the most important fruits in the Philippines, both economically and nutritionally. It accounted for the second highest share of total gross value added of the agriculture, forestry, and fishing (AFF) industry, just after rice. It is an emblematic crop of the country, playing an essential role in food security and farmers' incomes. Banana trees are native to Southeast Asia, the Philippines, Papua New Guinea and part of Indonesia. The biodiversity of this region is also of great importance in this respect.

General data

Main types of bananas grown: The main banana varieties grown in the Philippines include Saba, Cavendish, Latundan, Lacatan, and Bungulan.

Cavendish variety is produced for the export market; it is 19% of total banana production area but 50% of the production. It is sensitive to drought and flooding but is tolerant to strong wind. It is highly susceptible to black sigatoka disease, nematodes, and Fusarium Wilt TR4.

Saba variety is both for export market and local consumption covering 41% of total banana production area. It is susceptible to banana bract mosaic virus and the 'bugtok' disease.

Latundan is more for domestic market but with potential for export. The variety is highly susceptible to Race 1 of Fusarium Wilt, Sigatoka and is susceptible to nematodes (DA-BAR, 2022).

Lakana is produced for the domestic market. It is highly susceptible to banana bunchy top disease, sigatoka diseases, and nematodes.

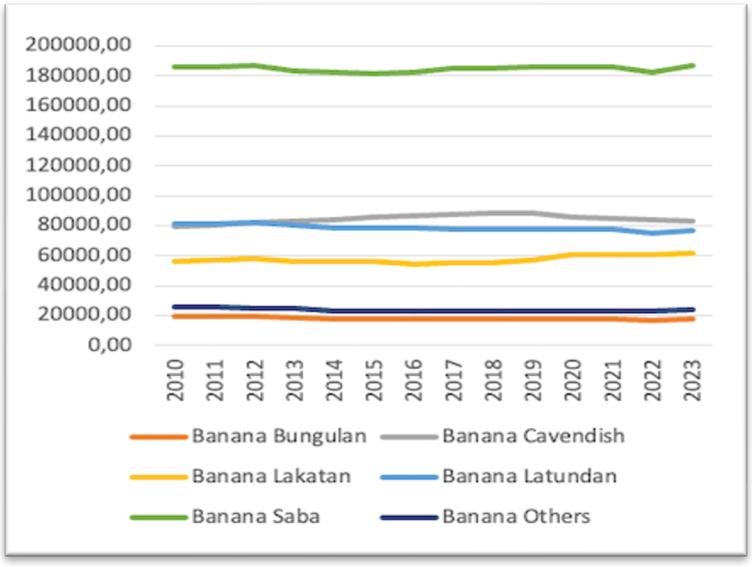

Figure 45: Annual area of banana harvested in Philippines in ha, 2010-2023 (Source: PSA).

Botanical description: The banana is a giant herbaceous plant of the Musaceae family, characterized by broad, flat leaves and clustered fruit.

Production data

- Cultivated area: In 2020, the cultivated area of bananas in the Philippines was approximately 449 000 hectares in 2023[20].

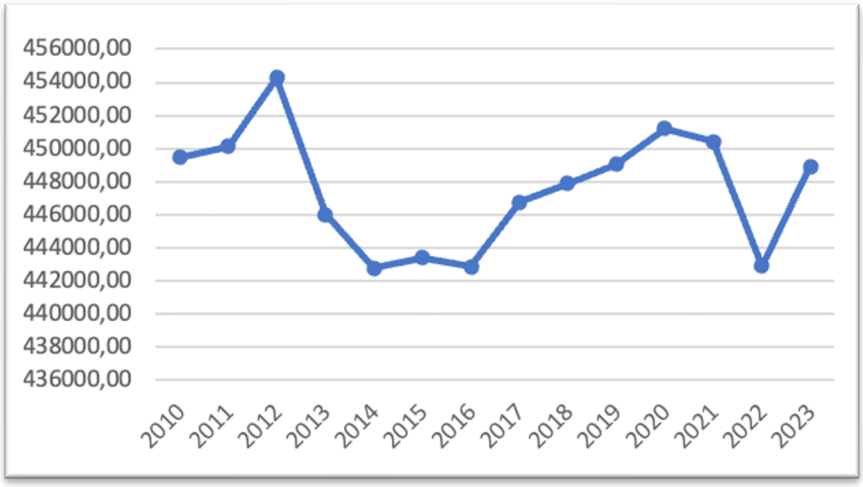

Figure 46: Annual area cultivated for banana in Philippines in ha, 2010-2023 (Source: PSA).

- Production volume: Annual banana production amounted to around 9.0 million tons in 2023[21]. The Philippines is the Asian Countries fourth largest banana producer after India, China and Indonesia. Large banana producers and exporters are also in Latin America (DA-BAR, 2022).

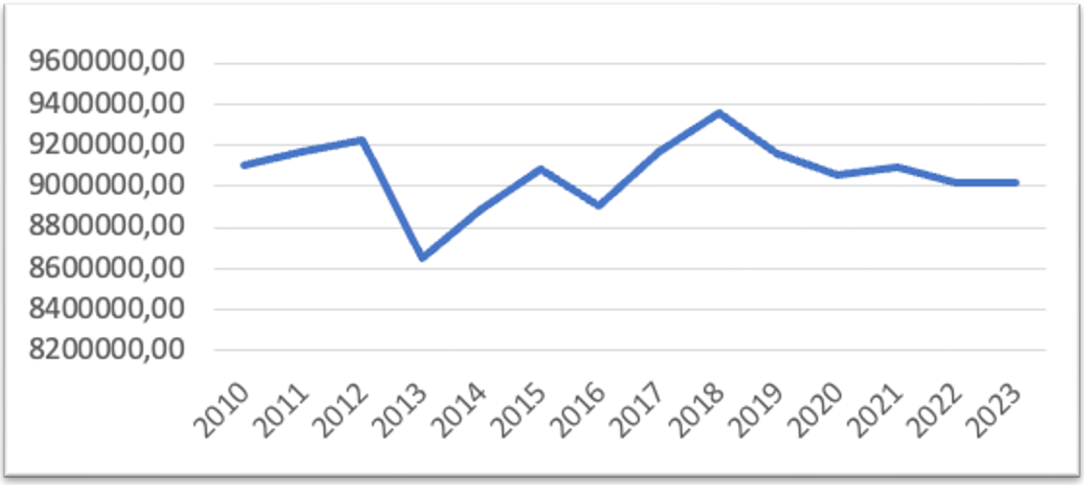

Figure 47: Banana annual production in metric tons, 2010-2023 (Source: PSA).

- Main producing regions: The main producing regions are Davao, Soccsksargen, Northern Mindanao, and SOCCSKSARGEN (Region XII) (DA-Bar, 2022). 85 % of total bananas volume is produced in Mindanao Island, then 7% in Luzon and 8% in Visayas (DA-BAR, 2022).

[20]Source: PSA : "Other Crops: Area Planted/Harvested, by Region and by Province, by Semester, 2010-2023" https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__CS/0072E4EAHO0.px/table/tableViewLayout1/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313

[21] Source: PSA "Other Crops: Volume of Production, by Region, by Quarter and Semester, 2010-2024" https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__CS/0132E4EVCP1.px/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313

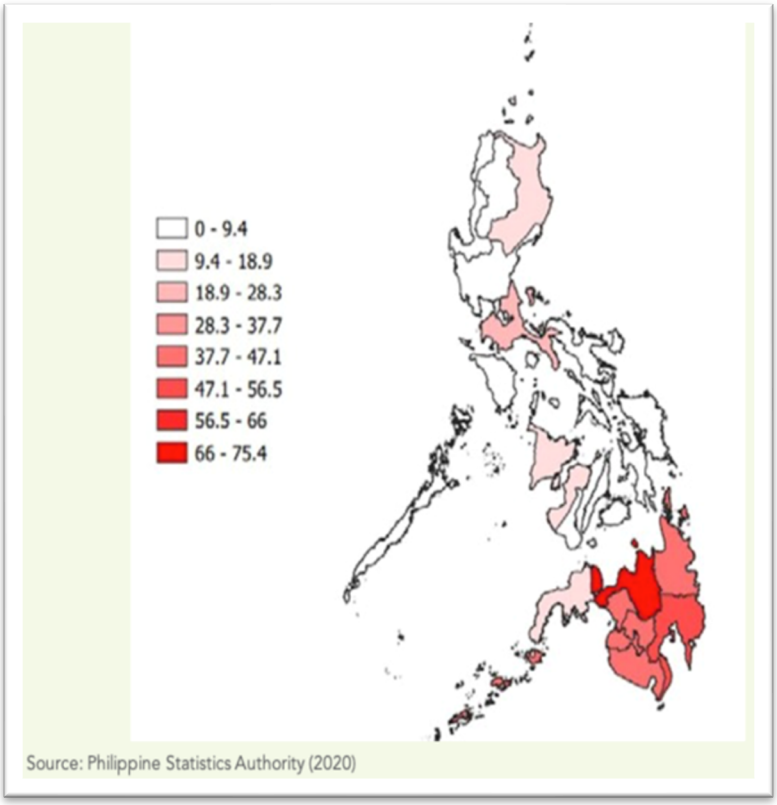

Figure 48: Cavendish bananas yields in metric-tons/ha (Source: DA-BAR 2022).

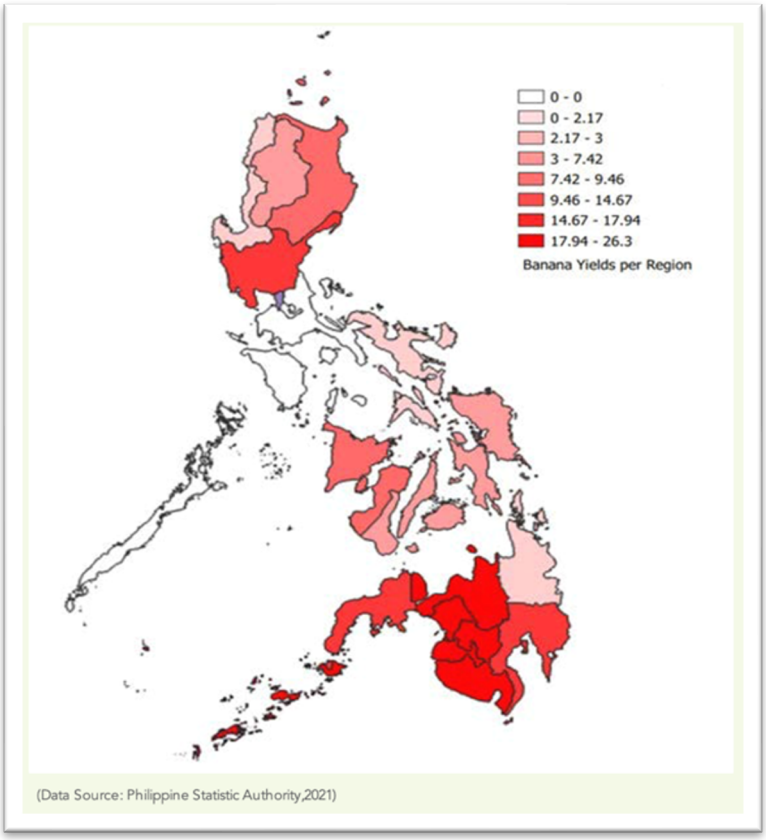

Figure 49: Lakatan bananas yields in metric-tons/ha (Source: DA-BAR 2022).

Consumption data

- Domestic consumption: Domestic consumption of bananas was high, with an average of 47 kilograms per capita per year (2013)[22]. Back in 2000, it was only around 30 kg per capita per year (FAOStat). Banana consumption was on the rise until 2015. However, in the recent years, banana per capita consumption in the Philippines was reduced to 31kg/year in 2019, 38% less than the per capita banana consumption in 2015 of 50kg/year (PSA, 2021 in DA-BAR). According to DA-BAR (2022) global banana situation has possibly been affected by the recent COVID 19 pandemic in terms of transportation and consumption. The consumption of fresh bananas was reduced due to shortages in supply and high prices in the market.

- Main uses: Bananas are mainly eaten fresh, but are also used in desserts, ready-made meals and snacks.

Export data

- Export volume: The Philippines is one of the world's largest banana exporters, with an export volume of around $1.3 Bn and 1.7 million tons in 2022 (Chatham House, 2022[23]). The Philippines is the 2nd world exporter after Ecuador in 2020 (DA-BAR, 2022). It's about 20% of Philippines agriculture products exportation which is $6.2bn.

- Main destination countries: The main destination countries for Philippine bananas are China, Japan, South Korea, Saudi Arabia and Hong Kong.

- Recent trends: After the COVID-19 pandemic, banana exports had a downward trend (Figure 51).

[22] FAO: "Food Balances (-2013, old methodology and population)" https://www.fao.org/faostat/en/#data/FBSH
[23] Source: Chatham House https://resourcetrade.earth

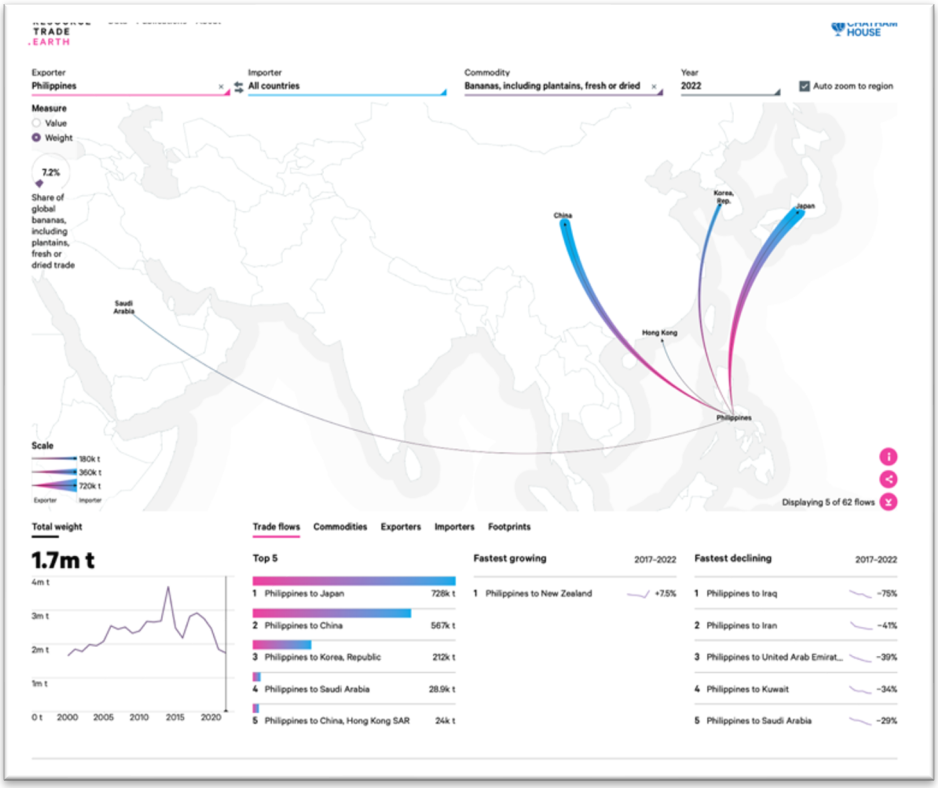

Figure 50: Banana exportation from the Philippines (Source: https://resourcetrade.earth).

Import data

- Imported volume: The Philippines imports a limited quantity of bananas, mainly to meet demand for specific varieties. In 2022, the imports amounted to $205,000 and 252 tons (Chatham House, 2022).

- Main supplier countries: The main supplier countries of imported bananas are Korea (Chatham House, 2022).

- Recent trends: Banana imports remain low, with a preference for high-end varieties.

Prices

- Average domestic price: In 2021, the average domestic retail price for bananas was around 40 to 84 PHP (Philippine pesos) per kilogram[24].

- Average export price: The average export price varies according to destination, but is generally between 600 and 800 USD (US dollars) per ton.

[24] PSA https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2M__RP/0042M4ARP07.px/table/tableViewLayout1/?rxid=10ff64b2-e133-4d03-a3d3-8d5953c98a93

Socio-Economic Aspects

The industry is dominated by multinational companies and large-scale growers which produce Cavendish owing to around 50% of the national production or Saba variety.

Small-scale growers and small-scale backyard subsistence farming cultivate other varieties like Lakatan, Saba and Latundan for domestic consumption.

Employment generated: Banana cultivation is a major source of employment, providing work opportunities for thousands of people, both on plantations and in related activities.

Impact on local communities: Banana plantations contribute to the economic development of rural areas, but they can also pose challenges in terms of land rights and working conditions.

Cultural importance: Bananas are deeply rooted in Philippine culture, playing a significant role in cuisine, traditions and celebrations.

Value Chain

The value chain involves many players from producers to multinational companies (Figure 52). Producers engaged in the Cavendish banana industry can be contracted or independent regarding the multinational Companies. The Cavendish outsourcing activities alone involves around 240,000 people (DA-BAR, 2022).

The main association involved in the growing and exportation of bananas in the country is the Pilipino Banana Growers and Exporters Association, Inc.

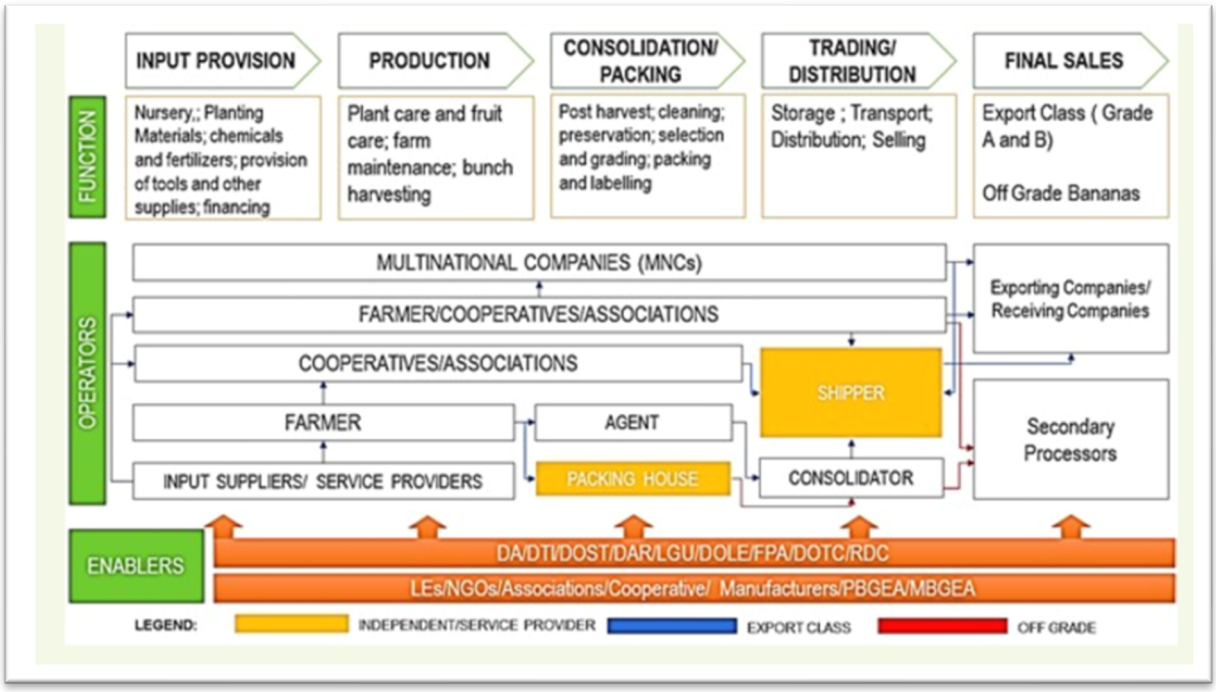

Figure 51: Value chain: Example of cavendish banana industry value chain in the Philippines (Source: DA-BAR, 2022).

Environmental Aspects and Climate Change

Impact of Climate Change:

- High temperatures: Rising temperatures can affect banana growth and reduce yields.
- Droughts: Prolonged periods of drought can reduce the availability of water, essential for banana cultivation.
- Storms and typhoons: Intensified tropical storms and typhoons can cause direct damage to banana plantations.
- Diseases and pests: Climate change favors the spread of diseases such as Fusarium oxysporum (Panama disease) and insect pests.
- Climate variability in the Philippines: Increased climate variability leads to unpredictable weather conditions, making agricultural planning more difficult.

Although the land area being planted to Cavendish was increasing over time since 2010, a significant drop in Cavendish production in 2013 can be observed. This is attributed to "Typhoon Pablo" in December 2012 as well as the increasing incidence of Fusarium wilt in the commercial banana plantations in Mindanao (DA-BAR, 2022).

Adaptations to Climate Change:

- Water Management: Adoption of more efficient irrigation systems and water conservation techniques.
- Varietal diversification: Introduction and cultivation of banana varieties more resistant to extreme weather conditions and disease.
- Ecosystem protection: Maintaining biodiversity and using sustainable agricultural practices to protect soil and natural resources.

Challenges and Opportunities

Current challenges:

- Disease resistance: Management of diseases such as Fusarium TR4 (Panama disease) that threaten banana plantations.
- Water Management: Responding to water shortages in times of drought and flooding during intense rainy seasons.
- Global Competition: Facing competition from other major banana-producing countries.
- Pesticide use in Banana industry is an issue for the quality of groundwater, air, soil and farmers health (DENR, 2016)

Opportunities:

- Development of resistant varieties: Invest in research to develop banana varieties resistant to disease and extreme weather conditions.
- Market Expansion: Diversification of export markets to reduce dependence on a few importing countries.
- By-products: Exploration of new banana by-products, such as fibers for textiles, to add value to production.

Adaptation Strategies to Climate Change

- Climate-Resilient Varieties: Breeding and promoting varieties that withstand extreme weather conditions.
- Integrated Pest Management (IPM): Reducing dependency on chemical pesticides through IPM practices.
- Water Management: Implementing efficient irrigation systems to conserve water.
- Diversification: Encouraging crop diversification to reduce dependency on a single crop and improve resilience.
- Sustainable Agricultural Practices: Promoting practices such as organic farming, agroforestry, and conservation agriculture.
- Extension Services: Strengthening extension services to provide farmers with the latest research findings and practical advice.

Policies and Programs

- Government policies: Policies aim to promote environmental and social sustainability in banana production, as well as to strengthen the industry's competitiveness in the face of climate challenges.
- Support programs: Support programs are in place to help farmers adopt sustainable farming practices and face the challenges of climate change, such as subsidies for irrigation and training in integrated crop management practices.

R&D Opportunities

Most Cavendish banana research is mostly carried out in private-sector laboratories, focusing on disease management and post-harvest technologies. There are also collaborations for R&D between private sector, SUCS and government research institutions. However, small-scale growers don't always have access to the most advanced technologies or new varieties, putting them at a disadvantage.

The Philippine government is taking steps to support banana research, including:

- Collaboration with Bioversity International (formerly INIBAP) to establish a national center at the Bureau of Plant Industry - Davao National Crops Research Development Center (BPI-DNCRDC) and a gene bank. This makes sense given the rich genetic diversity of bananas in the Philippines.

Bioversity also collaborates with the National Plant Genetic Resources Laboratory (NPGRL) of the Institute of Plant Breeding, UPLB in Los Baños as an in vitro repository.

- PCAARRD has also allocated a budget for the development of a banana technology package (POT for Banana) and for several research projects related to small-scale banana production (HNRDA, 2022).

- DA-BAR and BPI-DNCRDC have also funded research, extension, and rehabilitation activities for the mitigation and management of the recent Fusarium Wilt TR4 pandemic in Mindanao (DA-BAR, 2022).

DA-BAR has identified a need for more applied research. Such research is constrained by the limited access of SUCS to government funding (DA-BAR, 2022).

Research and Development Priorities

1. Disease-Resistant Varieties: Developing banana varieties resistant to major diseases is crucial.

   The sustainability and profitability of the Philippine banana industry (Cavendish, Saba, Lakatan) is threatened mostly by diseases primarily the fusarium wilt of banana which is caused by the soil-borne fungus *Fusarium oxysporum* f.sp. cubense (Foc) 'Tropical Race 4' (TR4). Research on clonal selections for adaptable Foc Tr4 resistant Cavendish varieties in the country is a priority (DA-BAR, 2022). In the 1950s, Fusarium wilt of banana caused by *Foc* race 1 (R1), commonly known as Panama disease, led to the decimation of banana plantations in the Latin Americas prompting the shift from the original export susceptible variety Gros Michel to the naturally resistant Cavendish. Nowadays, an impending epidemic is posed by TR4 which has spread across countries and continents despite strict quarantine regulations. The disease is present in the Mindanao Island group of the Philippines where 80% of the national banana production is situated. Cavendish and Lakatan are susceptible to TR4.

   As a known diversity hotspot for Musa, the Philippines hosts the greatest diversity of the wild banana progenitor *Musa balbisiana* (BB) including a number of natural hybrids of varying genomic constitution and ploidy level. The B-genome bananas exhibit resilience to abiotic stress like drought. Breeding programs would benefit from the incorporation of these desirable genes to elite cultivated banana varieties. However, this germplasm resource has been untapped for cultivar improvement. One of the biggest drawbacks on the use of these resources is the knowledge gap on endogenous banana streak virus (eBSV) in the Philippine B-genome bananas. Previous studies showed that *M. balbisiana* harbors eBSV which restricts its use in breeding and germplasm exchange and utilization. In addition, BSV is activated by abiotic stress and therefore poses a threat as an emerging disease together with the looming climate change crisis.

2. Sustainable Practices: Research into sustainable farming practices that reduce environmental impact and improve resilience to climate change is needed. Training of small banana growers on the proper management of the resistant varieties. Recommended inputs must be applied on resistant varieties to maintain its resistance to the disease.

3. Post-Harvest Technologies: Innovations in storage and transportation to minimize losses and extend shelf life are important.

Conclusion

The Philippines is one of the leading producers and exporters of bananas in the world. Banana is the most important fruit crop commodity in the Philippines. Fresh bananas are among the consistent top export commodities of the country.

The sustainability and profitability of the Philippine banana industry is threatened mostly by diseases primarily the fusarium wilt of banana which is caused by the soil-borne fungus Fusarium oxysporum f.sp. cubense (Foc) 'Tropical Race 4' (TR4). R&D Disease-Resistant Varieties is a priority for this industry.

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DENR 2016. Philippine Biodiversity Strategy and Action Plan 2015-2028 Bringing Resilience to Filipino Communities, 272p

FAO: "Crops and livestock products" https://www.fao.org/faostat/en/#data/QCL

7. Pineapple

Introduction

The Philippines is one of the world's largest producers of pineapples, contributing significantly to both the domestic economy and the global market. Pineapple cultivation is a vital agricultural activity, providing income and employment for many Filipino farmers.

General data

Types of pineapples grown: The most commonly grown variety is the 'Smooth Cayenne,' known for its sweetness and juiciness. Other varieties include Queen (Formosa) and Red Spanish (Native Philippine Red).

Botanical description: The pineapple (Ananas comosus) is a perennial tropical plant of considerable commercial importance within the Bromeliaceae family. Its fruit is composed of fused berries, giving it an appearance similar to a pine cone. Propagation of pineapples can be achieved through the use of crown cuttings extracted from the fruit. It initiates flowering within 20-24 months and produces fruit in the subsequent six months.

Production data

- Cultivated area: Approximately 70,000 hectares are dedicated to pineapple cultivation, with an annual production of around 2.7 million metric tons.

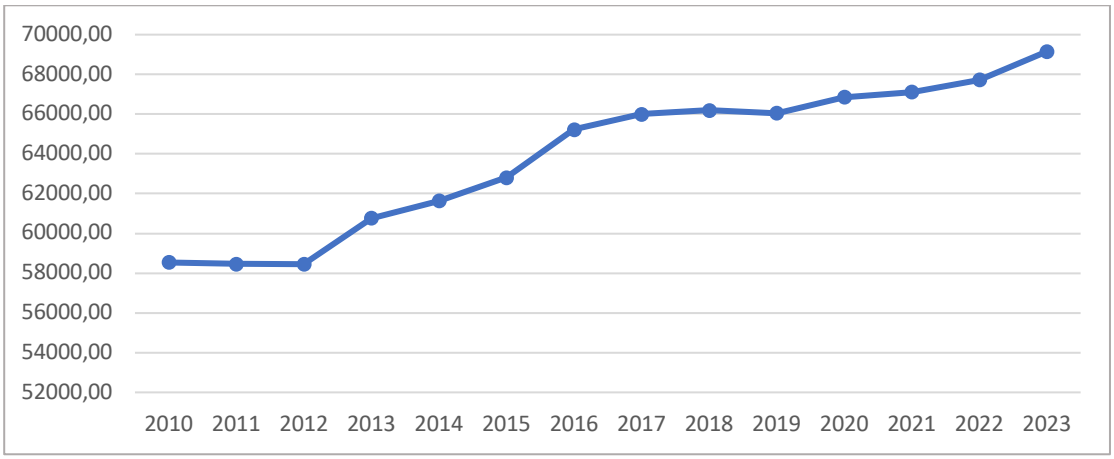

Figure 52: Annual area of pineapple harvested in the Philippines in ha, 2010-2023 (Source: PSA[25]).

[25] PSA (n.d.). Agriculture, Forestry, Fisheries. https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__CS/0072E4EAHO0.px/table/tableViewLayout1/?rxid=6ca1b124-5798-4ae4-b17b-abbf22bab3d2

- The Philippines is one of the largest pineapple-producing countries in the world. It was reported that in 2021 the country produced 2,860,202 metric tons of pineapple[26].

Country	Pineapple Production 2021
Costa Rica	2,938,334
Indonesia	2,886,417
Philippines	2,860,202
Brazil	2,317,554
China	2,301,836
Thailand	1,800,558
India	1,799,000
Nigeria	1,541,980
Mexico	1,271,521
Colombia	927,050

Table 18: Top 10 pineappple-producing countries (Source: World Population Review[26]).

- Main producing regions: Key regions include Northern Mindanao, specifically Bukidnon, and Southern Luzon, particularly Camarines Norte and Camarines Sur. SOCCSARGEN and Bicol Region were also included in the top three producing regions.[27]

Region	Banana	Pineapple	Coffee**	Mango
Philippines (in thousand mt)	**9,013.3**	**2,914.4**	**30.0**	**712.6**
Luzon	**7.7**	**10.3**	**10.2**	**46.2**
CAR	0.2	0.03	3.3	0.4
Ilocos Region	0.5	0.01	0.2	23.3
Cagayan Valley	3.7	1.5	2.1	6.6
Central Luzon	0.6	0.1	1.7	6.7
CALABARZON	1.1	2.4	2.7	6.0
MIMAROPA Region	0.8	0.02	0.1	2.9
Bicol Region	0.7	6.1	0.1	0.2
Visayas	**7.9**	**1.5**	**6.1**	**16.9**
Western Visayas	3.4	0.7	6.0	8.4
Central Visayas	1.8	0.5	0.1	8.5
Eastern Visayas	2.7	0.4	0.1	0.1
Mindanao	**84.5**	**88.2**	**83.6**	**36.9**
Zamboanga Peninsula	3.1	0.04	0.6	10.1
Northern Mindanao	22.6	59.2	10.4	7.4
Davao Region	36.6	0.9	17.8	6.3
SOCCSKSARGEN	12.9	27.9	35.0	8.4
Caraga	2.7	0.1	2.3	2.5
BARMM*	6.7	0.03	17.5	2.2

a/ Less than 0.005
**Excludes eight area clusters*
***From 2018 to 2021 coffee is in dried berries form. While in 2022, coffee is in green coffee beans.*
Source: Philippine Statistics Authority

Table 19: Percent distribution of major crops production by region,2022 (Source: Selected Statistics on Agriculture and Fisheries[28]).

[26] World Population Review (2024). Pineapple Production by Country 2024. https://worldpopulationreview.com/country-rankings/pineapple-production-by-country
[27] Pineapple. Philippine Statistics Authority (2023, April 1). https://psa.gov.ph/major-fruit-crops/pineapple
[28] Philippine Statistics Authority (2023). Selected Statistics on Agriculture and Fisheries. https://psa.gov.ph/system/files/main-publication/1-%28ons-cleared%29-Publication%20on%20SSAF-signed_0.pdf

Consumption data

- Per capita consumption: The annual production level per person of pineapple at 25.62 kilograms in 2018[29].

- Main uses: Pineapples are widely consumed fresh, as well as in processed forms such as canned pineapples, pineapple juice, and dried pineapples. Pineapple by-products are also used in various Filipino dishes. By-products from fruit processing can be used to make wine, vinegar, and 'nata' or gel. Additionally, pineapple leaves are utilized to weave fine-grade textile fibers for manufacturing piña cloth, twines, and cordage.

Export data

- Export volume: Pineapples and their derivative products constitute the third-largest export of the country, following bananas and coconut oil. The total weight of pineapples exported from the Philippines in 2022 was 380,000 tonnes, with a total export value of $369 million.

- Main destination countries: The Philippines is a major exporter of pineapples, with significant markets in China, Japan, South Korea, and the Middle East. Processed products, particularly canned pineapples and pineapple juice, dominate the export market[31].

- Recent trends: The total weight of pineapple exports from the Philippines increased steadily from 2000 to 2022 (see figure below)[31].

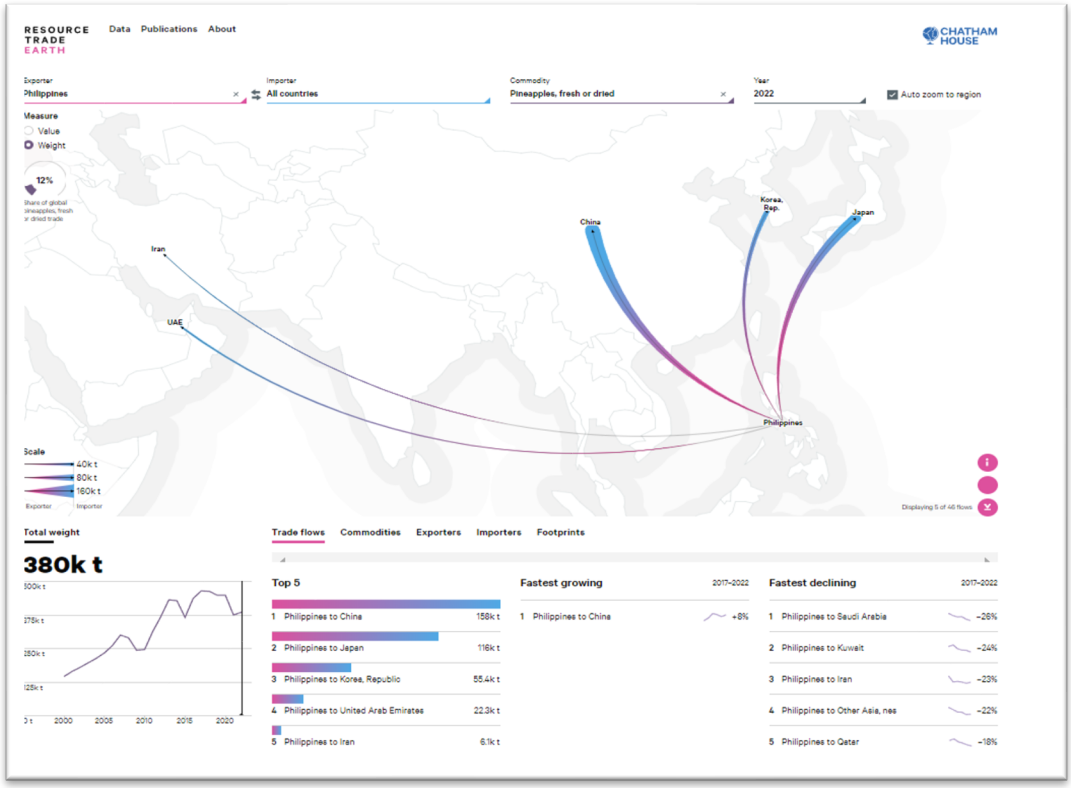

Figure 53: Pineapple exportation from the Philippines[30].

[29] Philippine Statistiscs Authority (2019). Food Consumption and Nutrition. https://psa.gov.ph/system/files/main-publication/ais_Food_Consumption_and_Nutrition_2019.pdf

[30] Chatham House (n.d.). Resource Trade. Earth. https://resourcetrade.earth

Import dataErreur ! Signet non défini.

- Imported volume: The Philippines imported 284 tonnes of pineapples in 2022, amounting a total value of $255,000 worth of pineapple products.

- Main supplier countries: The main supplier countries of imported pineapples are United Arab Emirates, Thailand, Vietnam, China, and United States.

- Recent trends: Pineapple imports to the Philippines from 2000 to 2022 fluctuated significantly, showing notable peaks and troughs over the years.

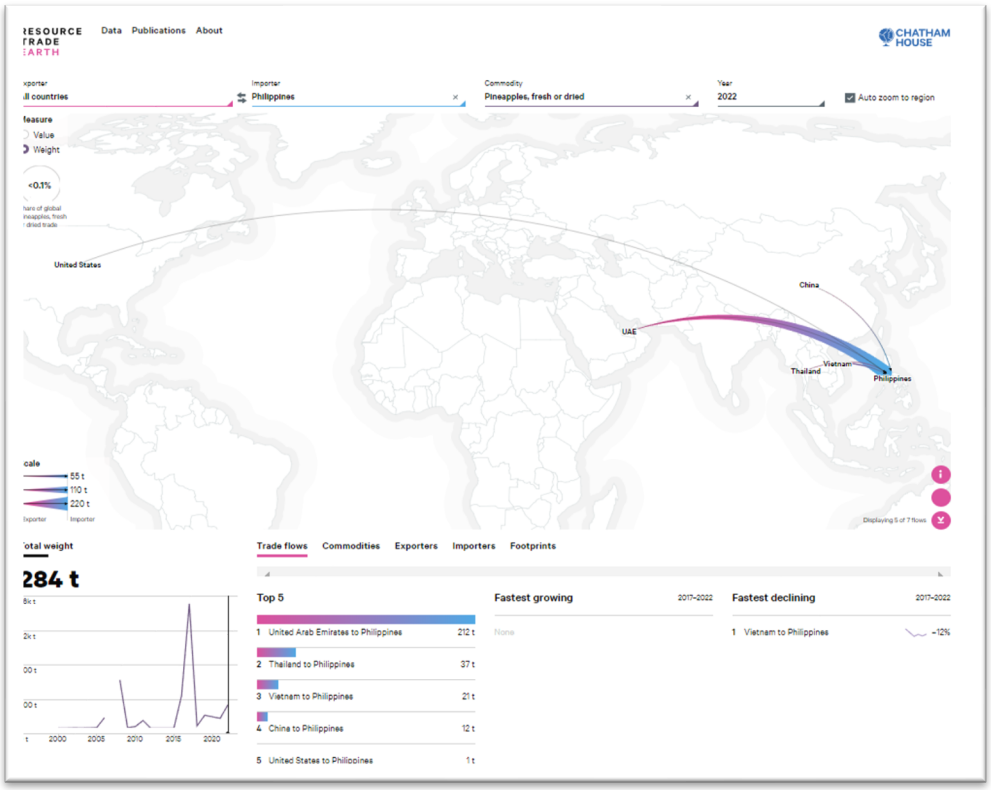

Figure 54: Pineapple importation to the Philippines[30].

Prices

- Average domestic price: The average retail price of pineapples in the Philippines was approximately PHP 63.89 per kilogram in 2022[31].

- Average export price: The average producer price varies by destination. According to the FAO report, it is approximately $362.4 per ton on average[32].

[31] Philippine Statistics Authority (2023). Selected Statistics on Agriculture and Fisheries. https://psa.gov.ph/system/files/main-publication/1-%28ons-cleared%29-Publication%20on%20SSAF-signed_0.pdf

[32] FAOSTAT (n.d.). Producer Prices. https://www.fao.org/faostat/en/#data/PP

Socio-Economic Aspects

Employment generated: Pineapple farming and processing provide employment to thousands of Filipinos, from smallholder farmers to workers in large plantations and processing plants. Pineapple farming is a significant source of income for many rural households. However, income levels can vary depending on farm size, yield, and market.

Value Chain

Figure 56 presents the value chain map of fresh and processed pineapples. It includes the provision of inputs, primary production, assembly, transformation or processing, distribution or marketing and the final sale of the product. The different tasks of the operators and enablers along the value chain are also mapped out.

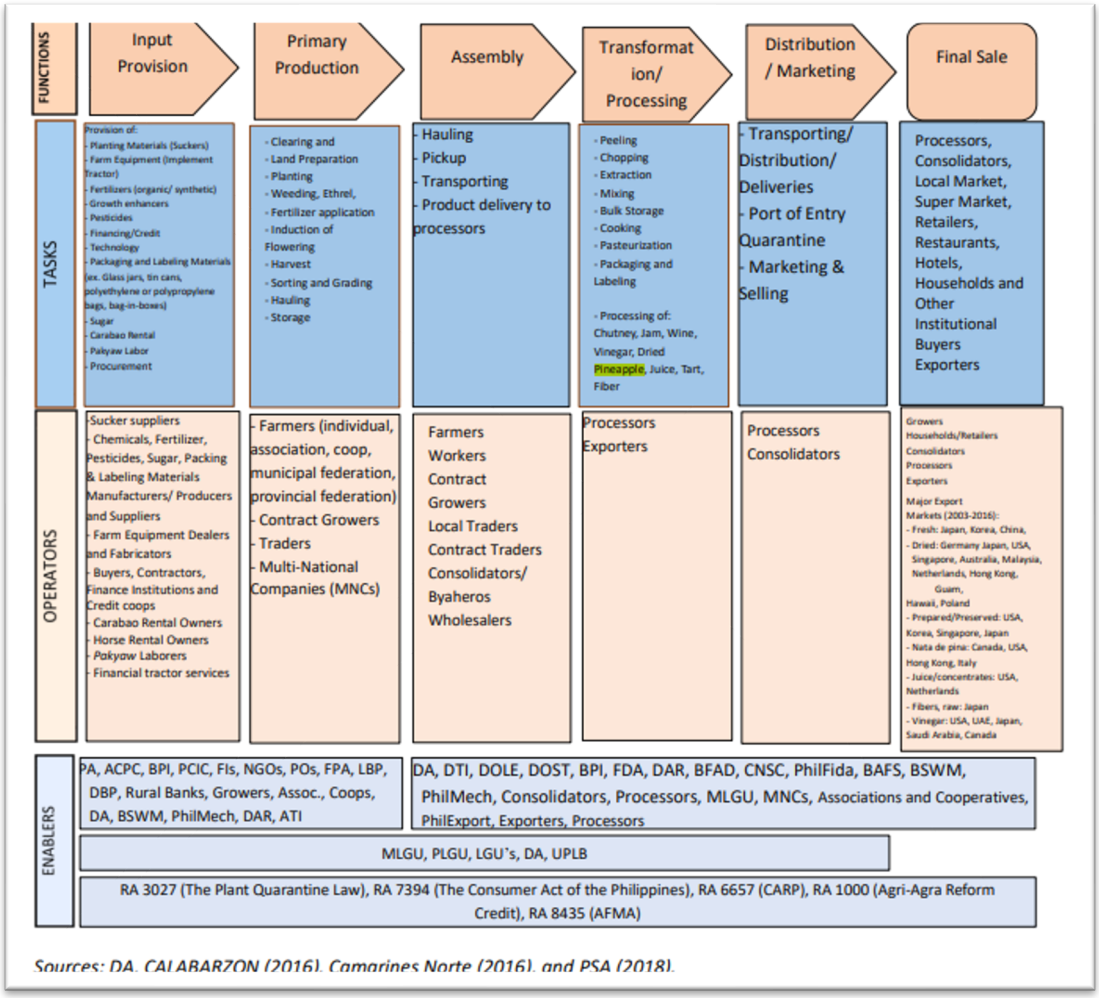

Figure 55: Value chain of fresh and processed pineapple from Processed Fruits and Nuts Industry Roadmap[33].

Income: According to the Philippine Statistics Authority (2023), the average producer's income from pineapples was approximately 3.63 pesos per kilogram in 2022[28].

[33]Inocencio, A., Tiongco, A., Baulita, Al., Baulita, Ar., and Inocencio A. (2019). Processed Fruits and Nuts Industry Roadmap. https://dtiwebfiles.s3.ap-southeast-1.amazonaws.com/ICE+Industry+Clusters+Roadmap/PFN+Roadmap.pdf

Item	Mango 1/	Pineapple	Mongo
		(PhP per hectare)	
Gross Returns	191,066	900,325	57,141
Cash Costs	73,638	129,175	9,953
Non-Cash Costs	8,343	2,270	3,850
Imputed Costs	47,445	24,774	13,048
Total Costs	129,426	156,219	26,851
Net Returns	61,640	744,106	30,290
Net Profit-Cost Ratio	0.48	4.76	1.13
Cost Per Kilogram *(PhP)*	33.46	3.63	30.22

1/ Cost of production refers to maintenance cost
Source: Philippine Statistics Authority

Table 20: Cost and return analysis of pineapple from Processed Fruits and Nuts Industry Roadmap[33].

Impact on local communities: Pineapple cultivation contributes to the economic development of rural areas, supporting local economies and infrastructure.

Cultural importance: Pineapples have a significant cultural value in the Philippines tradition. The fibers extracted from pineapples are used to produce Piña cloth, which is used in making traditional Filipino attire such as barongs and gowns, as well as in crafting various accessories like coin purses and pouch bags.

Environmental Aspects and Climate Change

Environmental Impacts

- Land Use: Large-scale monoculture of pineapples can lead to soil degradation and loss of biodiversity. Sustainable farming practices are essential to mitigate these impacts.
- Water Use: Pineapples require a moderate amount of water. Irrigation practices and efficient water management are crucial to ensure sustainable water use.
- Pesticides and Fertilizer Use: Intensive use of agrochemicals can lead to soil and water pollution. Integrated pest management and organic farming practices can help reduce these environmental impacts.

Impact of Climate Change:

- Temperature and Rainfall Changes: Pineapple yields are sensitive to changes in temperature and rainfall patterns. Extreme weather events such as droughts and heavy rains can adversely affect production.
- Pests and Diseases: Climate change can exacerbate pest and disease pressures, threatening crop health and yields.
- Soil Erosion: Increased rainfall intensity can lead to soil erosion, particularly in hilly pineapple-growing areas.

Adaptations to Climate Change:

- Diversification: Encouraging crop diversification and rotation to enhance soil health and reduce risks associated with monoculture.
- Infrastructure Improvement: Strengthening agricultural infrastructure to withstand extreme weather events and improve resilience.
- Water Conservation Techniques: Implementing water-saving technologies and practices, such as drip irrigation and rainwater harvesting.
- Soil Conservation Practices: Promoting soil conservation methods like contour plowing, cover cropping, and organic amendments to improve soil structure and fertility.

Challenges and opportunities[34]

Current challenges

- Pest Infestation: Pest and disease management to control infectious pests such as pink pineapple mealybug (PPMB) infesting, particularly the Queen Pineapple**Erreur ! Signet non défini.**. Other known pineapple parasites are *Phythophthora* and the *Fusarium*, fungi, nematode infestation, and *Symphylan*.
- Inadequate mechanization
- Inadequate knowledge in post-harvesting
- Addressing water shortages during droughts and managing flooding during intense rainy seasons.
- Lack of farm-to-market roads in pineapple planting regions, particularly in Northern Mindanao and SOCCSARGEN.
- Facing competition from other major pineapple-producing countries.

Opportunities

- Development of an alternative technique for rapid propagation of quality Queen Pineapple planting materials to increase “sweetest” pineapple variety production.
- Capacity building of pineapple growers by providing effective approaches and methods such as implementing optimum planting density, fertilizer rate, and intercropping systems.
- Educating key industry players will enhance farmers' bargaining power with traders and buyers.[35]
- Diversify export markets to reduce reliance on a limited number of importing countries.
- Explore various pineapple by-products for transformation into high value-added products such as biochar, biofertilizer, and adsorbent.

[34] DOST-PCAARRD. (n.d.). Queen Pineapple – Industry Strategic Science and Technology Plans (ISPS) platform. https://ispweb.pcaarrd.dost.gov.ph/queen-pineapple/

Policies and programs[33]

The Processed Fruits and Nuts (PFN) roadmap of the Philippines envisioned to be a globally competitive, quality-driven, and reliable supply of processed fruits and nuts industry that generates sustainable inclusive economic growth. Highlighted in the strategies are as follows:

Short (2019-2020) to Medium – term (2021 – 2023)

- Strengthen the PFN Industry Cluster
- Develop Stable Sources of Raw Materials and Strengthen Backward Linkages
- Develop and Promote Domestic and Export Markets
- Intensify Investment Promotions and Facilitation
- Establish Productivity and Efficiency Improvement Programs
- Continue and Strengthen Product Development
- Improve Business Environment

Long – term (2024 – 2029)

- Increase intensity of public-private partnership on R&D
- Accredit food testing laboratories and conduct assessments through Department of Trade and Industry (DTI) and the Food and Drug Administration (FDA)
- Investments in adequate testing laboratories
- Intensify product specialization
- Intensify investment on green technologies
- Enhance transparency of non-tariff measures (NTMs)
- Harmonization of national standards with international standards
- Strengthen regulatory services and international regulatory cooperation, and Good
- Regulatory Practice (GRP)

R&D Opportunities

1. Breeding and Genetics: Focus on breeding programs to develop high-yield, disease-resistant, and climate-resilient pineapple varieties through advanced genetic research.

2. Sustainable Agriculture Practices: Research into sustainable agriculture practices that enhance soil health, improve water use efficiency, and reduce environmental impact.

3. Water Management Innovations: Development of efficient irrigation systems and water management strategies to optimize water use and ensure availability.

4. Pest and Disease Management: Enhancing pest and disease management through integrated pest management practices, biological control methods, and resistant varieties.

5. Climate Adaptation Strategies: Investing in climate adaptation strategies, including crop diversification, improved infrastructure, and disaster risk reduction measures.

6. Extension Services and Farmer Education: Strengthening extension services to provide farmers with the knowledge and tools needed to adopt new technologies and practices, improve productivity, and enhance resilience to climate change.

7. Post-Harvest Technology: Improved post-harvest handling, storage, and processing technologies to reduce losses and add value to pineapple products.

Conclusion

The pineapple industry in the Philippines significantly contributes to the country's agricultural sector and economy. Recognized as one of the top pineapple producers in the global market, pineapple cultivation not only provides local employment but also bolsters the nation's export economy. However, the pineapple farming industry faces several challenges, including socio-economic, environmental, and climate-related issues that impact its production and sustainability.

In order to meet the growing demand and increase farm outputs, farmers have engaged in unsustainable practices that are impacting the environment. Large-scale monoculture plantations in the country have degraded the soil and led to biodiversity loss. Unsustainable water management practices on the farm are causing stress and affecting productivity. Intensive agrochemical use is polluting the soil and water. Climate change is adversely affecting productivity due to changes in temperature and rainfall, increased pest and disease pressures, and soil erosion. Furthermore, pineapple farming is facing challenges in terms of inadequate mechanization, insufficient knowledge of post-harvesting, and growing global competition.

Recognizing pineapple as an important commodity in the country, the government and other entities have initiated various efforts in the form of policies and programs to address pressing issues and challenges. These initiatives aim to ensure that the pineapple industry continues to thrive. Opportunities such as the development of quality planting materials, capacity building of pineapple growers, educating key players in the pineapple industry, market expansion, and exploration of high-value by-products could generate supplemental benefits for the pineapple industry.

Advancing research and development is crucial for sustaining pineapple production and enhancing the livelihoods of farmers. Focus areas include genetic research, sustainable farming practices, development of efficient irrigation, pest and disease management, climate adaptation strategies, capacity building, and post-technology adoption are pivotal in sustaining pineapple production and enhancing the livelihoods of pineapple farmers in the country.

By addressing these research and development priorities, the Philippines can bolster the sustainability and resilience of its pineapple industry, ensuring long-term economic benefits and environmental health

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DOST-PCAARRD. (n.d.). Queen Pineapple – Industry Strategic Science and Technology Plans (ISPS) platform. https://ispweb.pcaarrd.dost.gov.ph/queen-pineapple/

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8. Coconut

Introduction

Coconut production is a cornerstone of the Philippine agricultural sector, providing livelihoods to millions and contributing significantly to the national economy. The country is one of the world's top producers of coconuts, with vast plantations spread across its archipelago.

General data

Area and Yield: The Philippines has over 3.6 million hectares dedicated to coconut cultivation, yielding almost 15 million metric tons of coconuts annually.

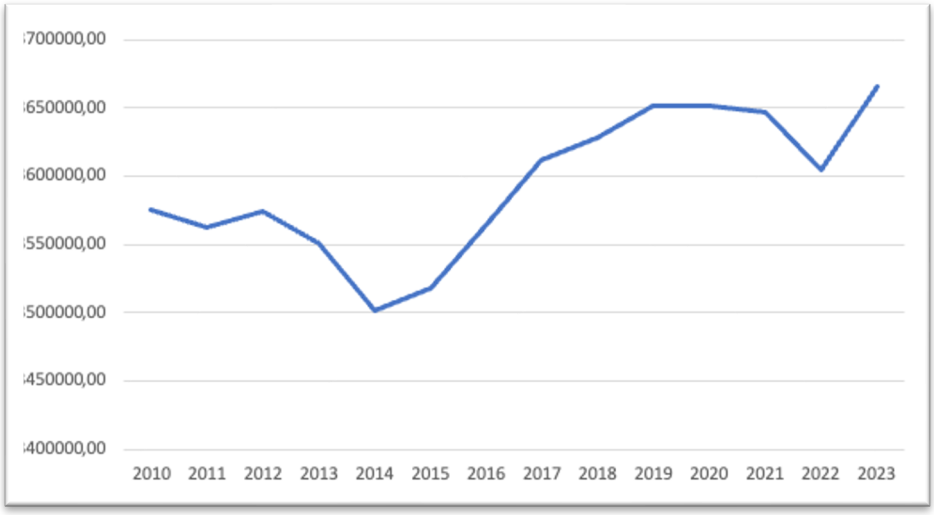

Figure 56: Annual area of Coconut harvested in ha, 2010-2023 (Source: PSA[36]).

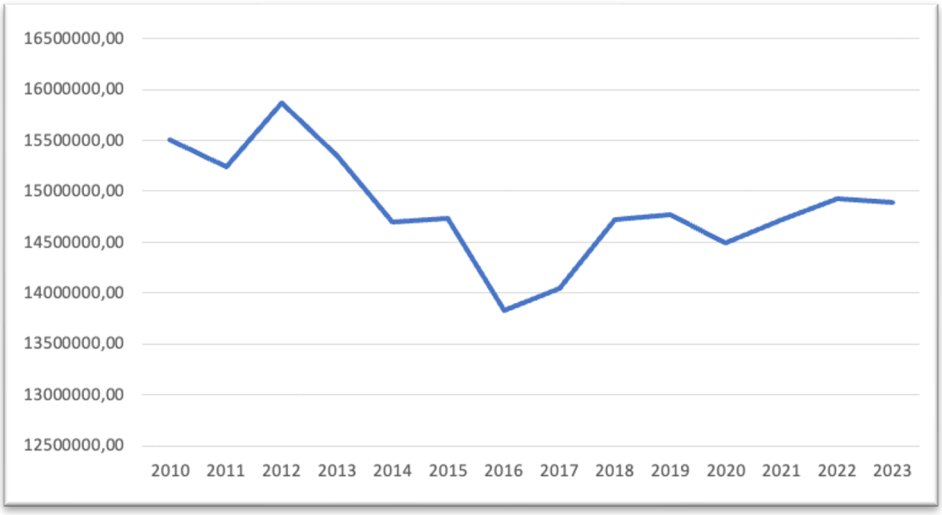

Figure 57: Annual yield of Coconut harvested in metric-tons, 2010-2023 (Source: PSA [37]).

[36] Source: PSA : "Other Crops: Area Planted/Harvested, by Region and by Province, by Semester, 2010-2023" https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__CS/0072E4EAHO0.px/table/tableViewLayout1/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313

[37] Source: PSA "Other Crops: Volume of Production, by Region, by Quarter and Semester, 2010-2024" https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__CS/0132E4EVCP1.px/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313

- Major Growing Regions: Key regions include Bicol, Eastern Visayas, and the Davao Region.

- Varieties: Common varieties include ‘Tall’ and ‘Dwarf’ coconuts, with hybrids being developed for improved yield and disease resistance.

Consumption

- Domestic Use: Coconuts are used extensively in Filipino cuisine, from cooking oil and milk to dried copra and fresh coconut water.

- Export Products: Major export products include coconut oil, desiccated coconut, coconut water, and copra meal. The Philippines is a leading global exporter of coconut oil.

Export data

- The main destination countries for Philippine fresh, shelled coconut are China and Hong Kong. Fresh coconut exports had a downward trend (4.4 k tons in 2013).

- The main destination countries for Philippine desiccated coconut are US and Europe with an upward trend (146 k tons in 2013), see Figure 29.

- The coconut trade is constantly growing and Philippines is the first world exporter, followed by Indonesia. The United States is the largest world importer followed by Europe (Source: https://resourcetrade.earth).

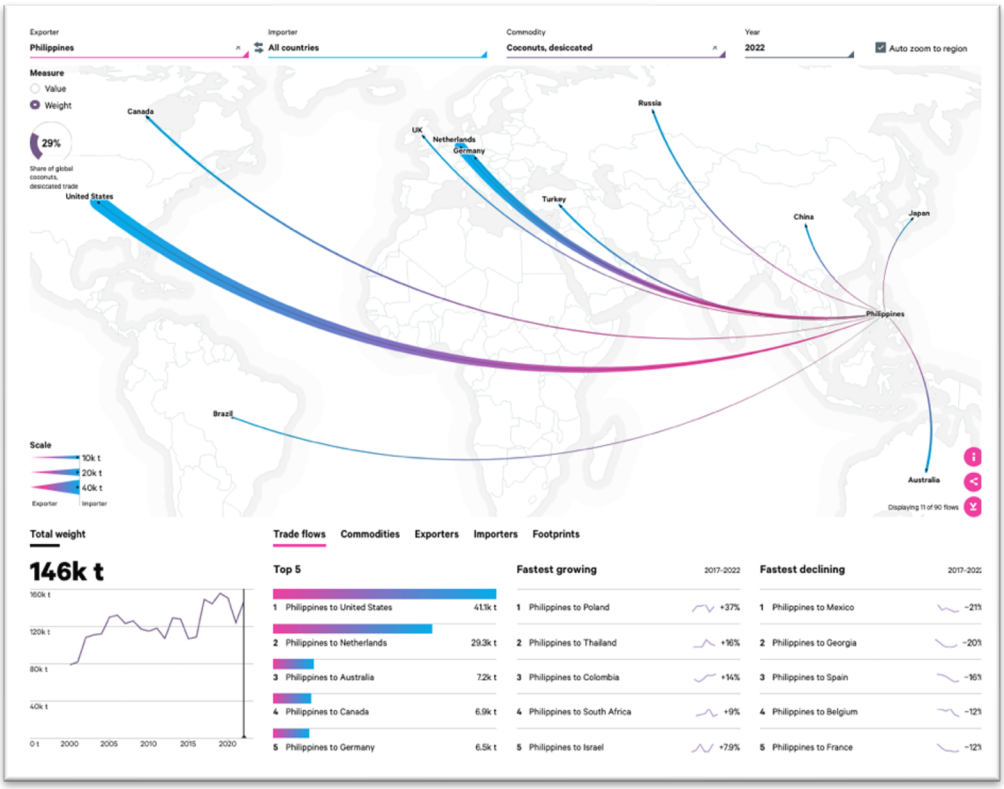

Figure 58: Desiccated coconut exportation from the Philippines (Source: https://resourcetrade.earth).

Socio-Economic Aspects

- Employment: Coconut farming provides direct employment to around 3.5 million farmers and workers.
- Income: Coconut farmers, often smallholders, typically have low incomes due to fluctuating market prices and productivity challenges.
- Cultural Significance: Coconuts are deeply embedded in Filipino culture and daily life, often referred to as the “Tree of Life” due to their diverse uses.

Value Chain

The Coconut Value chain (Figure 60) may be divided into the following 1) copra-CNO-oleochemicals value chain; 2) DCN value chain; 3) VCO value chain; 4) coco coir value chain; 5) young coconut value chain; 6) coconut sap value chain; and 7) activated carbon value chain.

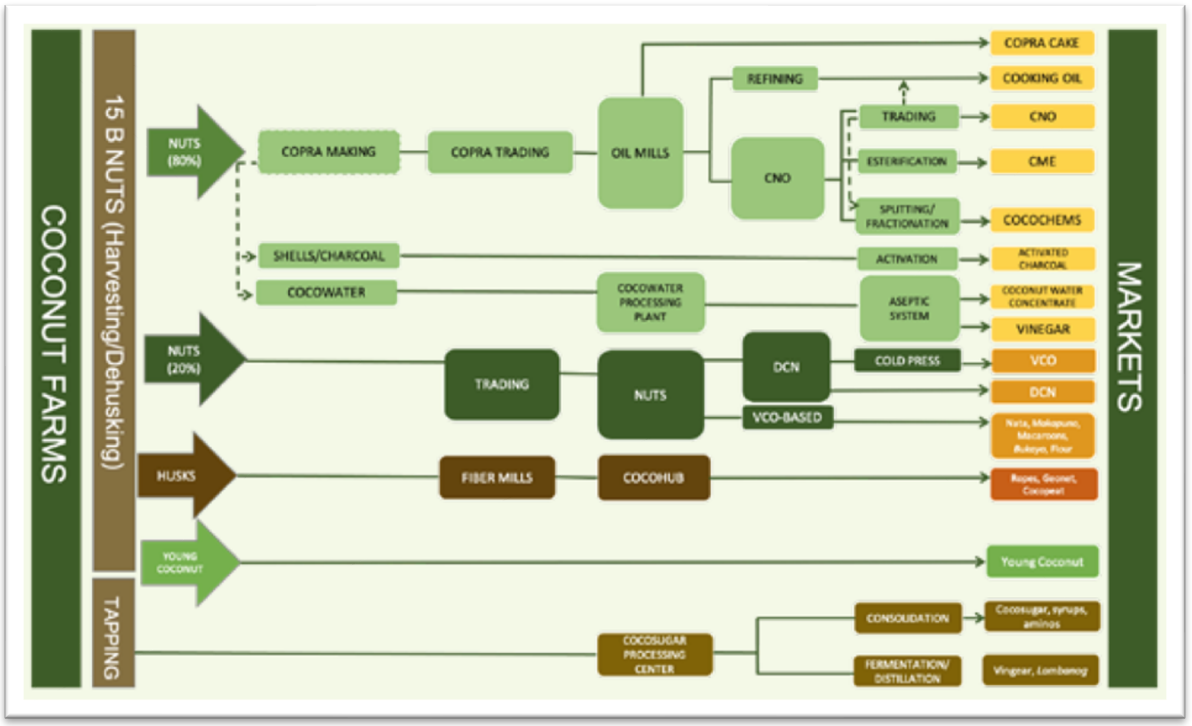

Figure 59: Coconut value chain (Source: DA-PCA, 2022).

1. Copra-CNO-oleochemicals value chain: Involves drying coconut meat (copra), extracting coconut oil (CNO), and using it to produce oleochemicals, which are chemicals derived from natural fats and oils.
2. DCN Value Chain: Refers to the production of Desiccated Coconut (DCN), which is dried and grated coconut used in various food products.
3. VCO Value Chain: Focuses on the production of Virgin Coconut Oil (VCO), which is made from fresh coconut meat and is valued for its purity and health benefits.
4. Coco Coir Value Chain: Involves processing the fibrous husk of the coconut (coir) into products like mats, ropes, and other textiles.
5. Young Coconut Value Chain: Pertains to the utilization of young coconuts, often used for drinking coconut water and consuming the tender coconut meat.
6. Coconut Sap Value Chain: Deals with products derived from the sap of coconut trees, such as coconut sugar and vinegar.

7. Activated Carbon Value Chain: Focuses on producing activated carbon from coconut shells, which is used for filtration and purification applications.

Each of these value chains represents a different aspect of the coconut industry and contributes to its overall economic impact.

Environmental Aspects and Climate Change

- Land Use: Extensive monocropping of coconuts can lead to soil degradation and biodiversity loss.
- Water Use: Coconut palms are relatively drought-tolerant, but water availability is a concern in dry regions.
- Pesticide Use: Minimal compared to other crops, though some pesticide application is necessary for pest control.

Current and Future Challenges Linked to Climate Change

- Temperature and Rainfall Changes: Increasing temperatures and changing rainfall patterns affect coconut productivity and health.
- Extreme Weather Events: Typhoons, droughts, and floods pose significant threats to coconut plantations.
- Pests and Diseases: Climate change may exacerbate pest and disease outbreaks, such as the coconut scale insect and lethal yellowing disease.

Challenges and Opportunities

Research and Development Needs

- Climate-Resilient Varieties: Development of new coconut varieties that are resistant to extreme weather conditions and pests.
- Sustainable Farming Practices: Research into intercropping, agroforestry, and organic farming to enhance sustainability and farmer incomes.
- Improved Post-Harvest Processing: Innovations in processing technologies to add value to coconut products and reduce waste.

Necessary Adaptation Strategies

- Diversification: Encouraging coconut farmers to diversify crops to reduce dependency on a single commodity and improve resilience.
- Disaster Preparedness: Strengthening early warning systems and infrastructure to protect against extreme weather events.
- Water Management: Implementing efficient irrigation systems and water conservation techniques to cope with changing rainfall patterns.

R&D Opportunities

1. Breeding and Genetics: Focus on developing high-yield, disease-resistant, and climate-resilient coconut varieties through advanced breeding techniques and genetic research.

2. Integrated Pest Management: Research into biological control methods and integrated pest management practices to reduce reliance on chemical pesticides.

3. Agroecological Practices: Promote sustainable agroecological practices that improve soil health, enhance biodiversity, and increase farm productivity.

4. Value-Addition Technologies: Develop innovative processing technologies to create high-value products from coconuts, such as biofuels, bioplastics, and health supplements.

5. Climate Adaptation Strategies: Invest in research to develop and implement climate adaptation strategies, including crop diversification, improved water management, and disaster risk reduction measures.

6. Farmer Education and Support: Enhance extension services to provide farmers with the knowledge and tools needed to adopt new technologies and practices.

By addressing these research and development priorities, the Philippines can enhance the resilience and sustainability of its coconut industry, ensuring long-term economic and environmental benefits.

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9. Sugarcane

Introduction

Since the 19th century, sugarcane production has had a great impact on both society and the country's economic structure. The industry has successfully achieved economic goals by expanding commercial cultivation areas and reducing production costs. Sugarcane production has a significant impact on the economy. However, its success is mostly measured on an economic standpoint rather than compared to other crops (Mirbakhsh & Zahed, 2023).

Sugar is one of the most important produced crops in the Philippines cultivated in the different parts of the country, however it is most abundant in the Negros Island, Western Visayas Region. As per 2020 data records, the total production of sugarcane reached the amount of $815 million, thus ranking as the fifth largest crop in terms of value following rice, bananas, corn, and coconuts. Historically, the Philippines exported more than half of the production to the United States but exports has reduced in response to the expansion of domestic demand. Majority of the sugar production goes to domestic uses and a small fraction is exported to the United States as part of the U.S. sugar tariff-rate quota.

In the Fiscal Year 2021, it was recorded that the allocation in the Philippines is 138,154 metric tons of commercial weight. In the present time, the United States is considered as the primary export market of the Philippine raw sugar, also being used by other sugar refineries on the west coast (Mojica-Sevilla, 2021).

General data

Botanical Description: Sugarcane, a tropical grass belonging to the Graminaceae family, serves as a raw material for the industrial production of rum and can also be transformed into energy, charcoal, or biofuel. This plant belongs to the Saccharum genus and has developed into contemporary variations through hybridization[38]. New varieties with higher yield and resistance to diseases are continuously developed by sugarcane breeders in the Philippines[39].

Production

- Cultivated area: The total land area utilized for sugarcane production across the country is more than 420,000 ha and with average yield of 57 tons/ha. In terms of land holdings, most landowners own less than 5 hectares while only a few owns 100 hectares[1] (see Figure 61) Covering a total of 207.02 thousand hectares, the majority of the reported area dedicated to sugarcane cultivation was allocated for the production of centrifugal sugar. However, a 12.6 percent decrease in the harvested area of sugarcane was observed, from thousand hectares in the same period of 2022 to 212.34 thousand hectares from January to June 2023[40] (see Figure 62).

- Yield: The sugar industry competitiveness had dwindled over time. During the second quarter of 2023 (April - June), the recorded production was at 2.83 million metric tons, reflecting a decline of

[38] Cirad. (2023, December 21). *Plant and uses*. CIRAD. https://www.cirad.fr/en/our-activities-our-impact/tropical-value-chains/sugarcane/plant-and-uses
[39] Bello, E. et al. (2019). Genetic Diversity Analysis of Selected Sugarcane (Saccharum spp. Hybrids) Varieties Using DArT-Seq Technology. Philippine Journal of Science. https://philjournalsci.dost.gov.ph/
[40] *Sugarcane | Philippine Statistics Authority | Republic of the Philippines*. (2023, April 1). https://www.psa.gov.ph/major-non-food-industrial-crops/sugarcane

11.3 percent compared to the output of 3.19 million metric tons in the corresponding quarter of 2022[5].

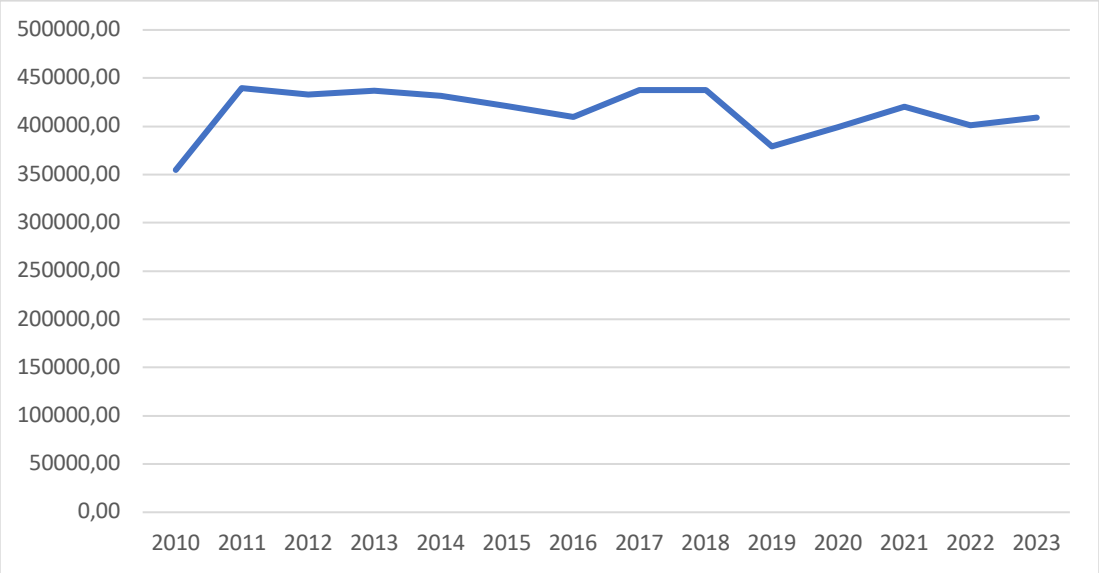

Figure 60: Sugarcane production in hectares (Source: PSA, 2023).

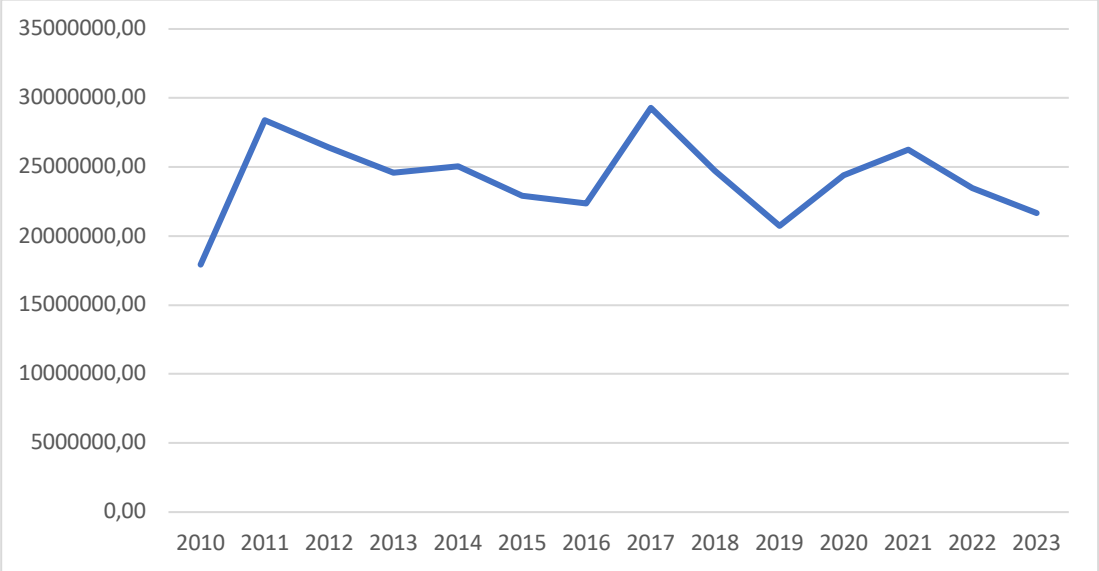

Figure 61: Sugarcane production in metric tons (Source: PSA, 2023).

- Top producing region: Around 65% of the country's total sugarcane area is located in the Visayas region, more specifically the island of Negros where which hosts 55% of the country's total sugarcane area. Meanwhile, 20% of sugarcane area is located in Mindanao and the remaining 15% in Luzon. Western Visayas (55%) is one of the top-producing regions by value of total production followed by Northern Mindanao (14.9%) and Central Visayas (13.4%) (Tobias, 2020) . See map below showing the sugarcane production areas in the Philippines. Seventeen provinces across eight regions in the country grow sugarcane.

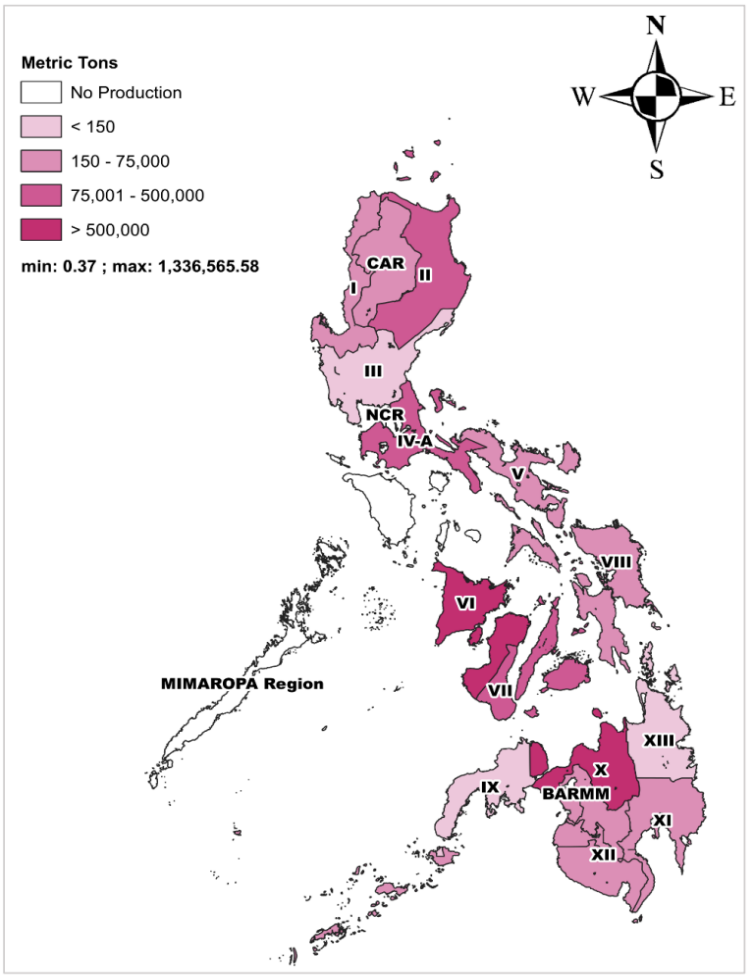

Figure 62: Sugarcane production by region, April-June 2023 (Source: PSA, 2023).

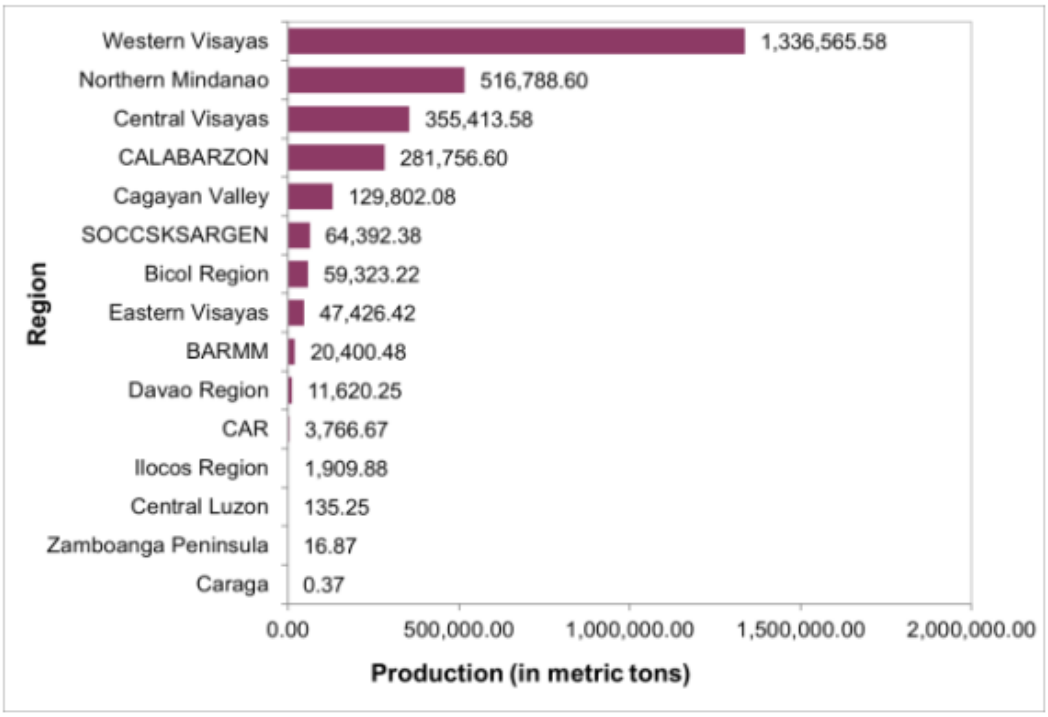

Figure 63: Actual sugarcane production by region, April-June 2023 (Source: PSA, 2023).

- Products: The main products made from sugarcane are centrifugal sugar, which constituted 95.6 percent of the overall sugarcane production. The other products are muscovado/ panocha, ethanol, basi/ vinegar, etc., accounting for the remaining 4.4 percent of the production[5].

- The major sugar-producing regions are in the Visayas Region, specifically in Negros Occidental and Cebu with various networks of sugar mills and refineries. At present, there are 27 sugar mills and 8 sugar refineries in the country, majority of which are in the Visayas, which accounts for approximately 73% of sugar production. Mindanao and Luzon account for about 17% and 10% of production respectively. The said areas were attributed to the favorable climatic conditions, water resources, and even its history in sugar production.

- Varieties: Some top high yielding varieties of sugarcane according to Sugar Regulatory Commission are, Phil 2000-0791, Phil 2000-2569, Phil 2006-1899, Phil 2003-1389, Phil 2004-1011[41] The Philippine Sugar Research Institute Foundation Inc. (PHILSURIN) developed three varieties in 2010: PSR 00-34, PSR 00-343, and PSR 00-161. PSR 00-34 is disease-resistant, suitable for dry areas. PSR 00-343 is high tillering, adaptable to various areas, and PSR 00-161 has high tonnage potential[42]. In addition, the, Phil 94-0913, Phil 93-1601, Phil 92-0051, Phil 92-0577, and Phil 99-1793 varieties are the best combinations to be planted for small sized farm with decreased productivity[43].

Consumption

Most of the sugar consumed is for household use, followed by institutional users from bakeries, restaurants, etc. and industrial companies for food and beverage productions. Majority of the sugar consumed are in the form of centrifugal (raw) or non – centrifugal (muscovado). Its by-products such as molasses and bagasse for industrial use[44].

Export

Philippines was known to be the top exporter of sugar in the 1970s, majority of total production are exported United States. However, with the recent Sugar Order (SO) No. 1 (2022), the 1.8 metric tons sugar production for Crop year 2022-2-2023[45], will be allocated for domestic consumption.

Import

The Philippine government anticipates importing 240,00 MT of refined sugar to stabilize prices and supply buffer stocks but plans to forgo importing raw sugar to safeguard domestic producers[6].

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[41] Gandia et al. (2021). Response of High Yielding Varieties of Sugarcane (Saccharum officinarum) to Waterlogging https://philjournalsci.dost.gov.ph/images/pdf/pjs_pdf/vol150no6A/response_of_high_yielding_varieties_of_sugarcane_.pdf

[42] 3 new sugar cane varieties developed. (2010, January 17). *Philstar.com*. https://www.philstar.com/business/agriculture/2010/01/17/541010/3-new-sugar-cane-varieties-developed

[43] Ardan et al.(2019).Production Optimization of Small – Sized Sugarcane Farms in the Philippines through Optimal Variety Mix using Compromise Programming. https://www.ieomsociety.org/ieom2019/papers/86.pdf

[44] Briones, R. (2020). Issues Paper on the Sugar Industry in the Philippines. PCC Issues Paper No. 04, Series of 2020. https://staging.phcc.gov.ph/

[45] Philippine News Agency. (2022). Over 1.8M MT sugar for domestic use only: SRA. https://www.pna.gov.ph/articles/1183593

Socio-Economic Aspects

- Employment: Approximately 700,000 Filipinos are directly employed by the sugarcane value chain, ranging from sugarcane planters to industrial manufacturers, while an additional 6 million are indirectly employed.[46]

- Income: The sugar industry provides income to diverse industry players from planting to processing. However, due to the declining productivity and changes in market causes incomes to fluctuate[6].

- Community Impact: The value chain of sugar cane industry has generated significant socio-economic opportunities to many rural communities, contributing to local economies and development[47].

Value Chain

The Philippines sugar industry includes a comprehensive value chain with farming as a starting point up to processing and distribution resulting in different products and catering to end-users (Figure 65) (Briones, 2020). In the Philippines, sugar is mostly produced from sugarcane grown by planters. Cultivation of sugarcane is being considered as the backbone of the sugar industry in the country from smallholder to large-scale farms and continuing to expand in different areas. The process begins in the preparation of lands for the planting of the sugarcane stalks, and includes the proper provision of irrigation and/or watering and fertilizers.

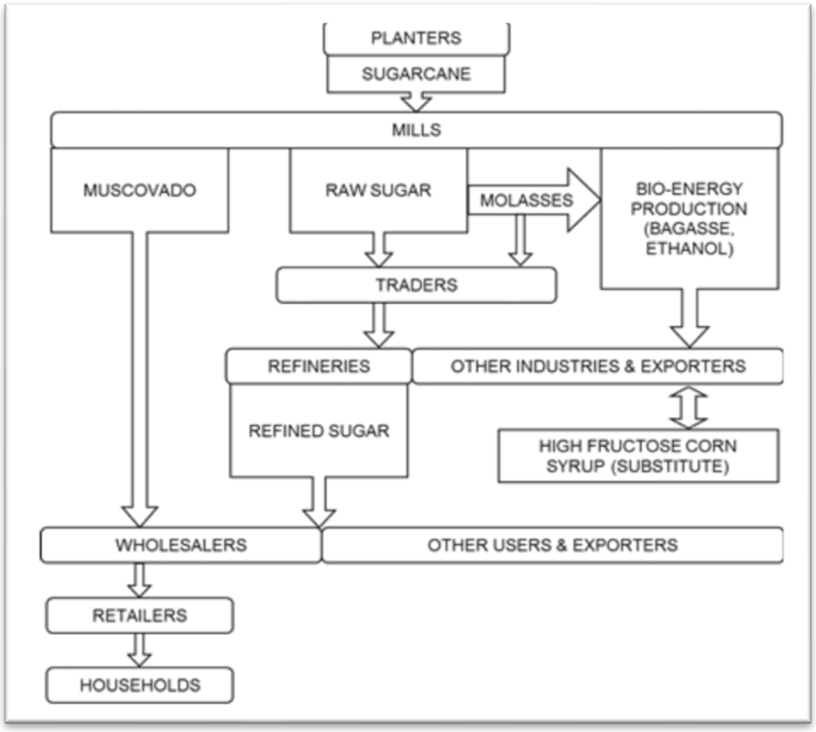

Figure 64: Sugar industry value chain (Source: Briones, 2020).

[46] Tobias, A. M. (2020, July 16). *Initiatives and implications of Philippine sugar liberalization*. FFTC Agricultural Policy Platform (FFTC-AP). https://ap.fftc.org.tw/article/1841

[47] Demafelis et al (2020). Socio-economic and Environmental Impacts of Bioethanol Production from Sugarcane (Saccharum officinarum) and Molasses in the Philippines. https://ovcre.uplb.edu.ph/journals-uplb/index.php/JESAM/article/view/339

From sugarcane to raw sugar

Production of sugarcane into raw sugar starts with planters who cultivate harvest, and transport the cane to the sugar mill for processing. The mill determines the sugar content of the cane, and the planters receive a share of the sugar and molasses in the form of quedans. Production incentives, trucking allowances, and subsidized harvesting services comprise additional payments.

Processing from raw to refined sugar

Sugarcane juice is obtained by extracting the liquid from the cane, which is then subjected to a series of processes including treatment, evaporation, crystallization, and separation from molasses using a centrifuge. The unrefined sugar, characterized by its brown hue, is readily available for use and necessitates the use of industrial-scale machinery. Raw sugar is generally consistent in quality, whereas refined sugar is manufactured. During the harvest season, mills oversee the coordination of deliveries by assigning schedules to planters in order to prevent congestion. In addition, they promote and incentivize farmers to cultivate sugarcane and supply it to them in order to prevent its underutilization. Mill operators utilize bagasse as a means to produce electricity and reduce their reliance on the power grid. Meanwhile, certain sugar mill power plants have the ability to sell any surplus electricity they generate back to the electrical grid, thereby generating additional income. The procedure necessitates the use of industrial-scale machinery and the resulting quality can differ based on the specific mill.

Processors to end-users

The end-users of sugar consist of either companies or households, and the sugar consumed are categorized into three different quality grades: refined white sugar, washed raw sugar, and basic raw sugar. Retailers and wholesalers offer refined white sugar, washed raw sugar, or raw brown sugar for sale to households and other commercial establishments. The stability of prices is attributed to the establishment of agreed-upon pricing mechanisms, while certain customers exhibit a preference for white sugar in comparison to brown sugar. Furthermore, the pricing is determined by comparing prices with the closest retail competitor, where upscale retailers tend to charge higher prices for sugar that is not branded. The competition is strong and profit margins are narrow within market segments (Briones, 2020).

Sugarcane ouputs

In the sugar production chain, the main processes are cane production, cane milling, marketing, and distribution of sugar. By the time the sugarcane reaches its maturity, the sugarcane is harvested and transported to processing plants or mills.

Processing of the sugarcane results in several outputs:

1. Raw sugar comes from the partially purified cane juice produced from a process of centrifugation and crystallization. It consists of sucrose crystals covered with a thin film of cane molasses. As per quality standard of a raw sugar, it must exhibit a sucrose content by weight (dry state) must correspond to a polarimeter reading of less than 99.5 degrees (PNS-BAFPS 81-2010).

2. Molasses is the by-product of the raw sugar production in a form of syrup and it also contains sugar and other compounds present from the extracted cane juice.

3. Muscovado sugar has a rich flavor and moist texture produced from a non-centrifugal process from the evaporation of fresh cane juice until it achieves the desired consistency (PNS–BAFS 144-2015). With the presence of molasses, it results in a dark and moist product being used in various culinary applications.

4. Refined or white sugar is raw sugar that has undergone further purification and crystallization, achieving polarity not less than 99.5 degrees at mill grade (PNS-BAFPS 82-2010). It also undergoes strict quality control measures to ensure its uniformity and purity.

5. Bagasse is obtained as a by-product of crushing of sugarcane with diverse applications. It is typically burned and used as fuel by the sugar mill and serves as another potential source of renewable energy feedstock being converted into ethanol.

6. Ethanol is produced from the fermentation of sugars, either in the cane juice or in molasses. Following fermentation, the distillation process can be aimed at producing either potable ethanol (for the beverage industry), or non-potable ethanol, as biofuel, or for household or industrial uses.

Environmental Aspects and Climate Change

- Land Use: Existing farming practices of most of the large-scale sugarcane plantations involves monoculture and intensive use of chemical inputs that can lead to lead to soil degradation and loss of biodiversity[48].

- Water Use: Water-intensive sugarcane often results in significant water use and the possible depletion of local water resources, which negatively impacts some fragile areas[49].

- Pesticide and Fertilizer Use: Intensive sugarcane production necessitates the use of large amounts of agrochemicals, which can accelerate ditch erosion and result in significant soil and nutrient losses, as well as water pollution, affecting local ecosystems and public health[50].

Challenges and Opportunities

Current and Future Challenges Linked to Climate Change

- Low productivity issues due insufficient irrigation, soil fertility, and planting materials, as well as decreasing planting areas and extreme weather and climate conditions, are some of the major challenges of the sugarcane sector for the past years[51]. Compared to other Southeast Asian countries like Thailand, which produces 100-ton canes per hectare, the Philippines only produces an estimated 60-ton canes per hectare. In addition, sugar farms were fragmented, leaving 140,000 hectares of land to 74,800 small farmers with limited cultivation capabilities[52].

- Temperature Changes: Temperature fluctuations will continue to be a major factor, as droughts and excessive rain have a negative impact on production. Low sugar content was also a result of excessive rain. Crop diversification is also an option, as some farmers may decide to pursue more profitable ventures[53].

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[48] Corsiga et al. (2018). Socio-Economic Assessment of Sugarcane-Based Cropping System in Negros Occidental, Philippines. PJAE (2)1. https://philair.ph/index.php/pjae/article/view/546/1643
[49] WWF. (n.d). Sugarcane Overview. https://www.worldwildlife.org/industries/sugarcane
[50] Chen et al. (2023). Slope planting patterns are superior to ditch grassing in reducing ditch erosion load to rivers: Evidenced from a five-year study in an intensive sugarcane growth watershed. Agriculture, Ecosystems and Environment, Volume 357. https://ui.adsabs.harvard.edu/abs/2023AgEE..35708685C/abstract
[51] United States Deparment of Agriculture Foreign Agricultural Service. (2023). Sugar Semi-Annual. https://fas.usda.gov/
[52] NEDA. (2020). An Assessment of the Reform Directions for the Philippine Sugar Industry. https://neda.gov.ph
[53] United States Deparment of Agriculture Foreign Agricultural Service. (2021). Sugar Annual. https://fas.usda.gov/

- Water Availability: In rainfed sugarcane fields, droughts can have a severe impact on yield, especially in the vegetative growth stage. Early sugarcane growth stages are susceptible to drought, which lowers cane yield and lowers sugarcane yield[54].

- Extreme Weather Events: Climate and weather phenomena such as flooding, water scarcity, and drought have a direct impact on crop production[55].

- Soil Health: Various abiotic and biotic factors, such as weed competition, soil nitrogen levels, and water deficit, can impose stress on sugarcane, thereby enhancing the vulnerability to herbivore attacks[56].

Necessary Adaptation Strategies

- Crop management modifications: Encouraging crop diversification, crop rotation, green harvesting and trash blanket, precision agriculture, organic matter amendment to enhance soil health and alleviate serious environmental risks and yield decline associated with monoculture practice[57].

- Water Conservation Techniques: Implementing water-saving technologies and practices, such as subsurface drip irrigation, furrow irrigation[58], and rainwater harvesting.

- Soil Conservation Practices: Promoting soil conservation methods like contour plowing, cover cropping, and organic amendments is crucial for sustainable sugarcane production under water-limiting conditions.

Policies and Programs

The Philippines sugar policy is controlled by the Sugar Regulatory Administration (SRA). The SRA oversees the sugar trade and domestic prices. In addition, the SRA supervises and controls domestic sugar supply and demand every year. They control supply under the "Quedan System", which allocates the percentages of local production that should be supplied to the domestic, US and other international markets. It was set up primarily to protect local sugarcane growers against unstable prices by controlling sugar supply and imports.

Sugarcane Industry Development Act of 2015

The Sugarcane Industry Development Act of 2015 (SIDA) is a program that maximizes the sugarcane resources including the improvement of incomes of farmers and farm workers through improved productivity, product diversification, job generation, and increased efficiency of sugar mills.

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[54] Reyes, J. et al. (2021). Drought impact on sugarcane production. *ResearchGate*. https://www.researchgate.net/publication/355768917_Drought_impact_on_sugarcane_production
[55] FAO (n.d). Multifaceted Impacts of Disaster in Agriculture. https://doi.org/10.4060/cc7900en
[56] Hussain, S., et al. (2019). Sugarcane Production under Changing Climate: Effects of Environmental Vulnerabilities on Sugarcane Diseases, Insects and Weeds. In *IntechOpen eBooks*. https://doi.org/10.5772/intechopen.81131
[57] Putra, R.V et al. (2020). Short Communication: Investigating environmental impacts of long-term monoculture of sugarcane farming in Indonesia through DPSIR framework. *Biodiversitas.* Vol. 21 (10). https://smujo.id/biodiv/article/view/6268/4313
[58] DOST PCAARRD. 2020. *Furrow and drip irrigation system effective in sugarcane production* https://pcaarrd.dost.gov.ph/index.php/quick-information-dispatch-qid-articles/furrow-and-drip-irrigation-system-effective-in-sugarcane-production

There are five (5) pillars under this program, namely:

1. Infrastructure Program – includes the facilitation of the sugarcane transport until it reaches the mills and distilleries, also to enhance marketing and sugar export including other products from sugarcane and to complement productivity improvement measures;

2. Block Farm Program – since majority of the sugarcane farms are small farms, this aims to consolidate the small farms including the agrarian reform beneficiaries, as one larger farm, with a minimum area of thirty (30) hectares within a two-kilometer radius to take advantage of the economies of scale, efficiency in machineries, maximizing the workers, volume purchase of inputs, financing, and other operations; it also includes recognition of the sugar mills, government financial institutions, private investors, however, the ownership of the small farms remains to the original landowners;

3. Scholarship Program – a program supporting those in need, particularly deserving college and postgraduate students taking up courses in agriculture, agricultural engineering and mechanics, chemical engineering/ sugar technology, and vocational courses and skills developments;

4. Socialized Credit Program – it is made possible through the Land Bank of the Philippines (LBP) for the acquisition of inputs, machineries, and implements crucial for the production of sugarcane; and

5. Research, Development, and Extension Program – it aims to intensify sugarcane high-yielding or flood-resistant varieties; pest control and prevention; latest farming, milling, refining, and biomass co-generation technologies; soil analysis and fertility mapping of sugarcane areas; weather monitoring and climate change adaptation measures; sugar and sweetener consumption; and other products from sugarcane.

R&D Opportunities

1. Climate-Resilient Varieties: Addressing climate change-induced low productivity can be achieved through improved planting materials, nurseries, fertilizer efficiency, irrigation systems, and developing drought-resistant sugar cane varieties[59].

2. Sustainable and Regenerative Farming Practices: Research into sustainable and regenerative farming practices such as minimum or zero tillas, crop rotation, use of biofertilizers, mulching to improve soil health, reduce water use, and minimize environmental impact[60].

3. Efficient Water Management: Adopting innovations in efficient irrigation techniques, managing water deficits, and choosing ideal varieties are some of the significant practices to enhance water use efficiency in sugarcane farming[61].

4. Integrated Pest Management: Adopting a range integrated pest management strategies such the application of decision support system, use biological agents, diversified cropping systems,

[59] Tobias, A. M. (2020, July 16). *Initiatives and implications of Philippine sugar liberalization*. FFTC Agricultural Policy Platform (FFTC-AP). https://ap.fftc.org.tw/article/1841

[60] Singh, Y., et al. (2021). Impact of Conservation Agriculture and Residue Management on Soil Properties Under Sugarcane-Based Cropping Systems. Springer, Singapore. https://doi.org/10.1007/978-981-16-0827-8_11

[61] Dingre, S., & Gorantiwar, S. (2021). Soil moisture based deficit irrigation management for sugarcane (Saccharum officinarum L.) in semiarid environment. *Agricultural Water Management*, *245*, 106549. https://doi.org/10.1016/j.agwat.2020.106549

behavioral manipulation, and selection of resistant varieties to reduce reliance on chemical pesticides thus reducing environmental impact[62].

R&D Priorities

1. Genetic improvement and breeding: Focus on breeding programs to develop high-yield, disease-resistant, and climate-resilient sugar cane varieties through advanced genetic research[63].

2. Variety Selection and Cultivation Methods: Identifying the optimal Philippine sugarcane varieties through the application of compromise programming. Developing cultivation practices specifically tailored for small-sized farms while taking into consideration the various factors such as flowering, yield potential, and disease resistance[10].

3. Land Suitability and Environmental Factors: Generating land suitability and vulnerability maps in various regions[64] and identifying vulnerable areas to flooding highlight the need for developing waterlogging-tolerant varieties[65].

4. Bioethanol Production and Residue Utilization: The Philippines can produce bioethanol from sugarcane leaves (SCL) and bagasse (SCB), however due to limited bioethanol, there is growing competition on bioenergy sources. The growing demand for bioethanol necessitates an evaluation of the feasibility of using sugarcane byproducts[66].

5. Biotechnological Research and Development: Incorporating research and development focused in employing genomics technologies for genetic engineering and pathogen characterization in sugarcane[67].

6. Climate Adaptation Strategies: Climate change impacts sugarcane production, affecting crop productivity, water consumption, and economic consequences. To increase sugarcane yield and ensure its long-term viability, it has been suggested to use climate-smart technologies and develop new varieties[68]. Other strategies that have been suggested include optimizing crop production methods, nutrient management strategies, and environmentally friendly biomass waste cycling[69]

Conclusion

Sugarcane is a prominent agricultural commodity in the Philippines, primarily cultivated for domestic consumption and export to the United States. The industry underwent substantial growth in the early 20th century, propelled by the increasing demands of the United States. Despite the increasing

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[62] Li, AM., et al. (2024). Sugarcane borers: species, distribution, damage and management options. *J Pest Sci*. https://doi.org/10.1007/s10340-024-01750-9

[63] Luzaran, R.T. *et al*.(2022) Sugarcane Breeding and Germplasm Development in the Philippines. *Sugar Tech* 24, 210–221. https://doi.org/10.1007/s12355-021-00979-3

Annex 6 [64] Alburo et al. (2019). Application of analytical hierarchy process (AHP) in generating land suitability index (LSI) for sugarcane in central Mindanao, Philippines. J. ISSAAS Vol. 25, No. 1: 148-158

[65] Gandia et al. (2021). Response of High Yielding Varieties of Sugarcane (Saccharum officinarum) to Waterlogging. Philippine Journal of Science. 150 (6A): 1507-1516. https://philjournalsci.dost.gov.ph/

[66] Go, A. W., et al. (2020). Sugarcane processing by-products for bioethanol production in the Philippines: a retrospective assessment from 2007 to 2017 and future challenges. *Biofuels*, *13*(5), 567–577. https://doi.org/10.1080/17597269.2020.1812999

[67] Kumar Gaur, R. (Ed.). (2022). Omics Approaches for Sugarcane Crop Improvement (1st ed.). CRC Press. https://doi.org/10.1201/9781003292425

[68] Cruz, DA et al. (2023). "Increasing Sugarcane Production Eco-Efficiency: A DEA Analysis with Different Sugarcane Varieties" *Sustainability* 15, no. 14: 11201. https://doi.org/10.3390/su151411201

[69] Bhatt, R. *et al.* (2023). Climate-Smart Technologies for Improving Sugarcane Sustainability in India–A Review. *Sugar Tech* **25**, 1–14. https://doi.org/10.1007/s12355-022-01198-0

domestic demand, sugarcane farmers face various challenges that hinder their ability to export. These obstacles include insufficient funds, limited crop yield, high expenses for inputs, and inadequate irrigation infrastructure. Consequently, the total production of sugarcane remains low.

Climate change and environmental issues heighten the vulnerability of smallholder farmers, resulting in the depletion of their means of subsistence, financial resources, and agricultural production. Adaptation strategies encompass diversification, infrastructure enhancement, water conservation methodologies, and soil conservation practices. These strategies have the objective of improving soil health, mitigating risks related to monoculture, and enhancing resilience in extreme weather conditions. Furthermore, by addressing the research and development priorities, the Philippines can enhance the sustainability and resilience of its sugar cane industry, ensuring long-term economic and environmental benefits.

10.Carabao

Introduction

The Carabao, or water buffalo (*Bubalus bubalis*), is a vital livestock species in the Philippines. It is valued for its multifunctional roles in agriculture, transportation, and milk and meat production. Carabao farming significantly contributes to the livelihoods of many Filipino farmers.

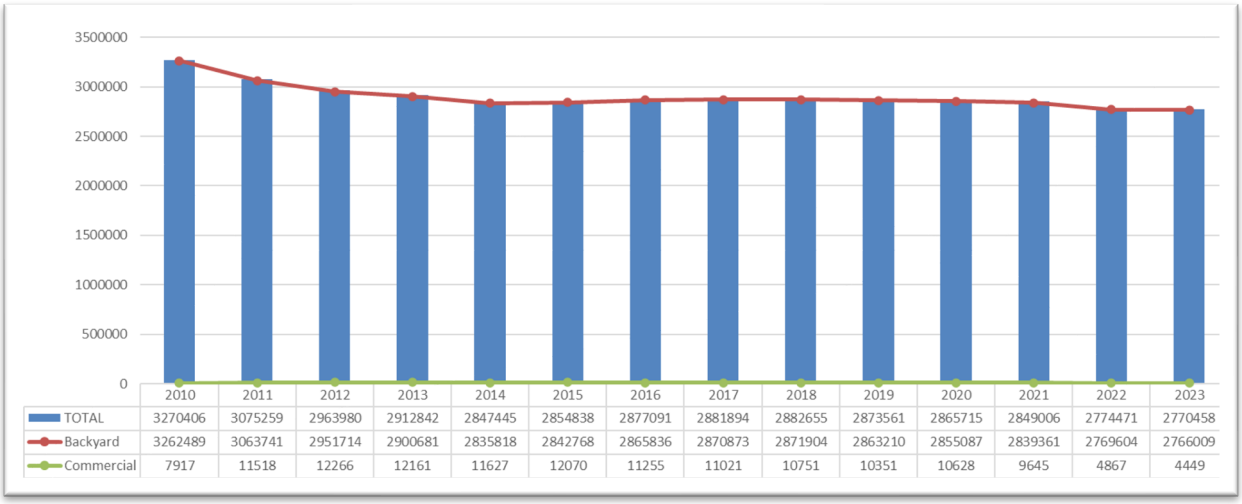
General data

Production

- Population: The Philippines has an estimated carabao population of around 3 million.

- Carabao farms are divided into three classifications (based on the new classification of animals per PSA Board Resolution No. 04, series of 2022 dated 13 May 2022):
    - Small hold farms: 1 to 10 sow level or 1 to 100 heads
    - Semi-commercial farms: 11 to 50 sow level or 101 to 500 heads
    - Commercial farms: 51 sow level and above or 501 heads and above

- Carabao farming is mainly dominated by backyard/small hold farms wherein they take up a majority of the total carabao population in the Philippines. The graph below shows the carabao inventory in the Philippines by farm type from 2010 to 2023 wherein the total inventory decreased from 3.27 million heads in 2010 to 2.77 million heads in 2023. The majority of carabaos are reared in backyard farms, with their numbers also declining from 3.27 million in 2010 to 2.77 million in 2023. In contrast, the commercial farm carabao population has remained relatively stable with a slight decline, though it constitutes a small fraction of the total. This trend indicates a consistent reduction in carabao populations, primarily driven by the decrease in backyard farm numbers.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
TOTAL	3270406	3075259	2963980	2912842	2847445	2854838	2877091	2881894	2882655	2873561	2865715	2849006	2774471	2770458
Backyard	3262489	3063741	2951714	2900681	2835818	2842768	2865836	2870873	2871904	2863210	2855087	2839361	2769604	2766009
Commercial	7917	11518	12266	12161	11627	12070	11255	11021	10751	10351	10628	9645	4867	4449

Figure 65: Carabao inventory in the Philippines by farm type (Source: PSA, 2023).

- As of June 30, 2023, the total carabao inventory was estimated at 2.73 million heads, reflecting a 1.2 percent decrease from the same period the previous year, which had a count of 2.77 million heads. Approximately 99.1 percent of the country's carabao population was from smallholder farms, with the remaining 0.8 percent and 0.1 percent coming from semi-commercial and commercial farms, respectively.

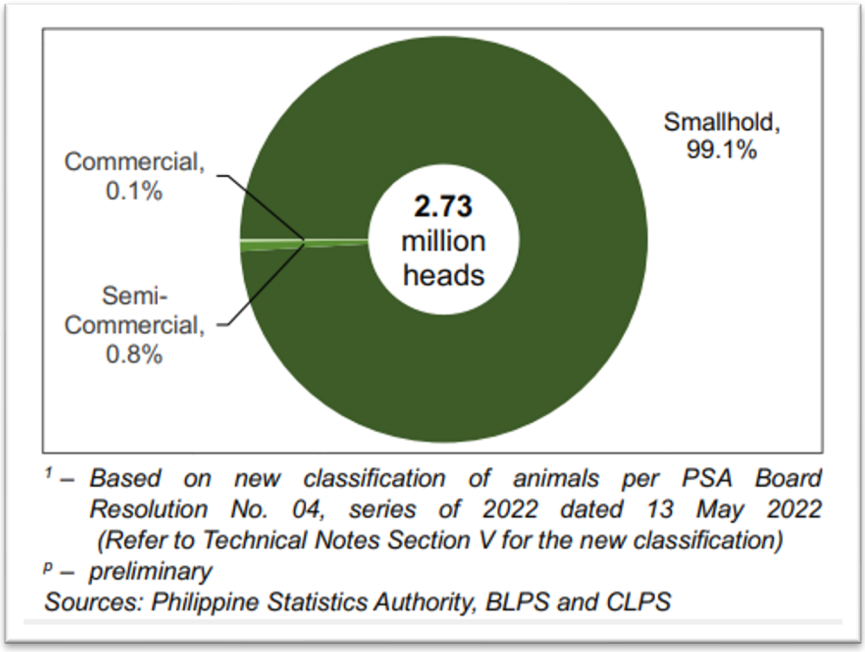


Figure 66: Distribution of carabao inventory by classification Philippines, 30 June 2023 (Source: PSA, 2023).

- Regions: Carabaos are raised nationwide, with significant populations in regions such as the Bicol Region and Western Visayas, each having 10% of the total carabao inventory of the Philippines from 2010-2023. They are closely followed by Region II (Cagayan Valley) and Region III (Central Luzon), each contributing 8%. Other significant contributors include Region XI (Davao Region) and Region VIII (Eastern Visayas) at 8% each. In contrast, the National Capital Region (NCR) has the smallest shares at less than 1%.

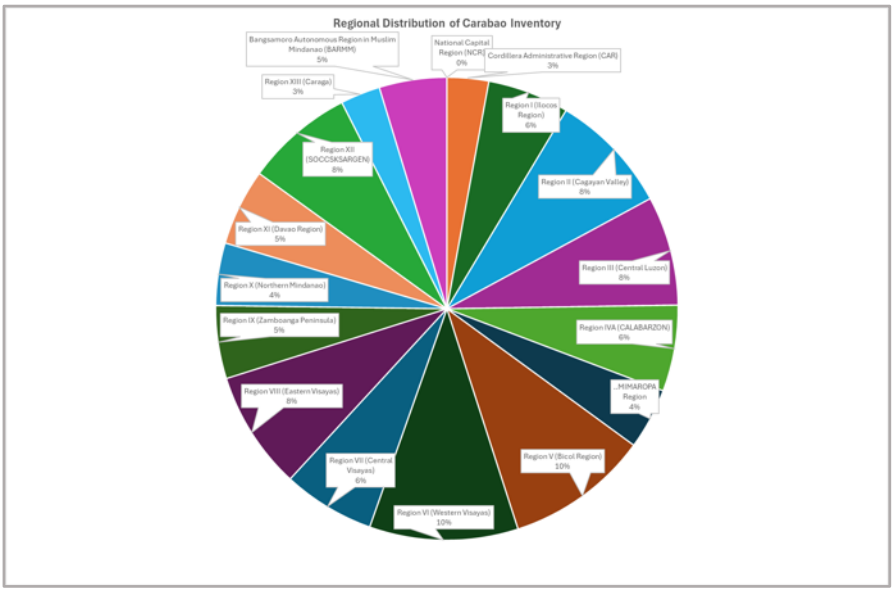


Figure 67: Total regional distribution of carabao inventory, 2010- 2023 (Source: PSA, 2023).

- The Philippine carabao, valued for its meat and draft power, primarily benefits smallholder farmers, who own 99% of the 2.85 million heads as of January 2015. Despite government efforts to introduce farm tractors, smallholder rice farms still rely heavily on carabao draft power. The carabao industry saw an annual growth rate of 0.52% from 1994 to 2015. Carabaos are widely distributed across the Philippines, with Region 7 having the highest population at 10.9%, followed by Regions 2, 3, 5, and 8, which together hold 45.2% of the total population. The Philippine

Carabao Center, established in 1983, oversees the industry's development, including upgrading native buffaloes through murrah buffalo importation (Calub et al., 2016).

- Uses: Carabaos are used for draft power in rice fields, milk production (notably the Murrah breed), and meat (carabeef).

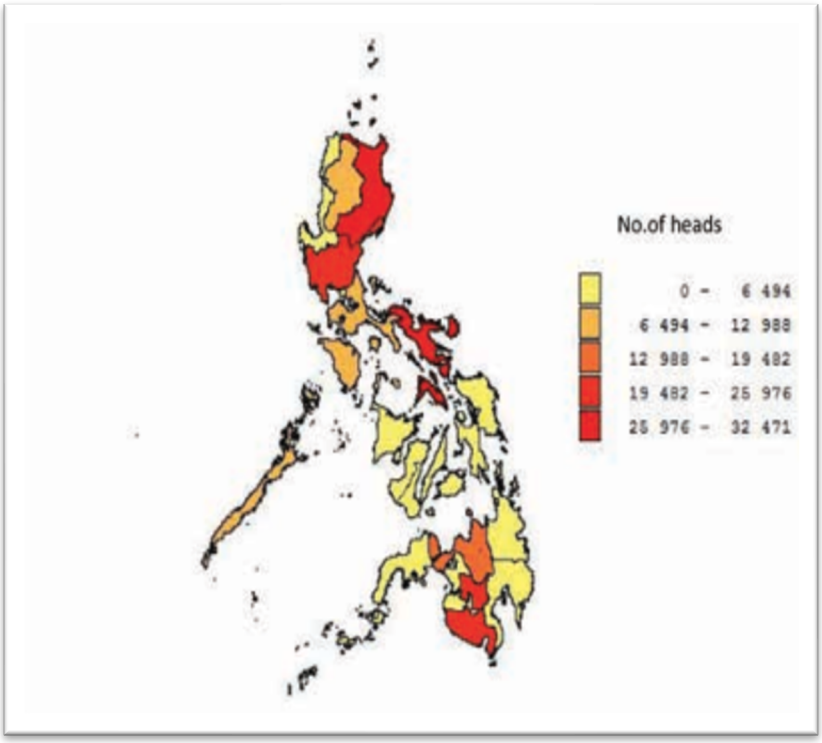


Figure 68: Regional distribution of carabao in the Philippines, 2015 (Source: Calub et al., 2016).

Consumption

- Milk: Carabao milk is rich and creamy, often processed into products like cheese (*kesong puti*), pastillas, and yogurt. It's particularly prized for its high butterfat content. From 2014 to 2019, local stocks of dairy buffalo produced 46.416 million liters of milk, accounting for 35% of the total locally produced milk during this period (Table 21). Additionally, the average annual growth rate in milk production by dairy carabaos was 4.66%.

Animal	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**	**% share**
Cattle	12,562.18	12,928.49	13,333.83	14,292.75	14,602.98	14,852.75	82,572.99	62.54
Carabao	6,859.02	7,121.80	7,435.08	8,014.71	8,378.96	8,606.69	46,416.26	35.15
Goat	306.32	335.84	387.09	447.97	709.35	857.93	3,044.50	2.31
Total	**19,727.52**	**20,386.13**	**21,156.00**	**22,755.43**	**23,691.29**	**24,317.37**	**132,033.75**	

Table 21: Milk production by animal type, '000 liters, 2014-2019 (Source: PCC, 2022).

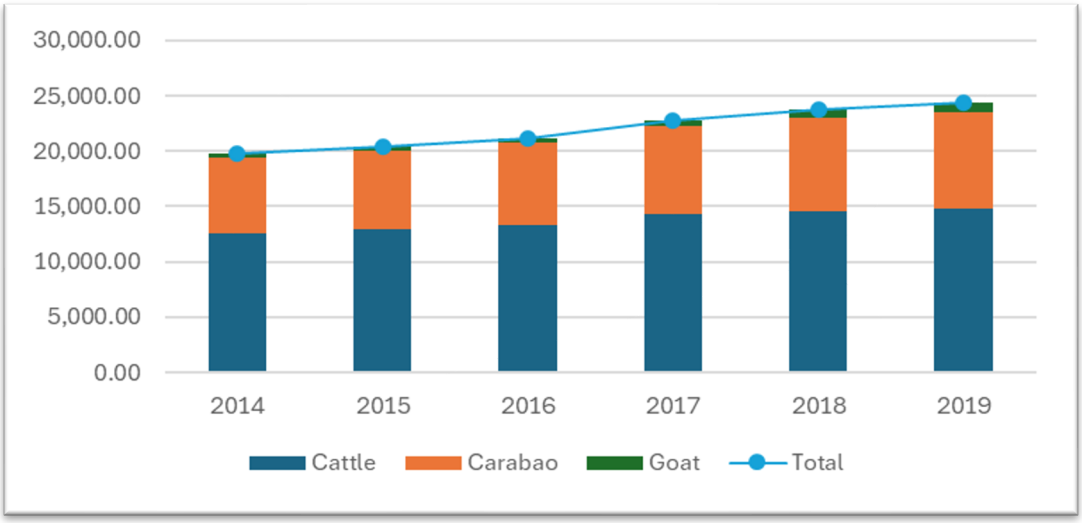


Figure 69: Milk production by animal type, '000 liters, 2014-2019 (Source: PCC, 2022).

- Meat: Carabeef is consumed locally, especially in rural areas, and used in various traditional dishes. Consumption of Carabeef peaked in 1999-2000 but significantly decreased until 2012. There is a slight recovery by 2015-2016, with consumption rising to about 0.175 kilograms per person. Overall, the trend indicates a general reduction in carabeef consumption over the two-decade period.

- By-products: Hide and horns are used in the production of leather goods and crafts.

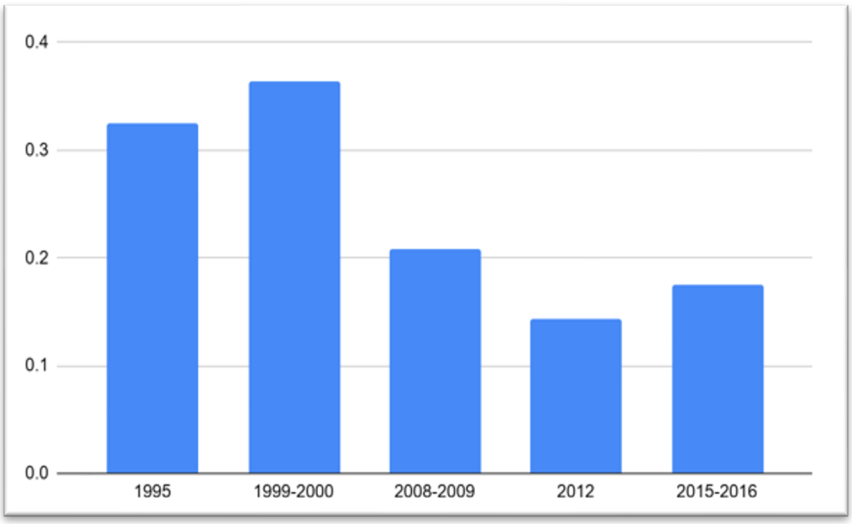


Figure 70: Annual per capita consumption of carabeef (Source: PSA, 2020).

Socio-Economic Aspects

- Employment: Carabao farming provides employment to millions of Filipinos, from smallholder farmers to workers in processing industries.

- Income: Carabao farming is a significant source of income, particularly for rural households, through the sale of milk, meat, and by-products.

- Community Impact: Carabaos are integral to the rural way of life, supporting farming operations, transportation, and cultural practices. However, there are constraints to Local Carabao Production. Carabaos are primarily used in crop-dominant farming systems where farmers prioritize crops for cash income and investment, often neglecting carabaos. Maintaining carabaos during their long rest periods is considered cumbersome, particularly during short planting seasons. However, areas with daily milk sales see improved carabao husbandry due to higher milk income. The low price of carabao meat, resulting from selling older draft animals, penalizes farmers who raise younger ones for meat, and the availability of cheap imported buffalo meat might impact local production. Carabao milk production for local consumption is feasible but requires stimulation to compete with imported milk. A significant constraint is the lack of capital, as existing credit options for small farmers have little impact (PCC, n.d.).

- In Filipino culture, the carabao, introduced by Malays centuries ago, symbolizes strength, good fortune, and community. It plays a vital role in agriculture, assisting in cultivation, land preparation, and transport. Preserving the carabao heritage is crucial for food security, rural development, and maintaining cultural identity.

Value Chain

A value chain encompasses the full range of activities required to bring a product or service from conception to the final consumer. The value chain for the carabao industry particularly for milk and dairy products (Figure 72) and meat and meat products (Figure 73) (Lantican et al., 2015; 2016).

There seven key stakeholders in the dairy carabao value chain: input providers, farmers, milk collectors, dairy processors, wholesaler-retailers, retailers, and consumers (Lantican et al., 2015; 2016). Input providers include dairy farmer cooperatives, the DA-PCC (as a breeder and source of forage materials and semen), AI technicians, and agricultural supply stores. These stakeholders are involved in production, milk collection, processing, and marketing. Supporting organizations include various national government agencies, international organizations, local government units, non-government organizations, and state universities and colleges.

Popular buffalo dairy products in the country include raw milk, pasteurized milk, flavored milk, pastillas de leche, yoghurt, white cheese, mozzarella, ice cream, milk candy, dulce gatas, choco-bar, milk bread, milk-o-gel, and milk soap.

Meanwhile, there are eight key players in the value chain of carabao meat and meat products in the Philippines: input providers, farmers, agents, livestock traders, meat dealers, processors-cum-wholesaler-retailers, retailers, and consumers (both household and institutional buyers) (Lantican et al., 2015; 2016). The key functions performed by these value chain players encompass input provision, carabao growing, live carabao assembly and trading, meat production, meat processing, and meat marketing. The enabling organizations supporting these activities are similar to those involved in the value chain for carabao milk and milk products.

In Luzon, business establishments involved include livestock auction markets for trading live animals and slaughterhouses for butchering carabaos. In the Visayas and Mindanao, in addition to auction markets and slaughterhouses, there are also seaport businesses for transporting animals to buyers outside the region.

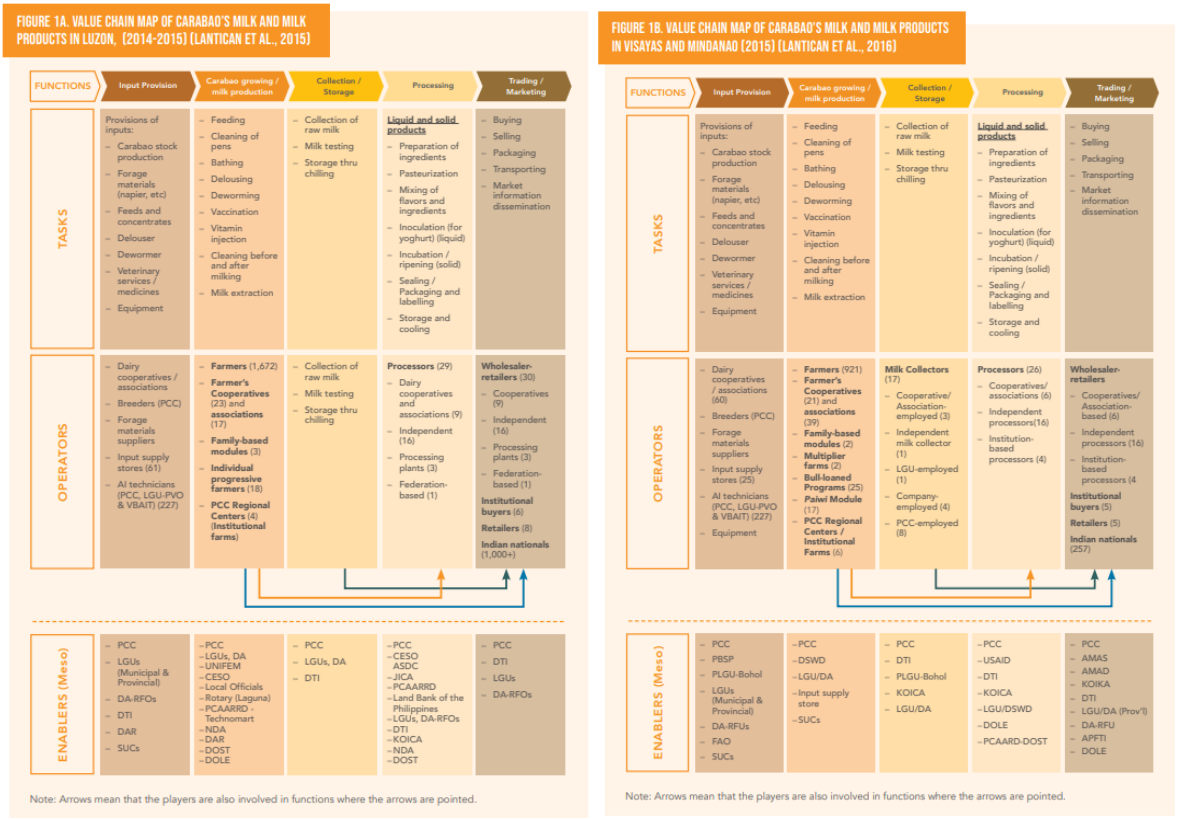


Figure 71: Value chain map of carabao milk production in Luzon, Visayas and Mindanao (Source: Lantican, et al., 2015; Lantican, et al., 2016)

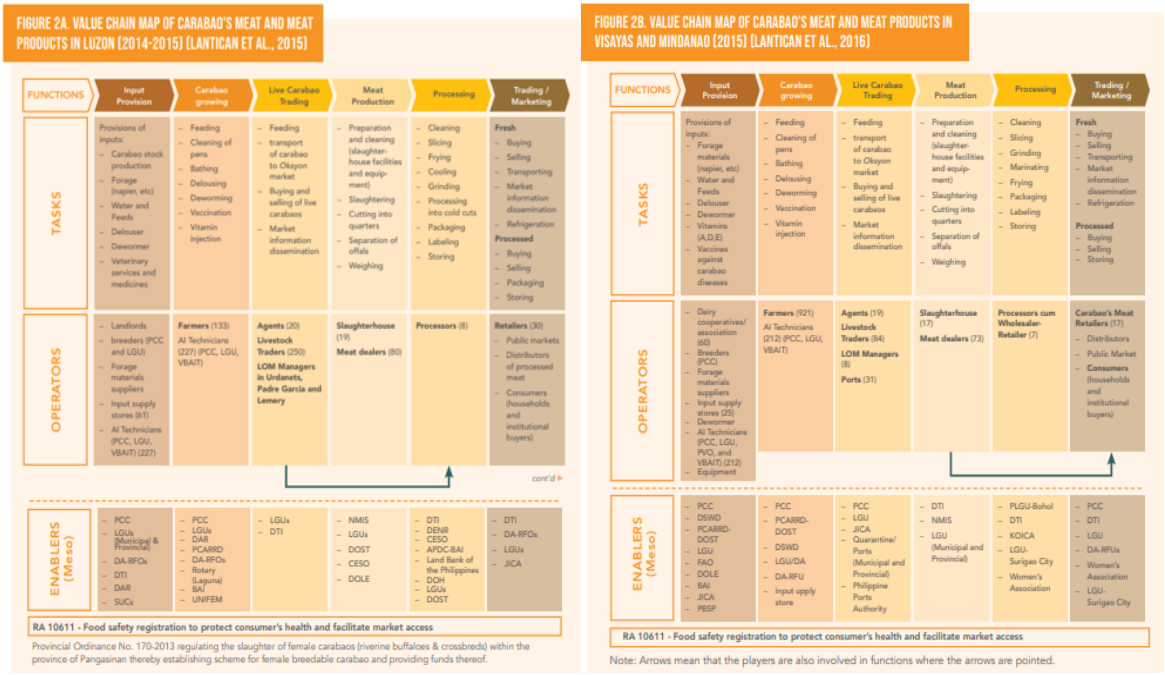


Figure 72: Value chain map of carabao meat production in Luzon, Visayas and Mindanao (Source: Lantican, et al., 2015; Lantican, et al., 2016)

Environmental Aspects and Climate Change

Environmental Impacts

- Land Use: Carabao grazing can impact land use, but integrated farming practices can mitigate negative effects. Implementing good pasture management and grazing principles, such as rotational grazing, significantly impacts land use by increasing forage quality and yield, providing a healthier environment for grazing buffaloes, enhancing their performance, and preventing nutritional problems that affect productivity. Healthy pastures benefit owners, animals, and the environment by preventing erosion and water loss, effectively managing soil nutrients and pH, and closely monitoring forage growth and animal consumption. Rotational grazing, which involves using cross fences to divide pastures into separate units called paddocks, promotes the growth of more nutritious and digestible forage for grazing animals and allows pastures to regrow, thereby improving feed quality and availability.

- Water Use: Carabaos require substantial water for drinking and wallowing, essential for thermoregulation and skin health.

- Manure: Carabao manure is a valuable fertilizer but can contribute to methane emissions, a potent greenhouse gas. Carabao manure holds significant economic value. It serves as an excellent organic fertilizer, containing 18.5% nitrogen, 43.7% phosphoric acid, and 9.6% potash. Additionally, it can be used as a fuel source, either as dried dung or for generating biogas or methane. When mixed with clay, the dung can be used as a building material or as plaster for threshing "palay" on the ground (Irang, 2015).

- In the absence of country-specific emission factors, methane and nitrous oxide emissions from livestock can be estimated using the IPCC Tier 1 approach. Estimates indicate that the carabao industries contribute the largest in methane emissions, 53.08% of the total methane emissions from enteric fermentation (Figure 74; Calub et al., 2016).

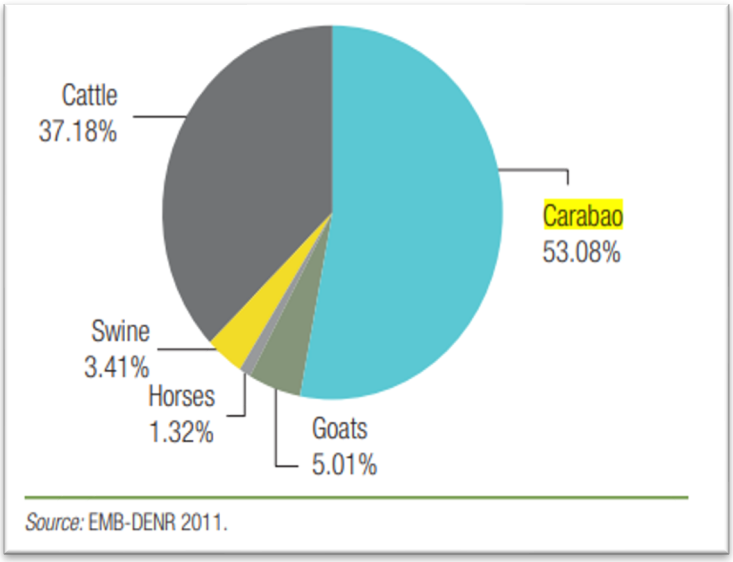


Figure 73: Summary of methane emissions of livestock industry from enteric fermentation, 2000 (Source: Calub et al., 2016).

The table below presents the 2014 greenhouse gas (GHG) emissions from livestock and poultry due to enteric fermentation and manure management, measured in tons of CO_2 equivalent per year. Carabaos contribute 3,297,338 tons of CO_2eq/year through enteric fermentation, surpassing cattle and goats in this category. For manure management, three scenarios are considered: Scenario A (25% manure properly treated, 75% potentially polluting), Scenario B (50% properly treated, 50% potentially

polluting), and Scenario C (90% properly treated, 10% potentially polluting). Carabaos emit 916,846 tons CO_2eq/year in Scenario A, 611,231 tons CO_2eq/year in Scenario B, and 122,846 tons CO_2eq/year in Scenario C. These figures highlight the substantial impact of effective manure management on reducing emissions. Overall, carabaos have a large contribution to GHG emissions among ruminants, emphasizing the need for targeted mitigation strategies in both enteric fermentation processes and manure management to achieve significant emission reductions.

	GHG Emissions			
		Manure[a] (tons CO_2eq/year)		
Animal	Enteric Fermentation[a] (tons CO_2eq/year)	Scenario A[b]	Scenario B[c]	Scenario C[d]
Ruminants				
Cattle	2,501,298	780,637	520,425	104,085
Carabao	3,297,338	916,846	611,231	122,846
Goat	385,790	334,905	223,270	44,654
Total	6,184,426	2,032,388	1,354,925	270,985
Non-ruminants				
Pig	251,994	2,515,467	1,676,978	335,396
Chicken	—	713,225	475,483	95,097
Total	251,994	3,228,692	2,152,461	430,493

[a] Based on the IPCC 2006 Tier 1 method and conversion factor of 1 kg CH_4 = 21 kg CO_2eq and 1 kg N_2O = 310 kg CO_2eq
[b] 25 percent of total manure production is properly treated or 75 percent is potentially polluting.
[c] 50 percent of total manure production is properly treated or 50 percent is potentially polluting.
[d] 90 percent of total manure production is properly treated or 10 percent is potentially polluting.

Table 22: GHG emissions of livestock and poultry from enteric fermentation and different manure management scenarios, 2014 (Source: Calub et al., 2016).

Table 23 highlights the potential for reducing pollution by utilizing waste and manure based on available studies and limited field observations. In Scenario A, 25 percent of manure is properly used, with 75 percent potentially polluting. Scenario B shows a 50:50 ratio, while Scenario C has 90 percent utilized and 10 percent polluting. The table also shows estimated manure production by livestock, including carabaos, which have a population of 2,854,838 heads producing 5,001,676 tons of manure per year. Under different management scenarios, GHG emissions from Carabaos' manure are as follows: Scenario A results in 3,751,257 tons/year, Scenario B results in 2,500,838 tons/year, and Scenario C results in 500,168 tons/year. This indicates that improving manure management significantly reduces GHG emissions from carabaos.

Animal[a]	Population (heads)	Estimated Manure Production as Excreted (tons per year)	Scenario A[b]	Scenario B[c]	Scenario C[d]
Cattle	2,534,243	3,884,995	2,913,746	1,942,497	388,499
Carabao	2,854,838	5,001,676	3,751,257	2,500,838	500,168
Pig	11,999,722	1,708,160	1,281,120	854,080	170,816
Chicken	176,469,099	2,462,373	1,846,780	1,231,186	246,237
Total		13,057,204			

[a] PSA 2015.
[b] 25 percent of total manure production is properly managed/utilized.
[c] 50 percent of total manure production is properly managed/utilized.
[d] 90 percent of total manure production is properly managed/utilized.

Table 23: Estimated manure management from estimated manure in different scenarios, 2014 (Source: Calub et al., 2016).

Current and Future Challenges Linked to Climate Change

- Heat Stress: Rising temperatures can cause heat stress, reducing productivity and reproductive efficiency.
- Water Scarcity: Changes in rainfall patterns and prolonged droughts can limit water availability, essential for carabao health and productivity.
- Feed Availability: Climate change can affect the availability and quality of forage, impacting nutrition and growth.
- Disease Incidence: Changing climate conditions can increase the prevalence of diseases and parasites, threatening herd health.

Necessary Adaptation Strategies

- Water Management: Implementing efficient water management practices to ensure adequate water supply during dry periods.
- Improved Shelter: Providing adequate shelter and shade to protect carabaos from extreme heat.
- Integrated Farming Systems: Promoting integrated farming systems that optimize the use of land, water, and other resources.
- Breeding Programs: Enhancing breeding programs to develop climate-resilient carabao breeds with improved productivity and disease resistance.

R&D Opportunities

Research and Development Needs

1. Heat-Resilient Breeds: Development of carabao breeds that are more resilient to heat stress and variable climate conditions.
2. Sustainable Farming Practices: Research into sustainable farming practices that improve forage availability, water use efficiency, and overall productivity.
3. Health Management: Enhanced understanding and control of diseases and parasites, particularly those exacerbated by climate change.
4. Nutritional Supplements: Development of nutritional supplements and feed strategies to maintain health and productivity during periods of forage scarcity.

R&D Priorities

1. Breeding and Genetics: Focus on breeding programs to develop heat-tolerant, disease-resistant, and climate-resilient carabao breeds through advanced genetic research.

2. Sustainable Agriculture Practices: Research into sustainable farming practices that enhance feed quality, improve water use efficiency, and reduce environmental impact.

3. Health Management Innovations: Development of improved health management strategies, including vaccines, treatments, and disease monitoring systems.
4. Nutritional Strategies: Research into nutritional strategies and supplements to enhance carabao health and productivity, particularly during periods of feed scarcity.

5. Climate Adaptation Strategies: Investing in climate adaptation strategies, including improved shelter, water management, and integrated farming systems.

6. Extension Services and Farmer Education: Strengthening extension services to provide farmers with the knowledge and tools needed to adopt new technologies and practices, improve productivity, and enhance resilience to climate change.

By addressing these research and development priorities, the Philippines can enhance the sustainability and resilience of its carabao industry, ensuring long-term economic benefits and environmental health.

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11. Chicken Egg

Introduction

Eggs are essential in the poultry industry in the Philippines, as they provide an affordable source of protein and make a significant contribution to food security and livelihoods. According to PSA, chicken eggs account for 3.3% of the country's output, in terms of gross value-added[70].

General data

Types of poultry egg: The poultry industry in the Philippines is composed of diverse bird species, including chicken, ducks, turkeys, geese, quail, and guinea fowl, among others. Chicken layer dominated poultry farming for egg production. In the Philippines, white eggs dominated the market. It was only in 2015 that brown eggs were introduced into the market.

Biological description: Poultry layers are domesticated chickens (*Gallus gallus domesticus),* raised primarily for egg production. Commonly raised breeds include Lohmann Layers and Dekalb.

Production data

- Production volume: Annual egg production in the Philippines reached 731.36 thousand metric tons in 2023, surpassing the previous year's output of 708.50 thousand metric tons in 2022 (Figure 75)[71].

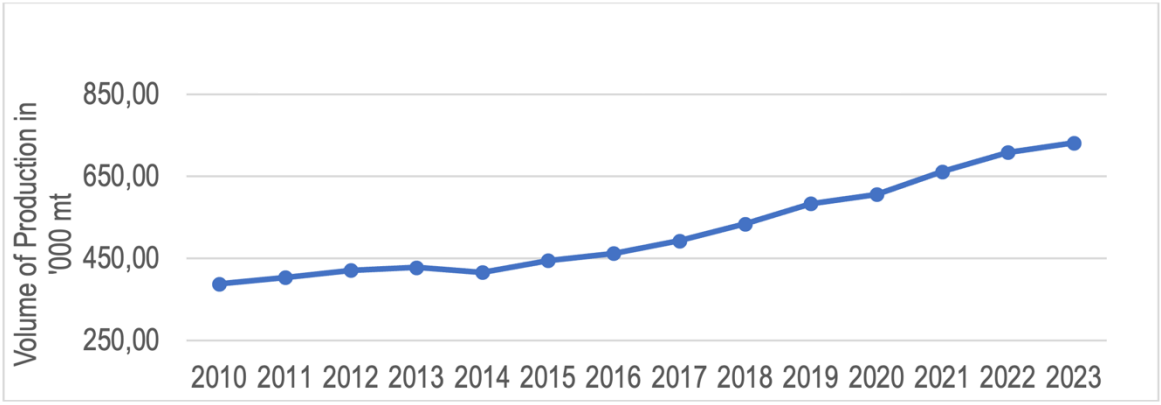

Figure 74: Egg annual production in metric tons, 2010-2023 (Source: PSA).

- Main producing regions: Most layer farms in the Philippines are located in three regions: CALABARZON, Central Luzon, and Central Visayas. These regions collectively account for 52.9% of the country's total chicken-laying flock population as of 2023[72].

[70] The Philippine Poultry Layer Industry Roadmap (2022-2040). (2022). In https://www.da.gov.ph/. Department of Agriculture - Bureau of Agricultural Research through the UPLB Foundation, Inc. Retrieved May 20, 2024, from https://www.da.gov.ph/wp-content/uploads/2023/05/Philippine-Poultry-Layer-Industry-Roadmap.pdf

[71] Source : PSA "Other Crops: Volume of Production, by Region, by Quarter and Semester, 2010-2024" https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__LP__PDN/0022E4FPPE0.px/table/tableViewLayout1/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313

[72] Chicken egg Situation Report | Philippine Statistics Authority | Republic of the Philippines. (2023, July 1). https://psa.gov.ph/livestock-poultry-iprs/chicken-egg/inventory

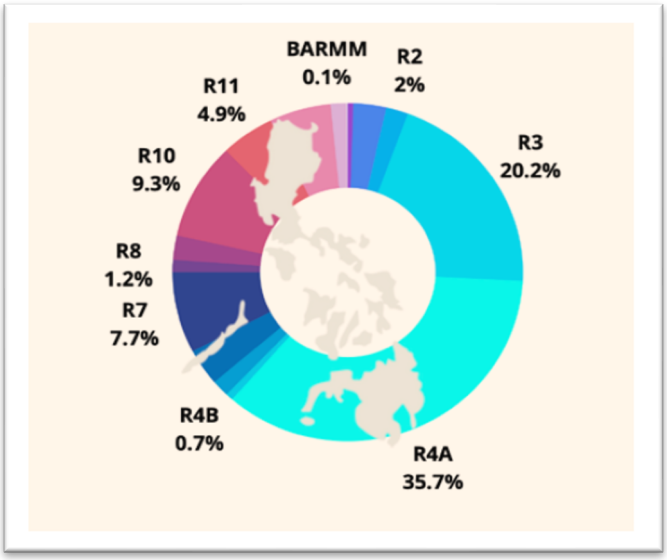

Figure 75: Key production regions (Source: Philippine Poultry Layer Industry Roadmap 2022-2040[70]).

Consumption data

- Domestic consumption: Egg consumption is relatively low, with an average per capita consumption of 5.27 kilograms per year in 2021, compared to the global average of 10.34 kilograms per capita in 2021[73].

- Domestic consumption at the regional level shows that NCR has the highest egg consumption with 123, followed by Region 3 with 106 and Region 4A with 109.

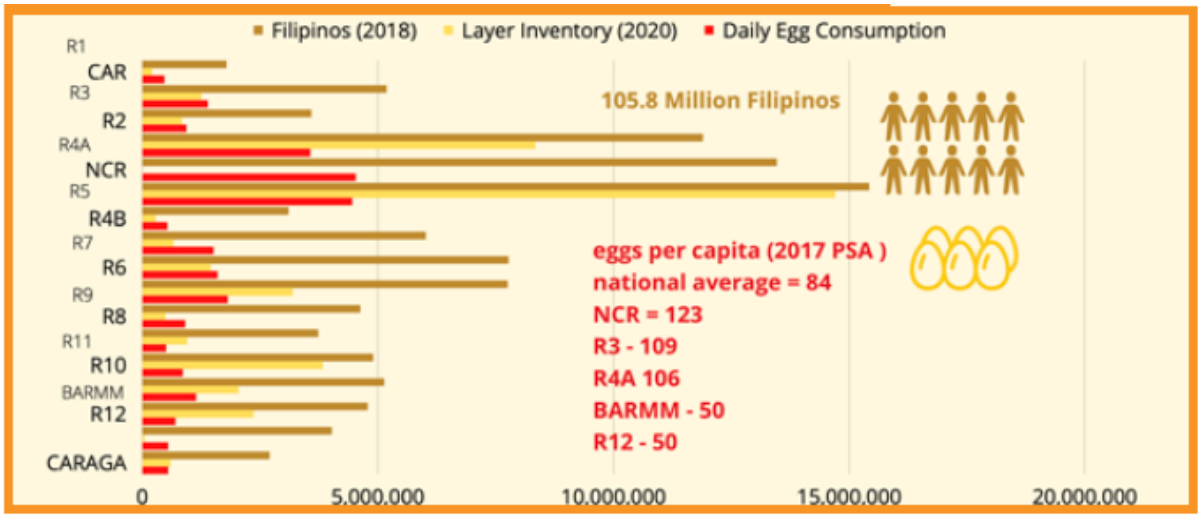

Figure 76: Egg consumption by region (Source: Philippine Poultry Layer Industry Roadmap 2022-2040[70]).

- Main uses: Eggs are consumed in many ways, such as fresh, boiled, fried, and as ingredients in countless dishes and baked goods. There are two main types of egg products available in the market: eggs sold in their shells (fresh, chilled, preserved) in trays or individually, and egg products (liquid, frozen, and dried) sold to institutional and selected retail outlets.

Annex 7 [73] FAO: "Crops and livestock products" https://www.fao.org/faostat/en/#data/QCL

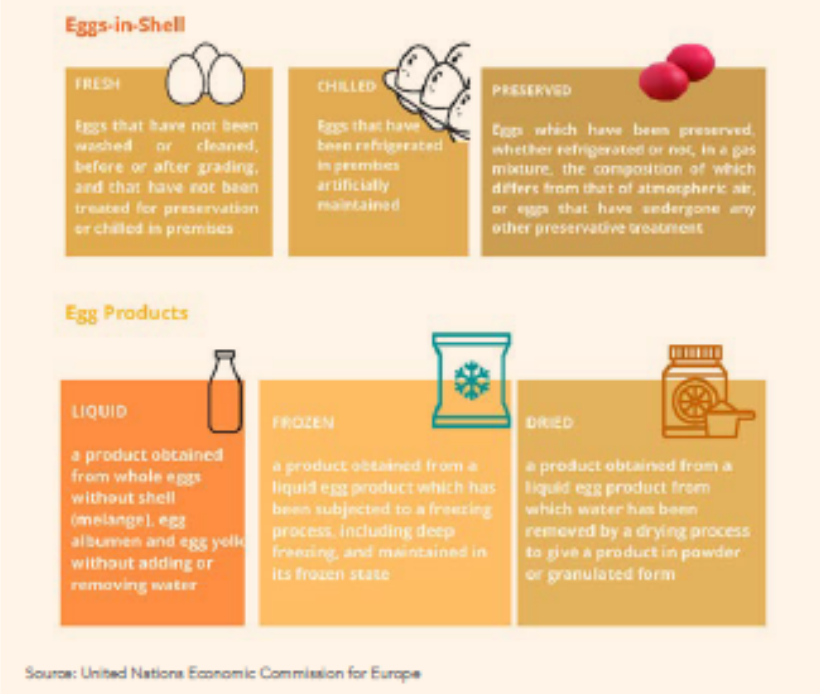

Figure 77: Products derived from the eggs (Source: Philippine Poultry Layer Industry Roadmap 2022-2040[70]).

Export data

- Export volume: The egg production in the Philippines is primarily for the domestic market, with a small volume of exports totaling around $46.9 thousand or 24 tons in 2022.

- Main destination countries: The main destination countries for Philippine eggs are Guam, Qatar, Cananda, Japan, and Bahrain.

- Recent trends: The import price per kilogram of eggs into the Philippines has seen a fluctuating over the years. While there is an increasing demand for egg in Guam, the Japan is seeing decline of import from the Philippines (Figure 80).

Import data

- Imported volume: Until the mid-1990s, the Philippines used to import eggs in shell. Currently, egg imports are limited only to processed forms such as dried egg yolk and powdered eggs, which are preferred and used by bakers, food manufacturers, and the food service industry. Import value of the country was estimated to about $18.6 million and 3.4 thousand tons in 2022.

- Main supplier countries: The main supplier countries of imported eggs are Spain, Italy, New Zealand, Denmark, and India.

- Recent trends: The export of eggs has significantly increased over the years, accompanied by a noticeable shift in trade partners (Figure 80).

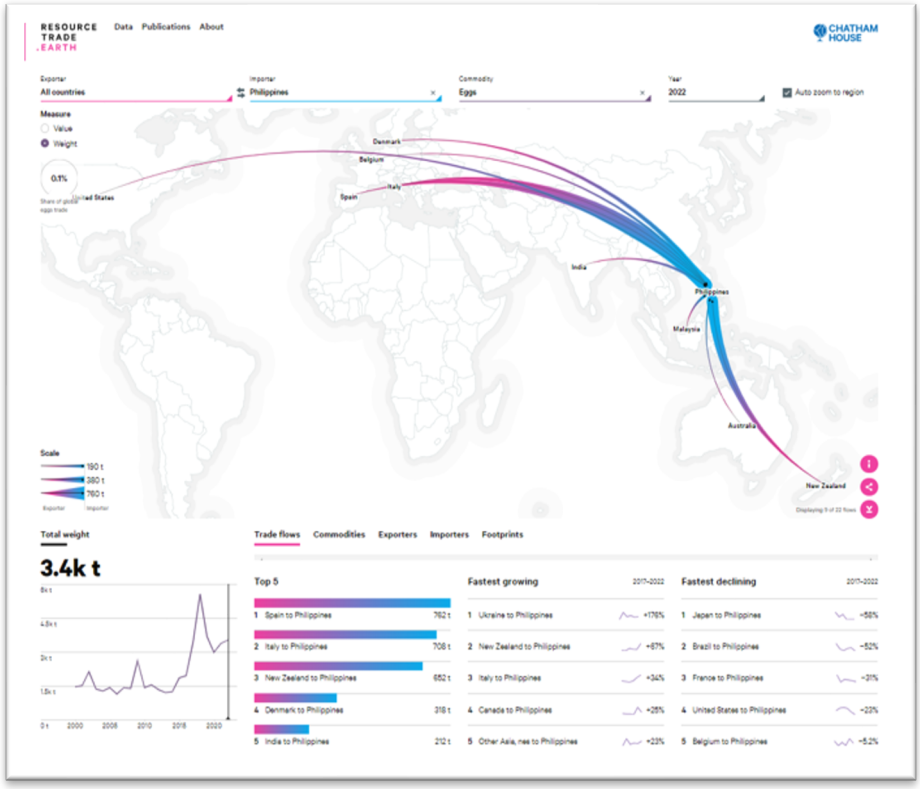

Figure 78: Egg exportation from the Philippines (Source: https://resourcetrade.earth).

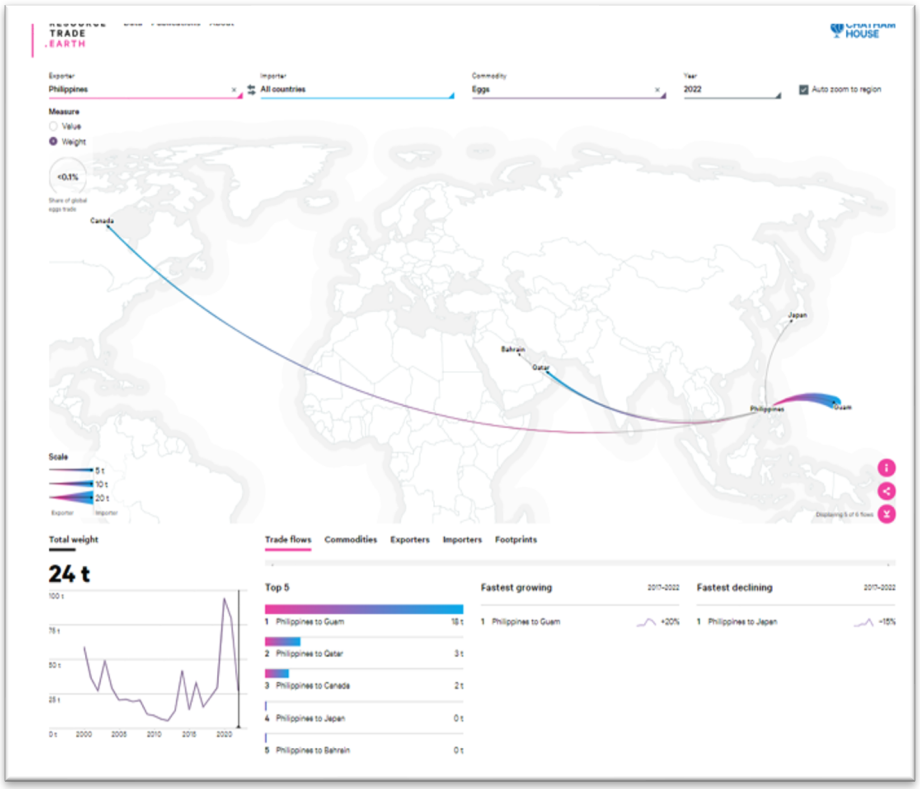

Figure 79: Egg importation to the Philippines (Source: https://resourcetrade.earth).

Prices

- Average domestic price: In 2021, the average domestic retail price for eggs was PHP 7.11 per piece. According to the 2024 PSA data, the farmgate price for native eggs was PHP 9.05 per piece, which is higher than the price of other eggs at PHP 6.74 per piece[70].

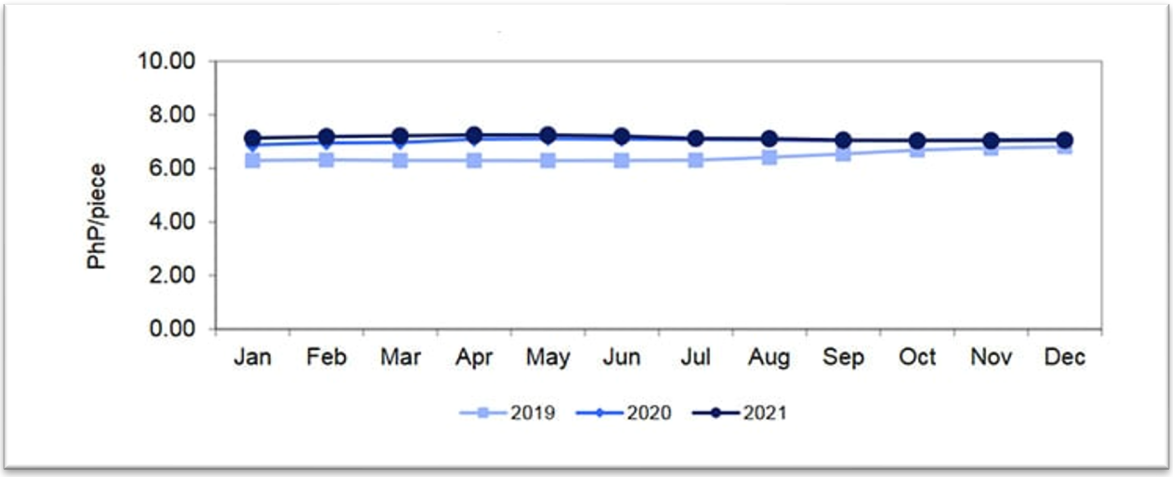

Figure 80: Monthly average retail prices of eggs (Source: Acosta, 2023).

- Average export price: The average export price of eggs from 2017 to 2021 has been fluctuating, ranging from 2.28 to 12.71 USD (US dollars) per kilogram[74].

Socio-Economic Aspects

Employment generated: Poultry production is the second important subsector in the agricultural industry in the Philippines[75]. Egg poultry farming is a significant source of employment, providing jobs at various stages of the market, from breeding and farming to feed supply, processing, and distribution.

Impact on local communities: Poultry farming contributes to the economic development of local communities by offering income opportunities and improving livelihoods. However, various challenges such as poultry diseases, climate change, and unsustainable poultry practices are faced by egg poultry industry.

Cultural importance: Table eggs are a vital part of the Filipino diet and culture, used in various traditional dishes and celebrations.

Value Chain

The egg industry value chain is composed of various players or key stakeholders, including input suppliers, distributors or dealers, farmer cooperatives, trading companies, food and beverage industry, biofuel industry, retail, food service, and customers. The different egg industry activities are and components are shown in the figure below.

[74] Selina Wamucii(n.d.). Philippine Egg Prices. https://www.selinawamucii.com/insights/prices/philippines/eggs/

[75] Acosta, A. (2023, January 24). Philippine egg industry update. Veterinaria Digital. Retrieved May 27, 2024, from https://www.veterinariadigital.com/en/articulos/philippine-egg-industry-update/

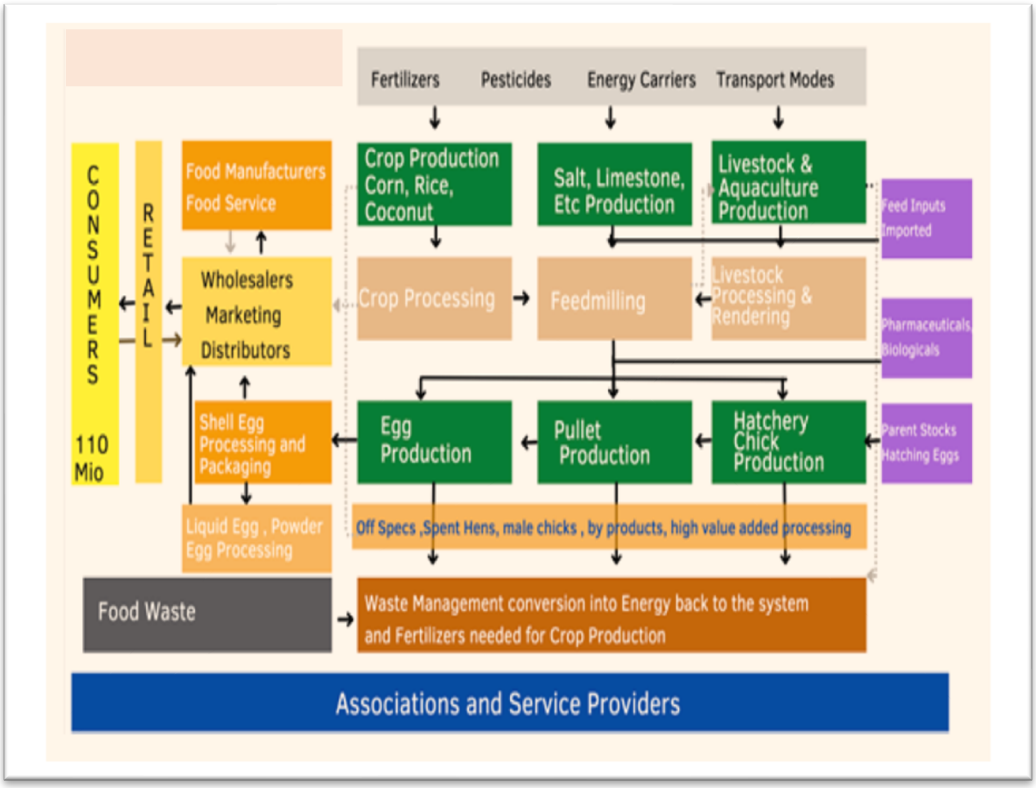

Figure 81: Egg industry value chain from (Source: Philippine Poultry Layer Industry Roadmap 2022-2040[70]).

Environmental Aspects and Climate Change

Impacts of Climate Change

- High temperatures: Increasing temperatures can induce stress in birds, leading to decreased egg production and compromised egg quality and quantity.
- Pest and diseases: Climate change can influence the spread of diseases such as Avian Influenza and mycotoxins that adversely impact poultry health.
- Unpredictable extreme weather events: Extreme weather events, such as typhoons, floods, and storm surges, can cause delays and disruptions in the distribution and delivery of chicks, feed, and other essential supplies to poultry farms due to power outages, route disruptions, and infrastructure damage.
- Climate variability in the Philippines: Climate variations can disrupt the availability and cost of feed ingredients, thereby influencing poultry production expenses.

Adaptation to Climate Change

- Improved poultry housing: Investing in climate-controlled housing to mitigate the effects of high temperatures and humidity.
- Disease management: Implementing robust biosecurity measures to prevent and control disease outbreaks.

- Climate-resilient infrastructure and comprehensive insurance policies. Investing in climate-resilient infrastructure and securing comprehensive insurance coverage are crucial steps to mitigate damages and losses caused by extreme weather events.

- Diversifying feed sources by exploring alternative, climate-resilient crop varieties can help mitigate the impact of changing weather patterns on feed availability and costs.

Challenges and Opportunities

Current challenges

- Disease Management: Controlling diseases such as Avian Influenza and Newcastle Disease.

- Feed Costs: Managing the high cost of feed, which is a significant component of production expenses.

- Market Volatility: Coping with price fluctuations and market demand variability.

Opportunities

- Increasing demand: The increasing population will create a larger market for egg production.

- Technological Advancements: Investing in technology to improve productivity, such as automated feeding systems and climate control.

- Sustainable Practices: Promoting sustainable and organic farming practices to meet growing consumer demand for environmentally friendly products.

- Value-Added Products: Developing value-added products such as egg powders, processed egg dishes, and specialty eggs (e.g., organic, free-range).

Policies and Programs

- Government Policies: Policies aim to enhance the competitiveness of the poultry industry, ensure food safety, and promote sustainable practices.

- Support Programs: Various programs support farmers through subsidies, training, and access to credit to improve productivity and sustainability. These include initiatives by the Department of Agriculture and local government units.

R&D Opportunities

1. Market Development: Exploring new markets and product opportunities to diversify income sources.

2. Disease Resistance: Research into breeds that are resistant to common poultry diseases.

3. Feed Efficiency: Development of more efficient and sustainable feed options to reduce costs and environmental impact.

4. Climate Adaptation: Developing strategies to mitigate the impacts of climate change on poultry farming, which may include among others heat stress management, water management, disaster preparedness and response, feed security, and climate-resilient breed.

5. Education and Training: Enhancing the adaptive capacity of egg poultry farmers by providing training on modern technologies and integration of sustainable poultry practices to withstand climate change impacts.

Conclusion

Egg poultry farming is crucial to the agricultural sector in the Philippines, making significant contributions to food security and economic development. It accounts for approximately 3.3% of the country's gross value-added. Eggs are primarily produced for domestic consumption, playing a vital role in Filipino households.

In recent years, there has been a growing trend in egg production volume in the Philippines, reflecting an increasing demand for local consumption. In addition to supporting food security and cultural significance, egg production creates employment opportunities that benefit most local communities. However, there are several factors that pose a threat to this industry, including disease management, high feed costs, and the impacts of climate change. Research and development are crucial to sustaining egg production in the country.

R & D should explore ways to increase egg production by developing value-added products, utilizing technology, and implementing sustainable poultry practices. Collaborative research should focus on breeding poultry more resistant to pests and diseases. Developing strategies for sustainable egg production is important to ensure continued success in meeting the growing demand despite climate change. Additionally, educating and training poultry farmers can help enhance their ability to adapt and incorporate modern technologies into sustainable farming practices.

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Acosta, A. (2023, January 24). Philippine egg industry update. Veterinaria Digital. Retrieved May 27, 2024, from https://www.veterinariadigital.com/en/articulos/philippine-egg-industry-update/

The Philippine Poultry Layer Industry Roadmap (2022-2040). (2022). In https://www.da.gov.ph/. Department of Agriculture - Bureau of Agricultural Research through the UPLB Foundation, Inc. Retrieved May 20, 2024, from https://www.da.gov.ph/wp-content/uploads/2023/05/Philippine-Poultry-Layer-Industry-Roadmap.pdf

12. Pork

Introduction[76]

The swine or hog sector is a crucial component of the livestock industry in the Philippines, contributing a significant role in providing both food and livelihood opportunities. The livestock industry, along with poultry and dairy, is predominantly operated by private entities and plays an important function in driving the Philippine economy. It holds the third position in terms of output within the agriculture sector. Backyard farms contribute to the majority of the country's pig production.

General data

Breeds/types[77]

- Belonging to the Suidae family, the common breeds or species of domesticated pigs or swine in the Philippines are Landrace, Duroc, Berkshire, Pietrain, Hampshire, and hybrids.

- Pigs are classified into breeders, piglets, and finishers depending on the purpose of production. Breeders include boars, sows, and gilts. Piglets are young suckling pigs, while finishers are raised for slaughtering purposes.

Production[81]

- The annual production of swine experienced a growth rate of 1.27 percent between 2011 and 2020, resulting in a total of 2,133.45 thousand metric tons per year. In contrast, there was a 1% decrease in 2019 and a more significant decrease of -6.71% in 2020, primarily attributed to the African Swine Fever (ASF) pandemic (see Figure 83).

[76] Briones, R. and Espineli, I. (2022). DP 2022-20: Towards Competitive Livestock, Poultry, and Dairy Industries: Consolidated Benchmarking Study. Philippine Institute for Development Studies. https://pids.gov.ph/publication/discussion-papers/towards-competitive-livestock-poultry-and-dairy-industries-consolidated-benchmarking-study

[77] Department of Agriculture National Livestock Program (NLP). (2022). The Philippine Hog Industry Roadmap (2022-2026). https://www.da.gov.ph/wp-content/uploads/2023/05/Philippine-Hog-Industry-Roadmap.pdf

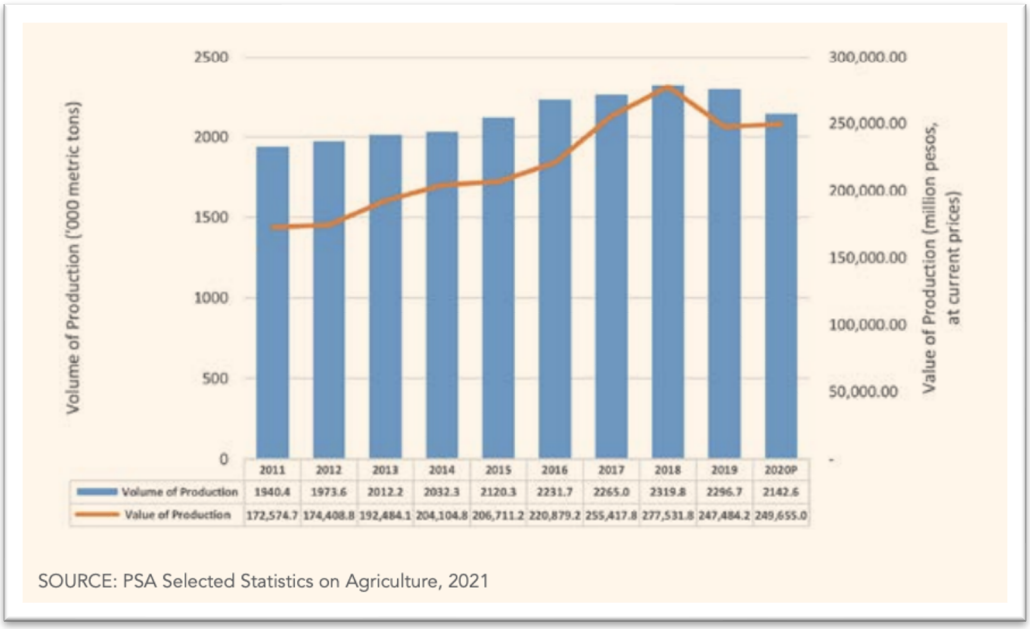

Figure 82: Swine volume and value of production, 2011-2020 (Source: DA NLP, 2022).

- African Swine Fever (ASF) and Covid-19 have had a major impact on the Philippine livestock and poultry industries. The local hog industry has been greatly impacted by ASF since its first outbreak in July 2019[78] and while some areas are expected to see an increase in production, others are expected to see a decline.

- The production of pigs is categorized by the farm structure. The two types of farm production, as categorized by the Philippine Statistics Authority, are backyard and commercial. These are differentiated based on the number of heads raised.

- Backyard farm growers have fewer piglets (1-40 piglets, or 1-10 sows with 1-21 piglets, or 1-20 finishers with no piglets) while commercial farms have more piglets (more than 10 sows with 22 piglets, or 21 or more finishers, or 41 or more piglets).

- In Q3 2023, the country's swine inventory was 9.86 million heads, a 2.1% decrease from the previous year count of 10.07 million heads was observed. The majority (67.5%) of the population was from small hold or backyard farms, while the remaining 29.2% and 3.3% were from commercial and semi-commercial farms (see Figure 84).

- CALABARZON Region has the largest swine population (1.35 million) in the country as of September 30, 2023, followed by 1.06 million heads in Central Luzon and 1.03 million heads in Northern Mindanao. These numbers represent 34.9% of the total swine population in the country[79] (see Figure 85).

[78] World Animal Health Information System. https://wahis.woah.org/#/in-review/3021?reportId=15912&fromPage=event-dashboard-url

[79] Philippine Statistics Authority. (2023). Swine Situation Report July-September 2023. https://www.psa.gov.ph/livestock-poultry-iprs/swine/inventory

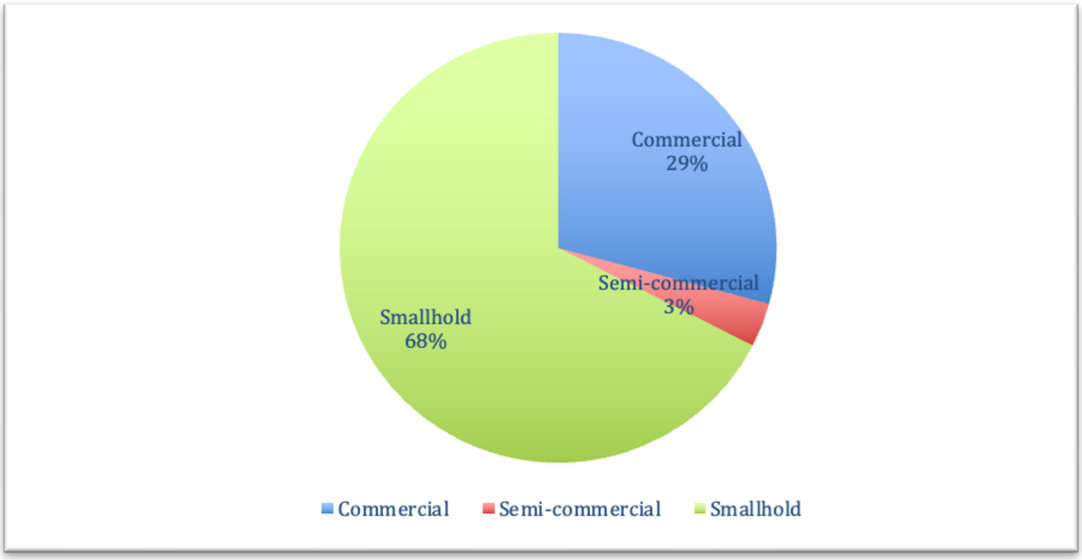

Figure 83: Distribution of swine inventory by farm classification.

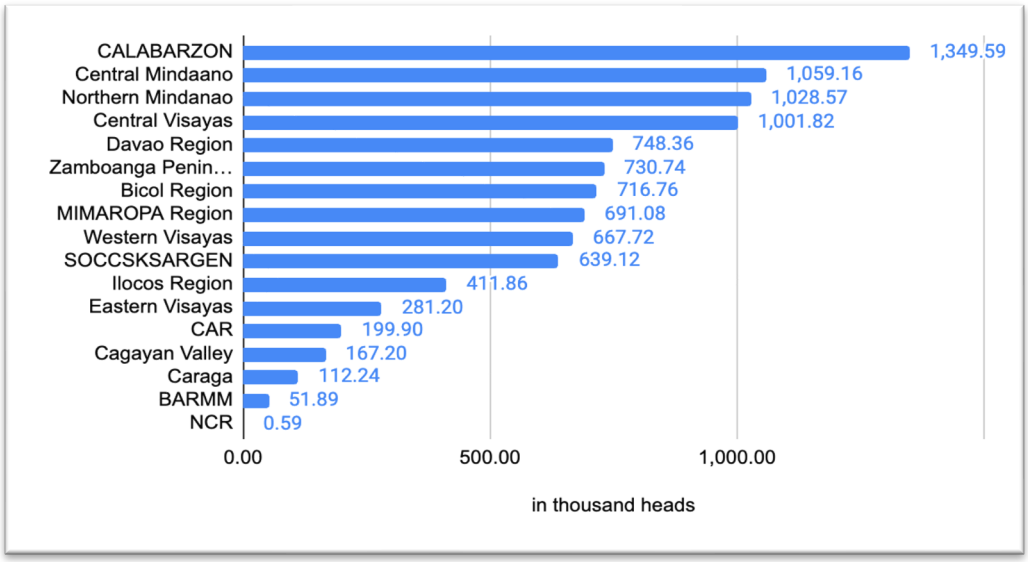

Figure 84: Distribution of swine inventory per region, July-September 2023.

Consumption

- Pork refers to pigs sold in markets either as live animals or meat. Live pigs are either used as breeders or grown as finishers for meat consumption. It could be cooked as is or further processed into various products such as *tocino, longganisa*, ham, bacon, sausages, etc.

- The per capita consumption of pork of Filipinos in 2020 is 14.90 kilograms of pork per person, a 4.91% decrease from 2019. The consumption is expected to fall to 14.17 kilograms in 2021 and several years due to the COVID-19 pandemic, reduced household spending, decreased food service, and logistical limitations[80].

[80] OECD-FAO Agricultural Outlook 2021-2030. https://openknowledge.fao.org/server/api/core/bitstreams/af0d6d72-b15b-46d6-af82-4949ddc0d004/content

Import

- Local pork production and meat imports fluctuated between 2010 and 2020. Pork imports consisted of 39% of pork cuts and 33% of offals. Fats, bellies, rind/skin, whole pork, and deboned were among the other imports[2].

- The Philippines imported a total of $940 million worth of pig meat in 2022, with the majority coming from Spain (26.5%), Canada (21.2%), and Brazil (18.4) (see Figure 86)[81].

Export

- The Philippines exported $298k worth of pig meat in 2022. 75% ($75k) of meat was primarily exported to Denmark, while 25% of it was in United Arab Emirates ($223). (See Figure 87)[81].

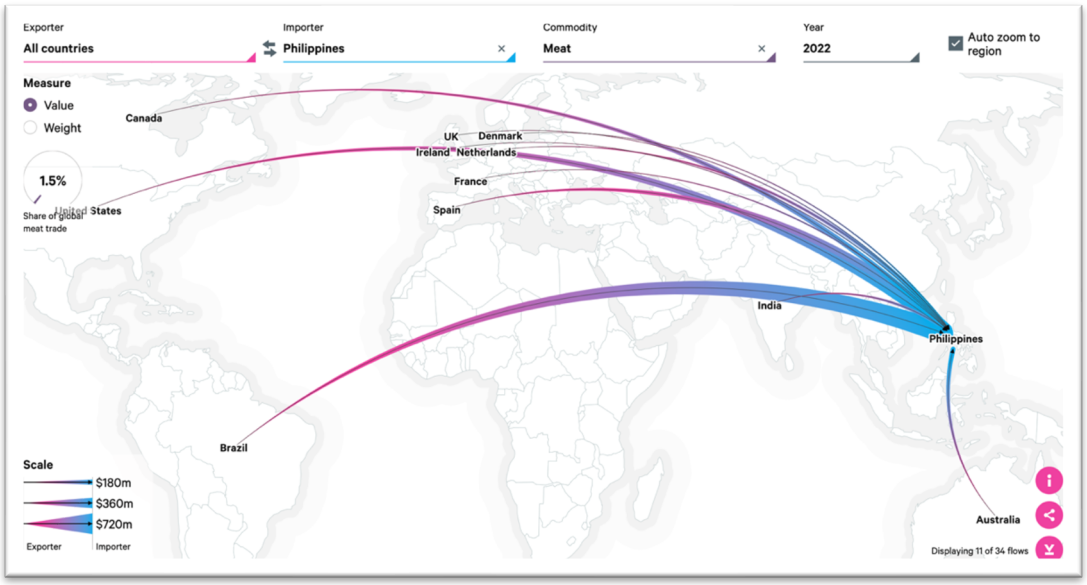

Figure 85: Pork importation in the Philippines (Source: https://resourcetrade.earth).

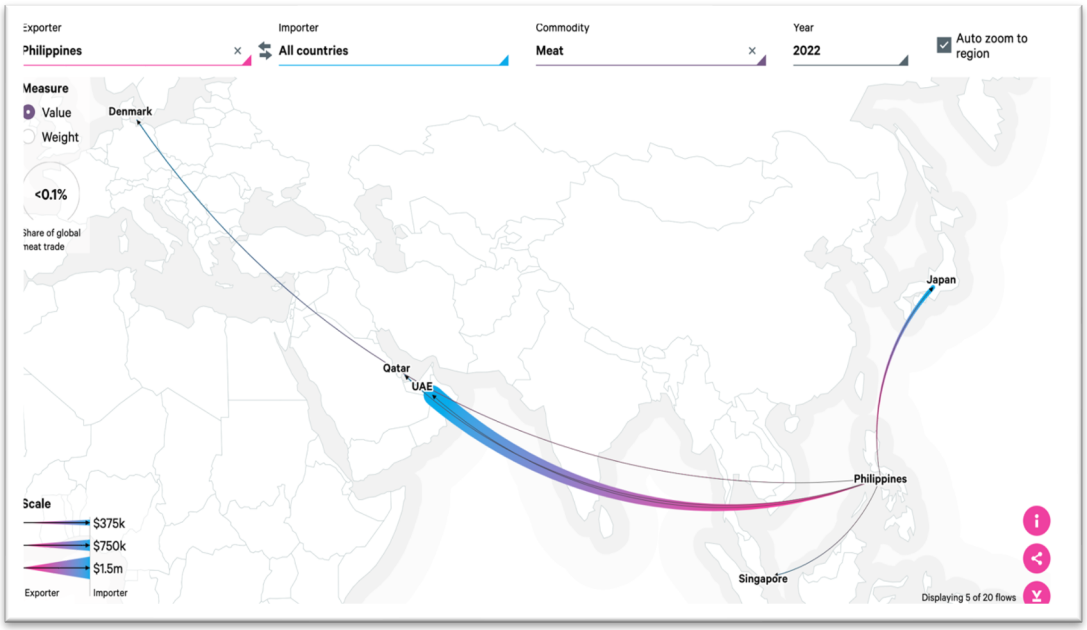

Figure 86: Pork exportation from the Philippines (Source: https://resourcetrade.earth).

[81]https://oec.world/en/profile/bilateral-product/pig-meat/reporter/phl

Prices

- Live pigs are retailed for between PHP 46.70 and PHP 124.91 per kilogram[82]

- The latest (as of May 2024) weekly average retail price of pork products such as ham is PHP 338.26 per kilo, while pork belly is PHP 379.03 per kilo[83] .

Trade

- Due to local processing requirements and disease incidence, the Philippines' imports of frozen pork fluctuated between 2012 and 2021; the ASF pandemic caused the highest importation to date in 2021.

- From 2010 to 2020, local pork production and meat imports varied. Pork cuts accounted for 39% of pork imports, while offals accounted for 33%. Other imports included fats, bellies, rind/skin, whole pork, and deboned.

Socio-Economic Aspects

- Value chain: The swine industry value chain consisted of various players and a sequence of activities. The key players were pig producers, traders, meat vendors, meat processors, and consumers[84]. The African Swine Fever (ASF) had an adverse effect, resulting in substantial losses for actors in the linked value chain[85].

- Employment: The domestic swine industry plays a significant role in the Philippine economy, specifically within the agricultural sector. The Agriculture, Fishery, and Forestry (AFF) sector, accounting for 24.8% of national employment, employed 9.75 million workers in 2020, out of a total labor force of 43.88 million.

- Socio-economic: In Q3 2021, there was a 15.2% decrease in livestock production, specifically a significant decline of 17.8% in hog production, which can be attributed to the African Swine Fever disease.

- Cultural: Recent findings uncovered profound emotional effects of ASF and the corresponding measures to control it, as farmers regarded pigs as companions and animal health workers as their own offspring.

[82] https://www.selinawamucii.com/insights/prices/philippines/live-pigs/
[83] DA price monitoring. https://www.da.gov.ph/price-monitoring/
[84] Fang, C. & Elca, C. An Assessment of Swine Industry in the Philippines. https://ageconsearch.umn.edu/record/323954
Annex 8 [85] Cooper et al. (2022). Beyond Numbers: Determining the Socioeconomic and Livelihood Impacts of African Swine Fever and Its Control in the Philippines. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8866713/

Environmental Aspects and Climate Change

Impacts of climate change

- High temperatures: Climate change may reduce pig productivity, increase heat stress, and increase disease susceptibility, affecting pig welfare and production capacity[86].

- Diseases: The findings indicate that ASF virus is spreading due to climatic changes, and that the future climate will be favorable for ASF virus spread[87].

- Environment impacts: Swine farming system generates greenhouse gases, ammonia, and volatile substances, resulting in a detrimental impact on environmental performance according to Life Cycle Assessment (LCA) analysis[88].

Adaptation to climate change

- Minimize emissions: To improve sustainability, the swine industry can reduce greenhouse gas emissions and fossil energy consumption, particularly by focusing on minimizing emissions from crop production and the breakdown of manure during storage[89].

- Anaerobic digestion: The utilization of anaerobic digestion processes and the production of biomethane from pig slurry can greatly reduce the consumption of fossil energy and the emissions of greenhouse gases, thus fostering environmental sustainability [90].

- Reduce heat stress: Methods such as insulation, ventilation, resilience breeding, and nutritional strategies have been recognized as effective measures to alleviate the adverse effects of heat stress on pig farming[91].

- Improved livestock management: Enhanced management of livestock systems, such as pig production, can effectively diminish carbon sequestration in pasturelands and rangelands, thereby contributing to climate change mitigation[92].

Challenges and Opportunities

Current challenges

- High production costs, elevated input costs, and the entry of smuggled pork undermine the ability of local producers to compete.

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[86] Renaudeau, D., & Dourmad, J. (2022). Review: Future consequences of climate change for European Union pig production. https://doi.org/10.1016/j.animal.2021.100372
Annex 9 [87] Tiwari et al. (2022). Climate Change Influences the Spread of African Swine Fever Virus. https://www.mdpi.com/2306-7381/9/11/606
[88]Froldi et al. (2023). Sustainable Transition of Meat and Cured Meat Supply Chain. https://doi.org/10.1007/978-3-031-34977-5_3
[89] Tallaksen, J. (2022). 189 Swine Production and Greenhouse Gases. https://doi.org/10.1093/jas/skac064.150
Annex 10 [90] Sánchez-Martín et al. (2023). Cost Model for Biogas and Biomethane Production in Anaerobic Digestion and Upgrading. Case Study: Castile and Leon. https://www.mdpi.com/1996-1944/16/1/359
Annex 11 [91] Llonch et al. (2024). Effects of climate change on pig welfare. https://doi.org/10.1016/B978-0-323-85676-8.00024-9
[92] Mottet et al. (2017). Climate change mitigation and productivity gains in livestock supply chains: insights from regional case studies. https://doi.org/10.1007/s10113-016-0986-3

- Smallholders were badly impacted by the African Swine Fever outbreak, found it difficult to repay loans, and the majority of backyard farms had to close due to biosecurity regulations[93]
- Insufficient disease control program
- Government policy promoting meat imports hinders local producers' growth; excess pork imports
- Few modernized post-production facilities
- Port congestion; high costs associated with swine logistics (inter-island transport); ineffective marketing system for small-scale producers

Current opportunities

- Substantial supply of readily available feed energy sources internationally
- Possible collaboration between regional farmers and meat processors
- Expanding domestic market
- Increasing demand for value-adding goods (producers can sell directly to consumers by processing food)
- High per-capita pork consumption

Policies and Programs

Policies

- The current government policies and programs for swine now target enhancing farm productivity, reduce input costs, modernize post-production and marketing systems, improve small hold farmers' access to information, adopt food safety regulations, and improve animal health.
- Local government units and agencies must adhere to DA Administrative Circular No. 12 to establish a National Zoning and Movement Plan for the prevention and control of African Swine Fever.

Support Programs[94]

- The Bureau of Animal Industry implements several programs to increase livestock production and productivity in the Philippines.
- Private-Public Partnerships are aimed at increasing productivity and efficiency in the Philippine swine industry through the application of animal genomics.
- Regular conduct of disease surveillance, livestock monitoring, and strict border control measures.
- Provision of access to technology, resources, support services, and infrastructure to increase livestock farmers' income.

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[93] Cooper et al. (2022). Beyond Numbers: Determining the Socioeconomic and Livelihood Impacts of African Swine Fever and Its Control in the Philippines. 10.3389/fvets.2021.734236

[94] https://ispweb.pcaarrd.dost.gov.ph/isp-commodities/swine/

R&D Opportunities

1. Further research is required to explore on other feed resources, such as cassava and malunggay to decrease production expenses while preserving animal nutrients, as multiple institutions have already conducted studies on these alternative options.

2. Initiatives focused on enhancing farm productivity and efficiency.

3. Improve native breeds of feed reproductive and production ability.

4. Collaborative research and programs to advance the development of secure and effective vaccines, which should also include post-vaccination surveillance[95] .

Conclusion

The Philippine swine industry plays a substantial role in the agriculture sector, representing 14.47% of the country's total value of production between 2000 and 2020. The industry is categorized into input, farm, and processing sectors, where backyard and commercial farms are the prevailing types. As of September 30, 2023, the CALABARZON Region boasts the highest swine population, totaling 1.35 million individuals. Pork, which refers to the meat of pigs, is available for purchase in markets either as live animals or as processed meat. It serves the purpose of being used as breeders or finished products for meat consumption.

Nevertheless, the Philippines has experienced a decline of 4.91% in per capita pork consumption since 2019, mainly attributed to the impact of the COVID-19 pandemic, decreased household expenditure, and logistical constraints.

Climate change has significant environmental impacts on the swine industry, including high temperatures, increased heat stress, and increased disease susceptibility. The ASF virus is spreading due to climate change, and the swine farming system generates greenhouse gases, ammonia, and volatile substances. Adaptations to climate change include minimizing emissions, using anaerobic digestion processes, reducing heat stress, and improving livestock management.

Current challenges include high production costs, high input costs, and the entry of smuggled pork. Opportunities include a substantial supply of feed energy sources internationally, collaboration between regional farmers and meat processors, expanding domestic markets, increasing demand for value-adding goods, and high per-capita pork consumption. Addressing these challenges is crucial for the sustainability of the swine industry.

The Philippine swine industry faces challenges such as high production costs, high input costs, and the entry of smuggled pork. Several government policies and programs are taking place to enhance farm productivity, reduce input costs, modernize post-production and marketing systems, and improve animal health. Further research is needed to explore alternative feed resources, improve native breeds, and advance vaccine development.

[95] https://asean.org/wp-content/uploads/2023/10/3.-ASEAN-African-Swine-Fever-Prevention-and-Control-Strategy.pdf

13. Tilapia

Introduction[96]

The tilapia is the second most important farmed fish in the Philippines next to milkfish *(Chanos chanos)*. It is often referred to as the "Aquatic Chicken" due to its rapid growth and adaptability, is a vital component of the Philippines' aquaculture sector. It is a major source of affordable protein for the Filipino population and supports the livelihoods of many small-scale fish farmers.

General data

Types of tilapia grown: The first tilapia introduced to the Philippines was the Mozambique tilapia (Oreochromis mossambicus) imported from Thailand in 1950 followed by Nile tilapia (O. niloticus) in 1972, which is currently is the main species of tilapia farmed in the Philippines and throughout tropical Asia and the Pacific, and other species (*O. aureus, O. hornorum, Coptodon zillii,* and *Sarotherodon melanotheron*)[96].

Botanical description: Tilapias belong to the family Cichlidae. Nile Tilapia belongs to the genus *Oreochromis*[96].

Production data

- Volume: The Philippines is one of the top producers of tilapia, with an annual production of approximately 300,000 metric tons[97].
- Major Producing Areas: Key tilapia farming regions include Central Luzon, Southern Tagalog, and Western Visayas.
- Species: The Nile Tilapia *(Oreochromis niloticus)* is the most widely farmed species due to its fast growth rate and adaptability to different environments.

[96] Bureau of Fisheries and Aquatic Resources. 2022. The Philippine Tilapia Industry Roadmap (2022-2025). Department of Agriculture, Diliman, Quezon City, Philippines. ISSN : 2945-4395

[97] Inland Municipal Fisheries: Volume of Production by Geolocation, Species, Year and Quarter https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__FS/0052E4GVIP0.px/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313

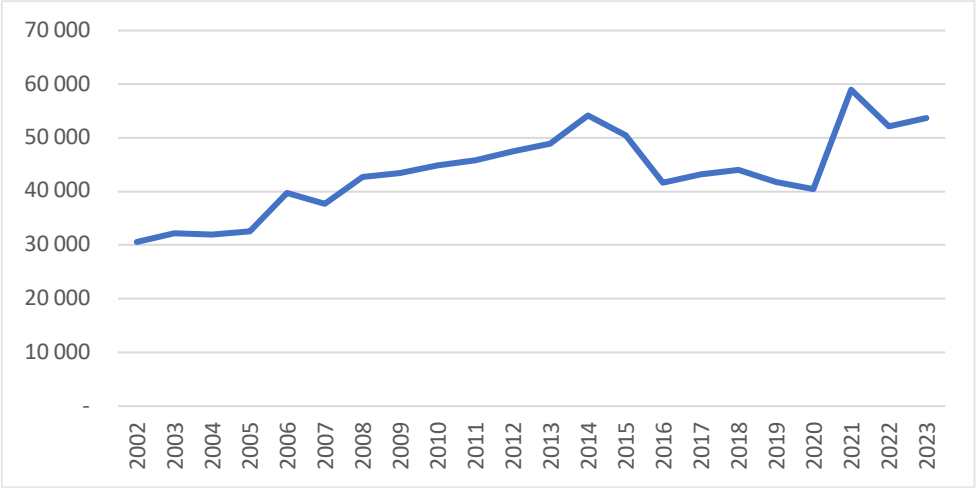


Figure 87: Tilapia annual production in metric tons, 2002-2023 (Source: PSA).

Consumption data

- Domestic Use: Tilapia is a staple in the Filipino diet, commonly consumed fresh, dried, or processed. It is a popular choice in markets and is featured in numerous local dishes.
- Product forms: Tilapia products in the Philippines comes in varied forms. It can be categorized into four major forms: (1) whole fish, (2) fillet, (3) pulp/minced parts, and (4) skin[96].
- Per capita consumption: In 2019, the average annual per capita consumption of tilapia of Filipinos is 2.9kg[96].

Export data

- The industry has been able to export tilapia with a total volume of 8,165 MT from 2005-2019. The highest volume of tilapia exported was in 2013 (5,319 MT). However, in 2005-2006, 2010-2011, and 2019, Philippines was not able to export tilapia[96].

Import data

- Tilapia importation was relatively low. The total volume of tilapia imported in the country from 2005-2019 was 813 MT. In 2019, a total of 62 MT of tilapia was imported into the country[96].

Prices[96]

- In 2019, the prevailing wholesale price of tilapia was PHP 80.60 while PHP 109.00 for the retail price.
- In terms of regional price variability, tilapia is cheaper in Luzon with the prevailing farm gate price of tilapia ranging from PHP 60 to 90.00/kg while in Visayas and Mindanao, price ranges from PHP 80 to 120.00/kg.

Socio-Economic Aspects

- Employment: Tilapia farming provides employment to thousands of Filipinos, particularly in rural areas. It supports both direct employment (farmers, workers) and indirect employment (feed suppliers, processors).

- Income: Tilapia farming is a significant source of income for many smallholder farmers, although profitability can be affected by market prices, production costs, and environmental factors.
- Community Impact: Tilapia farming contributes to rural development and food security, providing an affordable protein source and supporting local economies.

Environmental Aspects and Climate Change

- Water Use: Intensive tilapia farming requires significant water resources, often leading to competition with other water uses.
- Nutrient Pollution: Runoff from tilapia farms can contribute to nutrient pollution in water bodies, potentially causing algal blooms and other environmental issues.
- Habitat Alteration: The conversion of natural habitats to fish farms can impact local ecosystems and biodiversity.

Impacts of Climate Change:

- High Water Temperature: temperature higher than 32°C particularly in freshwater and brackish water ponds affects the growth rates, reproduction, and survival of tilapia[98].
- Extreme Weather Events: Increased frequency of typhoons, floods, and droughts can damage fish farms and disrupt production cycles.
- Water Quality: Climate change can alter water quality, impacting tilapia health and increasing susceptibility to diseases.
- Sea Level Rise: Coastal tilapia farms may be threatened by sea level rise and increased salinity in freshwater systems.

Adaptation to Climate Change:

- Diversification: Encouraging diversification of aquaculture species and farming practices to enhance resilience.
- Infrastructure Improvement: Strengthening infrastructure to withstand extreme weather events, such as typhoon-resistant enclosures and better drainage systems.
- Integrated Farming Systems: Promoting integrated farming systems that combine tilapia with other crops or livestock to optimize resource use and increase farm resilience.
- Early Warning Systems: Implementing early warning systems for extreme weather events to help farmers prepare and respond effectively.

Challenges and Opportunities

Current challenges

- High cost of production[98]

[98] Guerrero III, RD. 2019. Farmed Tilapia Production in the Philippines Is Declining: What Has Happened and What Can Be Done. Philippine Journal of Science 148 (2). ISSN 0031 – 7683.

- Volatility of farm gate price
- Weak mechanism for product traceability
- Numerous marketing layers
- Weak credit access
- Erratic climatic and weather conditions and the occurrence of natural calamities
- Poor breed of tilapia[98]
- Emergence of bacteria and diseases with zoonotic potential. The current bacterial tilapia diseases of significance (related to fish-welfare, economy, and society) are streptococcosis, aeromonasis, francisellosis, columnaris disease and vibriosis[99].

Opportunities

- Availability of local agri-by-products/agricultural wastes as potential raw materials for feeds and supplemental feeding
- Adoption of green water technology in the production of tilapia
- Increase of export demand in international market
- Increasing interest in tilapia production, processing, and marketing.

Policies and Programs

The Philippine Tilapia Industry Roadmap envisions a globally competitive and sustainable tilapia industry that is private sector led and market oriented, with strong government support that will improve the quality of life of Filipinos. This shall be achieved by meeting the following targets:

- Increase tilapia production through broodstock improvement, fingerling distribution and production, modernization of hatcheries, diversification, and technology dissemination.
- Ensure quality and traceability of inputs and outputs by implementing Good Aquaculture Practices.
- Promote use of environmentally friendly tilapia feeds and reduce cost of feed production by utilizing locally sourced raw materials.
- Improve postharvest practices through introduction of proper fish handling techniques and appropriate postharvest technologies.

[99] Haenen OLM, Dong HT, Hoai TD, Crumlish M, Karunasagar I, Barkham T, Chen SL, Zadoks R, Kiermeier A, Wang B, Gamarro EG, Takeuchi M, Azmai MNA, Fouz B, Pakingking R, Wei ZW, Bondad-Reantaso MG. 2023. Bacterial diseases of tilapia, their zoonotic potential and risk of antimicrobial resistance. Reviews in Aquaculture, 15(Suppl. 1) : 154-185. doi:10.1111/raq.12743

- Improve and/or develop a more efficient marketing system for the tilapia industry through the establishment of market information system, facilitate tilapia marketing, strengthening market networking and registration of traders.

R&D Opportunities

1. Climate-Resilient Strains: Development of tilapia strains that can tolerate a wider range of temperatures and salinities.

2. Sustainable Feed: Research into alternative and sustainable feed sources to reduce reliance on fishmeal and fish oil.

3. Disease Management: Enhanced understanding and control of diseases affecting tilapia, particularly those exacerbated by climate change.

4. Water Management: Improved water management practices to ensure efficient use and reduce environmental impact.

Conclusion

The tilapia is considered one of the most important farmed fish in the Philippines and a vital component of the Philippines' aquaculture sector. Similarly, it is regarded as a major source of affordable protein for the Filipino population and supports the livelihoods of many small-scale fish farmers.

With its massive contribution to Philippine economy and community welfare, addressing its current and future challenges is critical. Several of the research and development areas that need attention are identified in the following sentences. One, R&D programs focusing on breeding to develop high-yield, disease-resistant, and climate-resilient tilapia strains through advanced genetic research can help in addressing the problem of poor breed tilapia. Second, research on sustainable aquaculture practices is a must to minimize environmental impacts. Third, development of cost-effective and sustainable alternative feeds to lower its high production cost. Fourth, enhancement of disease monitoring and management strategies to ensure fish health and productivity. Fifth, investment in technologies and practices that help tilapia farmers adapt to the impacts of climate change. And lastly, strengthen extension services to capacitate tilapia farmers with the knowledge and tools needed to adopt new technologies and practices and improve their resilience to climate change.

By addressing these research and development priorities, the Philippines can bolster the sustainability and resilience of its tilapia industry, ensuring continued economic benefits and food security for future generations.

14.Tuna

Introduction

Tuna is one of the most valuable fishery resources in the Philippines, contributing significantly to the economy and food security. The country is one of the world's top producers and exporters of tuna, with various species such as yellowfin, skipjack, and bigeye being the most caught. Six species out of 21 species of tuna found in Philippine waters are used for commercial quantity namely: the yellowfin, skipjack, eastern little, frigate, big eye, and bullet. (Llanto et.al., 2018)

General data

Production

Volume

According to BFAR, tuna production in 2022 accounted for 10.25% of the country's fisheries production with more than 107,000 metric tons exported. The Philippines has also been a major producer of tuna since the 1970s. Back in 2003, the country ranked fourth in the world in the production of tuna and tuna-like species while in the Central Pacific Region, it ranked close to Indonesia in tuna production, accounting for 22% of the total catch in the region. (Barut and Garvilles ,2012)

Year	Commercial			Municipal			TOTAL
	Skipjack	Yellowfin	Bigeye	Skipjack	Yellowfin	Bigeye	
2018	229,349	59,913	21,932	29,026	32,524	9,202	**383,947**
2019	238,793	63,914	6,297	27,582	35,437	11,460	**383,483**
2020	234,521	62,649	6,005	26,083	32,240	13,929	**375,427**
2021	218,744	40,298	5,189	24,393	33,835	12,124	**334,580**
2022	219,505	49,358	8,717	37,333	35,397	10,322	**360,632**

Note: The annual tuna catch estimates for 2018-2022 includes all the tuna catch unloaded in Philippine ports regardless where they were caught and does not separate those catches from foreign waters or caught by foreign-flagged vessel which may account for around 150,928MT for 2022.

Figure 88: Total tuna catch per species, 2016-2022 (Source: PSA, 2022).

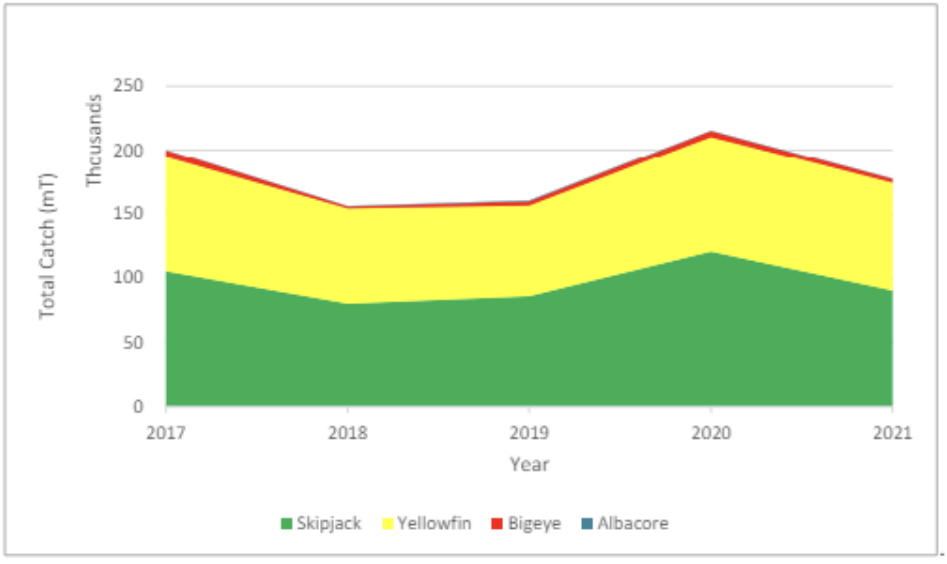


Figure 89: Historical annual catch per species.

Regions

Major tuna-producing areas include General Santos City (dubbed the "Tuna Capital of the Philippines"), Mindoro, and Palawan. Tuna can be caught throughout the Philippine waters with the major sources found in the Moro Gulf/Celebes Sea and the South China.

Methods

Tuna is caught in domestic and international fishing grounds using ring nets, purse seines, hand lines, and long lines by commercial fishing vessels categorized as small-scale or fishing vessels of 3.1 gross tonnes (GT) up to 20 GT in weight, medium-scale or fishing vessels of 20.1 GT up to 150 GT in weight, and large scale or fishing vessels of more than 150 GT in weight.

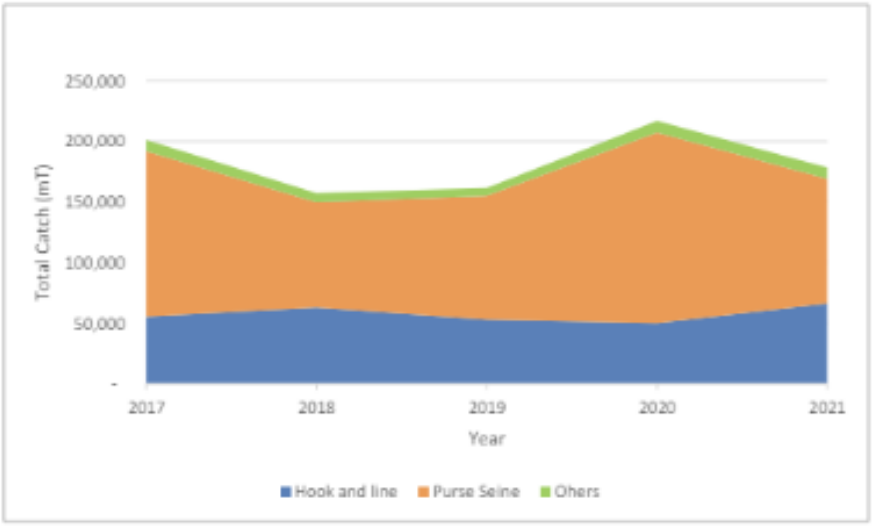


Figure 90: Historical annual catch by gear.

GEAR / SPECIES	SKJ	YFT	BET	ALB	TOTAL
Purse seine*	70,374	18,244	1,361	-	89,979
Hook-and-line*	12,015	34,289	1,434	105	47,843
Others	6,825	2,554	218	68	9,665
TOTAL	**89,215**	**55,086**	**3,014**	**173**	**147,488**

*Purse seine includes ringnet catches and Hook and line includes handline catches

Table 24: Tuna catch estimates by gear and species with the 2022 PSA total tuna catch estimates (in MT) (Source: 16th Philippines WCPFC Annual Tuna Catch Estimates Review Workshop Report, n.d.).

Year/ Species	Hook-and-Line[2]	Purse Seine[3]	Others	Total
2017				
Skipjack	13,780	89,162	4,878	104,820
Yellowfin	38,823	46,657	4,187	89,667
Bigeye	1,800	3,221	335	5,356
Albacore	114	19	90	223
Total	54,517	136,059	9,490	200,066
2018				
Skipjack	14,575	61,110	4,111	79,796
Yellowfin	45,941	25,083	3,123	74,147
Bigeye	987	307	201	1,49
Albacore	212	3	23	238
Total	61,715	86,503	7,458	155,676
2019				
Skipjack	12,236	69,226	4,230	85,692
Yellowfin	37,018	31,450	2,164	70,632
Bigeye	1,908	1,109	57	3,074
Albacore	645	13	27	685
Total	51,807	101,798	6,478	160,083
2020				
Skipjack	9,753	103,992	6,724	120,469
Yellowfin	37,391	50,050	2,581	90,022
Bigeye	1,576	2,767	137	4,480
Albacore	326	13	20	359
Total	49,046	156,822	9,462	215,330
2021				
Skipjack	14,387	70,400	5,499	90,286
Yellowfin	49,444	31,045	3,310	83,799
Bigeye	1,133	1,397	123	2,653
Albacore	306	7	27	340
Total	65,270	102,849	9,000	177,078

Table 25: Estimated catch of oceanic tuna species, by gear type, for 2017-2021 in Western and Central Pacific Oceans (in MT).

Consumption

Domestic Market

Tuna is widely consumed locally, both fresh and processed into products like canned tuna, which is a staple in Filipino households. The tuna constitutes 37.91% (153,110 MT valued at PHP 8.44 B (USD 186.051M) of the total fisher import volume of 403,840 MT valued at PHP 18, 79 B (USD 414.154 M). It is mostly in the form of fresh/chilled/frozen varieties used as raw materials for canning, which came from Indonesia, Taiwan, and Papua New Guinea.

Fish Product	Consumption per Capita (kilogramme/year)
Tuna	4.35
Tilapia	3.06
Milkfish	2.62
Round scad	1.71
Shrimp and prawn	0.53
Crab	0.36
Oyster	0.23
Mussel	0.19

Source: Philippine Statistics Authority (2015)..

Table 26: Per capita fish consumption, 2014.

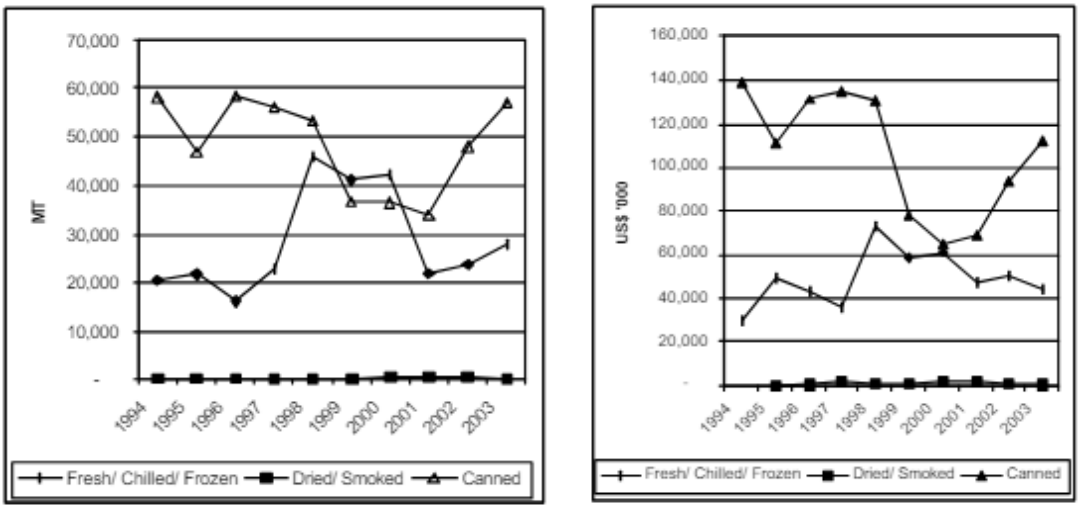
Export Market

The Philippines exports a significant portion of its tuna catch, particularly canned and frozen tuna, to markets such as the United States, Japan, and the European Union. Tuna exports can be classified into three forms: fresh/chilled/ frozen, dried/smoked, and canned. With canned tuna being the top export. Tuna has dominated the Philippine fishery exports since 2004 and is likely to continue in subsequent years. In 2015, tuna exports accounted for 42% of the total fisher exports of the country with a total of 226,281 tons valued at PHP 13.4 billion (USD 293.009 million) with Japan, USA, and Italy for fresh/chilled/frozen varieties and USA, Canada and Japan for the preserved varieties.

Tuna commodity, by volume (MT)	2018	2019	2020	2021	2022
Fresh/chilled/frozen	32,938	30,150	43,102	9,941	35,202
Dried/smoked	5,274	2,620	3,420	1,776	0
Canned	152,780	87,185	88,547	83,035	72,599
TOTAL VALUE (million USD)	492.53	477.72	489.03	384,694	401.187

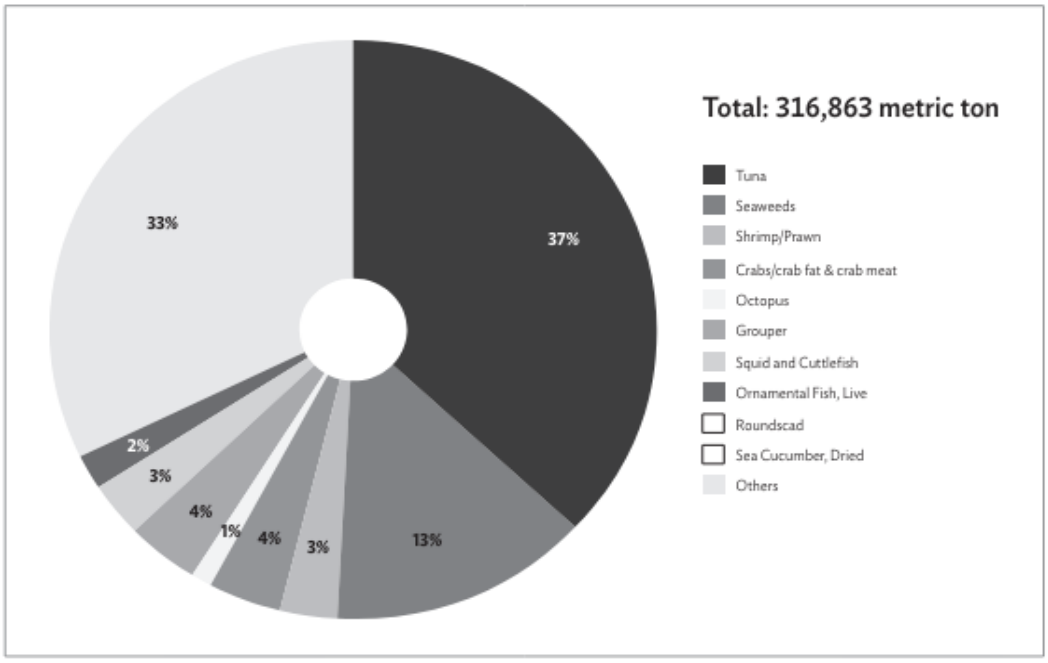
** 2022 provisional data*

Table 27: Major Fishery Export Products (MT), 2018-2022, (Source: PSA Fisheries Statistics for 2018-2022).



Source: BAS

Figure 91: Tuna Exports (a) volume in tons and (b) value in US$, 1994-2003.



Sources: Philippine Statistics Authority; Bureau of Fisheries and Aquatic Resources, n.d.

Figure 92: Major fishery export products (MT), 2014.

Socio-Economic Aspects

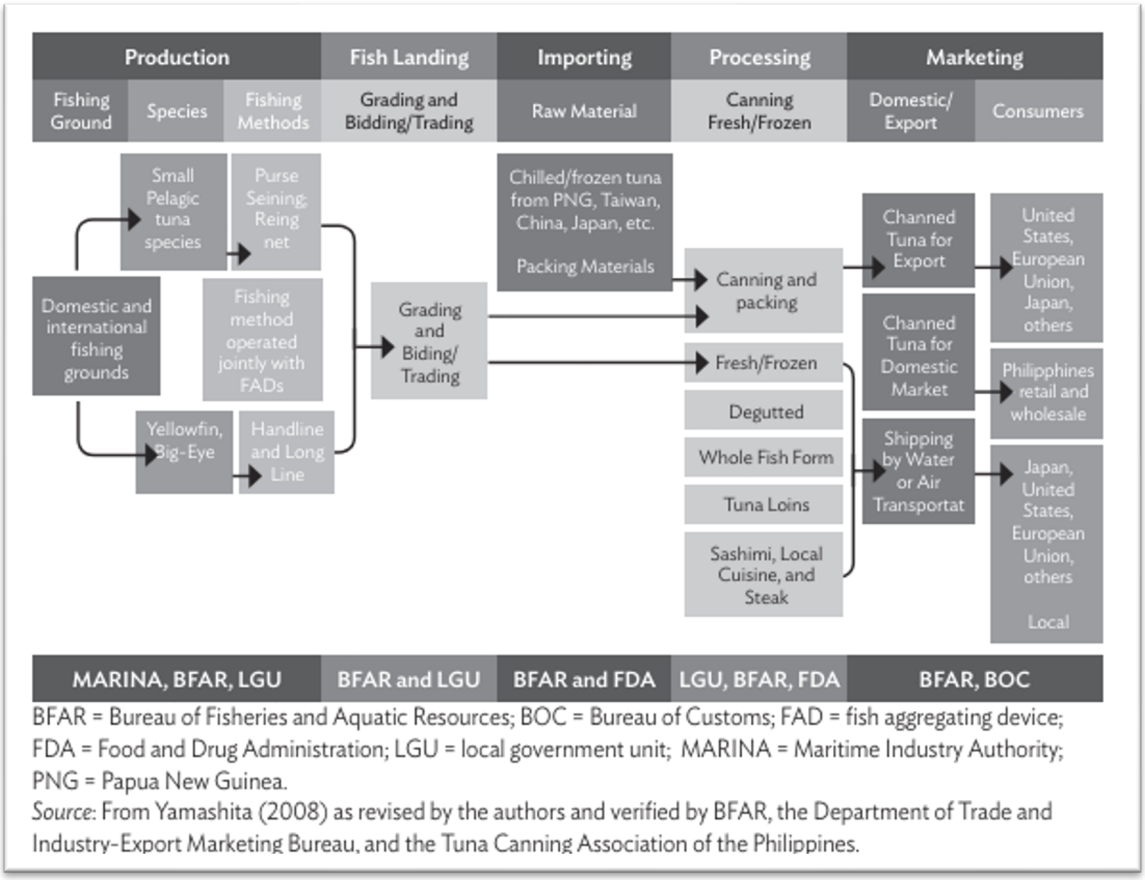
- Employment: The tuna industry employs around 120,000 Filipinos, including fishers, processors, and those in ancillary industries. There are more than 17 frozen tuna processors in the Philippines, 70% of which are in General Santos City and supports about 3,000 jobs. Close to 8,000 people are working in the tuna-canning industry of General Santos and it is noted as the biggest private-sector employer in the city. Most cannery workers are hired by canning firms through co-operatives like Maverick Employees Co-operative (MAVEMCO). The terms of employment are based on contracts that are continuously renewed based on performance and the labor needs of the canning corporations (BFAR, 2018).

- Income: Tuna fishing is a critical source of income for coastal communities and contributes significantly to the national economy. Approximately 90% of the national tuna production is in Mindanao which has an annual direct revenue of $400 million.

- Rural Development: The industry supports rural development by creating jobs, enhancing local economies, and providing infrastructure improvements.

Value Chain

The tuna value chain and regulatory agencies involved along the chain are shown in Figure 94. The tuna value chain has five main activities from production, fish landing (unloading), exporting, processing and marketing. Key players along the value chain include the fishers (and their financiers), fish graders and traders, brokers and exporters, canning corporations and processors, and local and international market players.



BFAR = Bureau of Fisheries and Aquatic Resources; BOC = Bureau of Customs; FAD = fish aggregating device; FDA = Food and Drug Administration; LGU = local government unit; MARINA = Maritime Industry Authority; PNG = Papua New Guinea.
Source: From Yamashita (2008) as revised by the authors and verified by BFAR, the Department of Trade and Industry-Export Marketing Bureau, and the Tuna Canning Association of the Philippines.

Figure 93: Tuna value chain and regulatory agencies.

Environmental Aspects and Climate Change

- Overfishing: Intensive fishing practices have led to concerns about overfishing and depletion of tuna stocks usually by illegally encroaching into municipal waters and the widespread use of destructive fishing practices (cyanide fishing, dynamite fishing) (Hipolito & Vera, 2006).

- Bycatch : Tuna fishing often results in bycatch, including non-target species such as mackerel scad (*Decapterus macarellus),* various species of billfishes, and other species such as dolphin fish (*Coryphaena hippurus*), wahoo, opah, rainbow runner (*Elagatis bipinnulatus*), triggerfish, shark species, and juvenile oceanic tunas (BFAR, 2018).

- Habitat Degradation: Fishing practices, particularly those involving large nets and destructive fishing techniques such as dynamite fishing lead to habitat destruction such as coral reefs.

- Carbon Footprint: The tuna industry contributes to greenhouse gas emissions through fuel use in fishing vessels and processing plants. The byproducts from industries that process tuna into export products contribute to water pollution around the area (Hipolito & Vera, 2006).

Challenges and Opportunities

- Climate Change: Changes in sea temperature, ocean acidification, and altered marine currents due to climate change impact tuna migration patterns and spawning grounds.

- Regulatory Compliance: Meeting international standards and regulations for sustainable fishing practices is challenging for local fishers. The need for proper management of tuna fisheries and adequate implementation and surveillance capacities are necessary to avoid Illegal Unreported Unregulated (IUU) fishing, which includes poaching by foreign vessels, poaching by Philippine vessels in neighboring countries, unauthorized commercial fishing in municipal waters, the use of unregistered/unlicensed/undocumented fishing boats.

- Market Competition : Competition from other tuna-producing countries affects the profitability of the Philippine tuna industry.

Policies and Programs

The policies related to tuna conservation and management are outlined in the table below.

Area of concern	Related regulations / policies
1. Registration and licensing policy	a. FAO 198-1 s. 2018 : Amended rules and regulations on commercial fishing in Philippine waters and distant fishing b. BAC No. 153 s. 2018 : Moratorium on the issuance of commercial fishing vessel and gear license and other clearances c. FAO 254 s. 2014 and FAO 254-1 s. 2018 : Regulation and implementing guidelines on group handline fishing operation in the high seas of the WCPFC Convention area d. FAO 245 s. 2012 and FAO 245-1 s. 2018 : Regulations and implementing guideline on group tuna purse seine operations in High Seas Pocket No. 1 as a special management area e. FAO 246-1 s. 2018 : Moratorium on the issuance of commercial fishing vessel license f.
2. Limitations on fishing operations	a. FAO 226 s. 2015 : Regulation on the mesh size of tuna purse seine net and trading of small tuna b. FAO 245 s. 2012 : Regulation and implementing guidelines on group tuna purse sine operations in High Seas Pocket No. 1 as a special management area c. FAO 236 s. 2012 : Rules and regulations on the operations of purse seine and ring net vessels using fish aggregating devices during the FAD closure period as compatible measures to WCPFC CMM d. FAO 236-5 s. 2018 : Extension of 236-4 on the Rules and regulations on the operations of purse seine and ring net vessels using fish aggregating devices during the FAD closure period as compatible measures to WCPFC CMM 2017-01 e. Fao 244 s. 2012 : National tuna fish aggregating device management policy f. FAO 258 s. 2018 : Establishment of tuna conservation and management zones in Mindanao/Celebes Sea
3. Data collection policy	a. NSAP-expanded data collection for tuna in collaboration with WPEA project b. Catch logsheet requirements for all vessels c. Stowage plans for carrier vessel d. PFDA landing reports e. Observer reports
4. Total allowable catches for commercial fishing vessels, etc.	a. BAC 253 s. 2014 : Moratorium on the issuance of commercial fishing vessel and gear license and other clearances b. Ongoing process for the establishment of fisheries management areas and respective reference points and harvest control rules
5. Monitoring control and surveillance and IUUF	a. Traceability : BAC 251, s. 2014 – Traceability system for fish and fishery products; implementation of electronic catch documentation and traceability system b. Catch certification : FAO 238 s. 2012 – Rules and regulation governing the implementation of Council Regulation EC No. 1005/2008 on the Catch Certification Scheme c. Inspections : FAO 227 s. 2008 – Rules and regulations governing the export of fish and aquativ products to European Union member countries ; FAO 228 s. 2008 – Rules governing the organization and implementation of official controls on fishery and aquatic products intended for export to the EU market for human consumption ; National plan of Control and Inspection d. Enforcement : SO 486 s. 2011 and FOO 241 s. 2011 – Creating the BFAR Fishery Resources Protection and Law Enforcement Section/Quick Response Team ; Aquisition of vessels ; Regularization of 778 Fishery Regulatory Officers ; Training of 343 Law Enforcement Officers e. Adjudication : Establishment of Adjudication Committees effective 2018 ; Hiring of hearing officers and legal assitants ; Investigation and resolution of cases ; Fines and penalties collected f. Training and awareness-raising measures : National capacity-building program for fishery law enforcers, traiing for fish examiners, seafood safety training, fisheries observers training ; bantay dagat ; Operation and maintenance of MCS vessels g. PHILO Project Phase 1 and 2 – Integrated Marine Environment Monitoring System

Table 28: Current policies on tuna fisheries.

Improved Management

Strengthening fisheries management and enforcement to prevent overfishing and ensure sustainable practices. The Philippines has been under the following pieces of legislation: The Philippine Fisheries Code or RA no. 8550 as amended by RA no. 10654 which gives the general framework for managing the country's fisheries sector and assigned the BFAR as the main government agency responsible for conservation and management of fishery resources beyond municipal waters, The Local Government Code of 1991 gives the LGUs the jurisdiction and responsibility to manage fisheries within their jurisdiction which is within 15 km from the shoreline. This also grants them preferential use of municipal waters to fisherfolks residing in the same municipality. Lastly, the Agriculture and Fisheries Modernization Act of 1997 which modernizes the fisheries sector.

Along with these policies are the establishment of Tuna Regional Fisheries Management Organizations (RFMOs), such as the Inter-American Tropical Tuna Commission (IATTC), established in 1950, which is responsible for the conservation and management of tuna and other marine resources in the eastern Pacific Ocean. In the 70s, the Expert Committee on Skipjack Tuna and Skipjack Tagging Program are established by the South Pacific Commission as its initiatives spurred interest among US and Asian countries to access tuna resources in the Pacific. While in 1976, the US government established the Pacific Tuna Development Foundation (PTDF) which expands US purse seine operations in the western and central Pacific.In the late 1970s, the South Pacific Forum established the Forum Fisheries Agency (FFA) to help members from Pacific Island benefit from the tuna resources in their water. (BFAR, 2018)

Marine Protected Areas: Establishing and effectively managing marine protected areas to conserve tuna habitats and spawning grounds.

Capacity Building: Training fishers in sustainable fishing practices and compliance with international regulations. Continuous capacity building is vital in improving the socio-economic status of tuna stakeholders which includes proper handling of tuna products to improve market price.

Diversification: Encouraging diversification of income sources for fishing communities to reduce dependency on tuna.

R&D Opportunities

1. Sustainable Fishing Practices: Research into and promotion of sustainable fishing methods that minimize bycatch and habitat damage.

2. Stock Assessment: Enhanced scientific research to accurately assess tuna stock levels and inform management decisions. There are ten tuna species caught in the Philippines, classified as either oceanic or neritic. Stock assessments conducted in 2016 and 2017 show that there are no species of tuna that are overfished.

3. Climate Impact Studies: Research on the impact of climate change on tuna populations and migration patterns.

4. Sustainable Fishing Technologies: Developing and promoting fishing technologies that reduce bycatch and environmental impact.

5. Stock Monitoring and Assessment: Investing in scientific research and monitoring to provide accurate data on tuna stock levels and health .

6. Climate Change Adaptation: Researching and implementing strategies to mitigate the impact of climate change on tuna fisheries.

7. Market Access and Development: Enhancing market access through improved trade policies, certifications for sustainable fishing, and value-added product development

8. Extension Services : Strengthening extension services to disseminate research findings and best practices to fishers and industry stakeholders.

9. Infrastructure Improvement: Improving infrastructure for fish landing, processing, and storage to maintain product quality and reduce post-harvest losses.

10. Community Engagement and Education: Engaging fishing communities in conservation efforts and educating them about sustainable practices and climate adaptation.

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Hipolito, Z., & Vera, C. A. (2006). The Philippines tuna industry: a profile.

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15. Seaweed

Introduction

In the Philippines, seaweeds are one of the most economically important fishery products which comprise 60-70 percent of the total aquaculture production. It consistently ranks as one of the top three exports of the fisheries sector[100].

General data

Types of seaweed grown: The Philippines is endowed with 1,065 seaweed species[101]. However, production is mainly *Eucheuma* and *Kappahycus*. The cultivation of the carrageenan-bearing seaweed *Eucheuma* was pioneered in the Philippines leading to its dominance in commercial seaweed production and recognition as the top seaweed producer in the international market[100].

Botanical description: Seaweeds are marine algae grown in the sea or cultured in ponds that are categorized based on their pigmentation: red algae *(Rhodophyceae)*, brown algae *(Phaeophyceae)*, and green algae *(Chlorophyceae)*[100].

Production data

- In 2016, there were approximately 102,000 ha of productive seaweed farms in the Philippines with an estimated 400,000 individual farmers which means that on average each farmer has a one-fourth hectare of seaweed farm[102].

- Production volume: Philippine annual seaweed production amounted to around 1.6 million tons in 2023[103].

- On average, the usual one-fourth hectare using monoline stakes seaweed farm produces 9,000 kilograms of fresh seaweeds per cropping or equivalently 36,000 kilograms for a one-hectare farm[103].

- Main producing regions: The main producing regions are the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), MIMAROPA (Mindoro, Marinduque, Romblon, Palawan), and the Zamboanga Peninsula[103].

[100] Bureau of Fisheries and Aquatic Resources. 2022. The Philippine Seaweed Industry Roadmap (2022-2026). Department of Agriculture, Diliman, Quezon City, Philippines. ISSN : 2945-4417

[101] Lastimoso and Santianez 2021. Updated Checklist of Benthic Marine Macroalgae of the Philippines. Philippine Journal of Science 150 : 29-92

[102] Philippine Rural Development Project (PRDP). 2018. National Value Chain Analysis for Seaweeds.

[103] Philippines Statistics Authority (PSA). Aquaculture: Volume of Production by Species, Geolocation, Year and Quarter, 2010-2023. https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/DB__2E__FS/0092E4GVAP1.px/?rxid=bdf9d8da-96f1-4100-ae09-18cb3eaeb313t

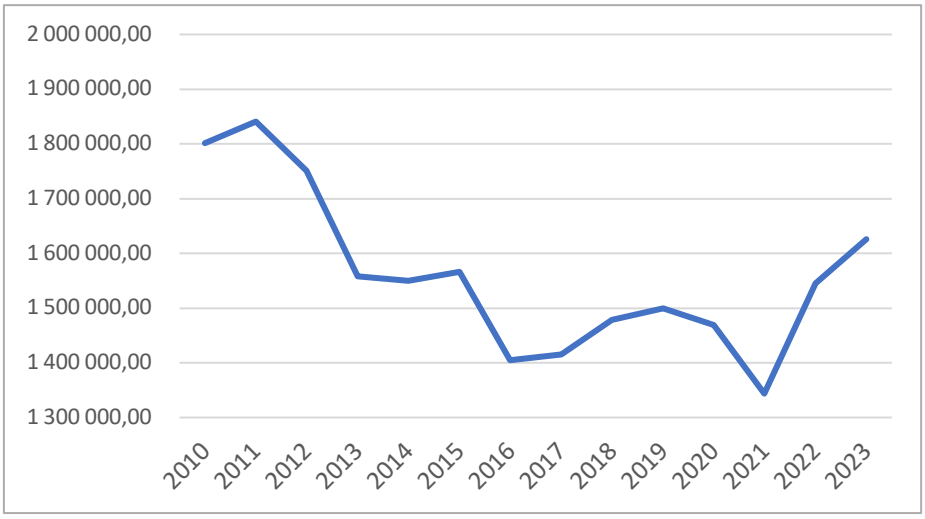

Figure 94: Seaweed annual production in metric tons, 2010-2023 (Source: PSA).

Consumption data

- Consumption of seaweed globally has displayed a substantial gain over the years with a consistent increase from 1990 to 2018 registering a total of 32.9 million metric tons (mt) in 2018 from 5.05 million mt in 1990[104].

- Specifically, in 2013, global seaweed consumed as food was registered at 14.3 million mt while seaweed utilized for other commercial uses such as in cosmetics and pharmacy as well as for fertilizer and animal feeds tallied 8.9 million mt and 312,000 mt, respectively[104].

- In the Philippines, seaweed is marketed in food and industrial forms. Food forms are sold as Raw Fresh Seaweeds (RFS), seaweed chips, and seaweed noodles, whereas industrial forms are usually Raw Dried Seaweeds (RDS) and Carrageenan, either semi-refined (SRC) or refined (RC).

Export data[105]

- Export volume: The Philippines is one of the world's largest seaweed exporters, with an export volume of around 13.5k tons ($45.7m) in 2022.

- Main destination countries: The main destination countries for Philippine seaweed are China, the United States of America, France, Spain, and Germany.

- Recent trends: From 2017-2022, Germany is the fastest growing exporter (+398%) while Brazil is the fastest declining (-32%) (see figure below).

[104] FAO-Fisheries and Aquaculture Department (FAO FishStat). (2021). Retrieved from http://www.fao.org/fishery/statistics/en.

[105] Chatham House, The Royal Institute of International Affairs. (2020). Resource Trade. Earth. https://resourcetrade.earth

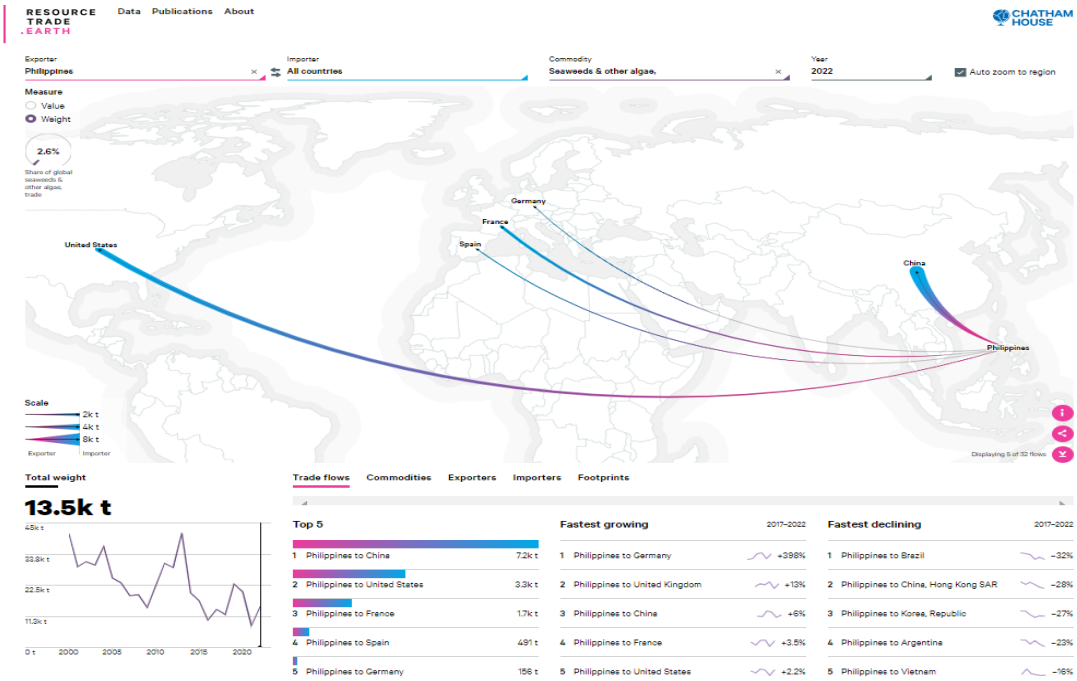

Figure 95: Seaweed export from the Philippines (Source: https://resourcetrade.earth).

Import data[105]

- Imported volume: The Philippines imports 773 tons ($5.8m) in 2022.
- Main supplier countries: The main supplier countries of imported seaweeds in the Philippines are Indonesia and Korea.
- Recent trends: From 2017-2022, Korea is the fastest growing importer (+40%) while Thailand is the fastest declining (-44%).

Prices

- The dynamics in the international prices of seaweed affect the domestic seaweed market with a price of 7.36 per kilogram in 2023.
- Edible raw seaweeds cost $1,664 whereas non-edible raw seaweed was priced at $2,162 in 2019. Carrageenan prices also showed growth in the past years amounting to $7,488 in the same year.

Socio-Economic Aspects

- Seaweed farming is usually small-scale, averaging 0.25 ha of seaweed farm per farmer.
- Seaweed production in the Philippines is characterized as a family enterprise with specific roles and contributions from each member of the household.
- The sector offers a vast opportunity for employment generation and inclusive growth and development currently supporting the livelihood of more than a million Filipinos.

Environmental Aspects and Climate Change

Impacts of Climate Change[106]

- High temperatures: Increasing Sea surface water temperature in shallow areas where fixed-off bottom farms are located exacerbates the decline in seaweed production.

- El Niño and La Niña: Exposure of the farmed seaweeds to increased seawater temperature during El Niño and lowered salinity from unusually heavy rainfall during La Niña, could all interact to increase the stressful conditions experienced by seaweeds cultured at the surface compromised growth.

- Storms and typhoons: The increasing intensity of typhoons and storm surges causes wide-scale damage to the seaweed production-related infrastructure.

- Diseases and pests: Climate change increases susceptibility to 'ice-ice' disease and epiphyte/ pathogen attacks on seaweed.

Adaptation to Climate Change

- Seaweed farming absorbs carbon emissions, generates marine protein, and creates biofuel and renewable plastics[108].

- Seaweed aquaculture contributes to climate change adaptation by damping wave energy and protecting shorelines, and by elevating pH and supplying oxygen to the waters, thereby locally reducing the effects of ocean acidification and de-oxygenation[107].

Challenges and Opportunities

Current challenges

- Disease resistance: Management of diseases and pests such as Ice-ice disease and epiphytic (Epiphytic filamentous algae) pests that are prevalent in the major seaweed-producing areas in the country[108].

- Repeated vegetative propagation of the same plant has led to low genetic diversity hence, a shortage or inadequate supply of good quality eucheumatoid cultivated varieties or strains[108].

- Limited and incoherent biosecurity legislation and policy especially in the transfer of new seedlings from one farm to another[108].

- Lack of capital and access to financial resources.

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[106] Largo DB, Chung IK, Phang SM, Gerung GS, Sondak CFA. (2017). Impacts of Climate change on Eucheuma-Kappaphycus Farming. Tropical Seaweed Farming Trends, Problems and Opportunities, 121–129. doi:10.1007/978-3-319-63498-2_7

[107] Duarte CM, Wu J, Xiao X, Bruhn A, Krause-Jensen D. (2017). Can Seaweed Farming Play a Role in Climate Change Mitigation and Adaptation? Frontiers in Marine Science. 4:100. doi: 10.3389/fmars.2017.00100

[108] Hurtado AQ, Luhan MRJL, Ferriols VMEN, Faisan JP Jr., Mateo JP, Sibonga RC, Suyo, JGB. (2021). Towards a robust and resilient seaweed aquaculture in the Philippines. Policy Brief #1. Retrieved from: https://repository.seafdec.org.ph/bitstream/handle/10862/6293/Towards-a-robust-and-resilient-seaweed-aquaculture-in-the-Philippines.pdf

- Inadequate knowledge of technical and developmental aspects of seaweed farming due to limited reach and quality of technical training and assistance.

- Unpredictable weather conditions and increased frequency and magnitude of natural disasters

- Limited promotion and development of value-added products.

- Global Competition: Facing competition from other major seaweed-producing countries such as Indonesia.

Opportunities

- Area development / Increase Production: The potential area for expansion of the Philippine seaweed industry is huge with an estimated aggregate of 700,000 hectares of the farmable area but only 8% are being utilized.

- Market Expansion: The global demand for seaweed and its products is expanding. Its popularity and reputation as healthy food increases its demand along with its usage in other applications such as food gels, processed meats, pharmaceuticals, cosmetics, fertilizers, and biotechnology, among others.

- Environmental Benefits: It provides food, habitat, and breeding grounds for many marine species and organisms and promotes ecological stability and sustained productivity. It is also considered as one of the eight commodities of national importance identified in the commodity prioritization under the World Bank-assisted Philippine Rural Development Project (PRDP).

Policies and programs

- Formulation and implementation of government policies and programs towards achieving the goal of regaining the country's international seaweed market position and becoming the "Global Market's Preferred Seaweed and Carrageenan Supplier."

- Policies aim at addressing issues at the production and marketing level particularly the value chain gaps by promoting the commercialization of other seaweed products like food and other applications.

- Programs that shall strengthen the industry's production thrusts such as product diversification, new market opening, livelihood sustainability, food security, climate change adaptation, and marine resources conservation.

R&D Opportunities

1. R&D on existing and new cultivars, and farming technologies to address the problem of propagules availability.

2. R&D on the identification of strains of good traits which includes resilience to changes in temperature and salinity.

3. Diversification of seaweed products by product development, complementary processing facilities and tools and equipment provision, and effective consumer marketing strategies to enhance economic gains of farmers in the value chain.

4. Climate Forecasting and Early Warning: Improving climate forecasting and early warning systems to help farmers anticipate and respond to extreme weather conditions.

5. Education and Training: Capacity building for farmers through ongoing training programs on new technologies and best agricultural practices.

Conclusion

Seaweeds are one of the most economically important fishery products in the Philippines comprising 60-70 percent of its total aquaculture production. Endowed with 1,065 seaweed species, the country has pioneered the cultivation of the carrageenan-bearing seaweed *Eucheuma* which led to its dominance in commercial seaweed production and recognition as the top seaweed producer globally.

With the rapid expansion of global demand for seaweed and its products and the vast potential for area development and utilization in the Philippines, the seaweed industry will play a crucial role in improving the socio-economic conditions of its stakeholders and the country in general as well as in promoting ecological stability. However, these benefits are threatened by various issues and challenges that would require further research and development to be addressed.

The decline in seaweed production is caused, among others, by pests and disease outbreaks leading to the unavailability of good-quality seedlings. Science-based measures, strategies, and practices to counter Ice-ice disease and epiphytic (Epiphytic filamentous algae) pests, which are prevalent in the major seaweed-producing areas in the country, should be determined and investigated. In line with climate change, strains of good traits which include resilience to changes in temperature and salinity should also be identified. In terms of production and marketing wherein a huge gap in supply and demand is recognized, studies on product development, complementary processing facilities and tools and equipment provision, and effective consumer marketing strategies should be focused on. Lastly, there is also a need for capacity development activities for seaweed farmers/ fisherfolks to introduce new technologies and best and sustainable farming practices and resolve the inadequate knowledge on technical and developmental aspects of seaweed farming.

Concluding Remarks

The findings of the value chain analyses supports the conclusions presented in Part 1, particularly the assertion that the agriculture and fisheries sectors are faced with climate and ecosystem changes. These changes affect industry productivity and the livelihoods of the communities and different actors and sectors who are involved at various points of the value chain. Recognizing these challenges, it is imperative for research and development institutions to pivot and address the need for adaptation and mitigation strategies. This will enable various commodity industries to adapt to the negative impacs of climate change and other stressors and uncertainties. The following figure and paragraphs present the summary of challenges and issues and research and development opportunities across the fifteen (15) commodities.

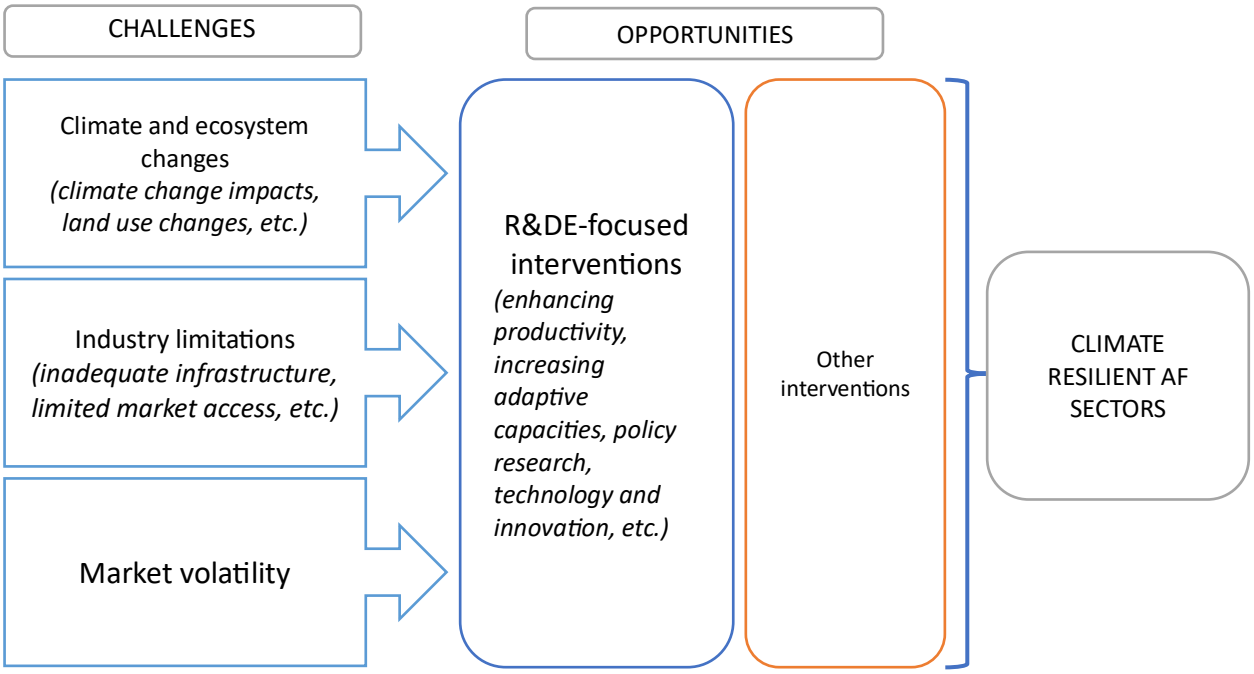

Figure 96: Visual presentation of the challenges and opportunities for the agriculture and fisheries sectors.

Challenges and Issues

The challenges and issues for the fifteen (15) commodities provide a glaring picture of how climate change alters ecosystem functioning, impacting species interactions with each other and their environments. Climate change results to more and frequent occurrences of extreme weather events, which in turn are causing a decrease in production, a decline in food quality for consumers, and the possibility of damage to infrastructure (CGIAR, 2023). When combined with other ecosystem changes resulting from human activities, these challenges are furhter compunded, the intensifyinng the difficulties faced by the different stakeholders involved.

Crops, livestock and the fisheries sectors' productivity are all directly affected by extreme weather events, temperature changes, water availability, and soil health. The challenges and issues are felt at the front-end of the value chain, if we divide the value chain broadly from pre-production, production, post-production (with or without) industrial processing, and marketing.

Meanwhile, the agriculture and forestry sectors are also limited in terms of post production and processing due to industry limitations such as inadequate infrastructure such as access to affordable power, route disruptions due to effects of typhoons and other climate disasters. For the fisheries sector,

access to infrasture such as fish landing, and cold storage facilities are some of the concerns. Access to markets is another layer of challenges faced by producers and value-adding players.

Another challenge, while not directly impacted by climate change, is the fuctuating market price of the different product and value added products affecting profit.

R&D Opportunities

A wide range of research and development interventions can be looked into to increase the adaptive capacities of the agriculture and fisheries sectors. These are summarized in the table below.

R&D opportunities	
Enhancing productivity	**Crops[1], Livestock[2], Fisheries[3]** Development and adoption of climate-resilient and disease-resistant varieties or strains (breeding and genetics) **Livestock[2]** Research of nutritional strategies and supplements
Increasing adaptive capacity through extension services	**Crops[1], Livestock[2], Fisheries[3]** Promotion of sustainable farming and fishing/aquaculture practices, capacity-building (efficient water management, pest and disease management, various climate adaptation strategies, value-adding, etc.)
Policy research	**Crops[1], Livestock[2], Fisheries[3]** Policy research to balance agricultural land use and developmental needs in an era of climate change, improve trade policies, marketing, etc.
Technology and innovation	**Crops[1], Livestock[2], Fisheries[3]** Development and introduction of technology and innovations to enhance and/or modernize post-harvest handling (value addition), enhancement of disease monitoring and management, climate forecasting and early warning **Livestock[2]** Development and introduction livestock health management innovations **Fisheries[3]** Development and introduction of tuna stock monitoring and assessment innovations

Table 29: Research and development opportunities for the agriculture and fisheries sectors.

[1] Rice, corn, tomato, onion, mango, banana, pineapple, coconuts, sugarcane ; [2] Carabao, chicken egg, pork ;
[3] Tilapia, tuna, seaweed