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Production, processing and marketing of agriculture subsystems in the Philippines: A review

Moseb H. Mamasao [1,*] and Abdani D. Bandera [2]

[1] *Department of Plant Science, College of Agriculture, Mindanao State University-Main Campus, Marawi City, Philippines.*
[2] *Department of Agribusiness Management, College of Agriculture, Mindanao State University-Main Campus, Marawi City, Philippines.*

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Abstract

Agriculture remains a vital pillar of the Philippine economy, yet its development is hindered by the fragmentation and weak integration of production, processing, and marketing subsystems. This study presents a systematic literature review analyzing scholarly works from Scopus-indexed journals, Web of Science, Google Scholar, and Philippine-based repositories to examine the interconnections, challenges, and opportunities within these agricultural subsystems. The review reveals that while mechanization has progressed, persistent productivity gaps remain due to climate change impacts, limited technology adoption, and inadequate support services for smallholder farmers. The processing subsystem emerges as the weakest link, characterized by insufficient infrastructure and substantial post-harvest losses. Meanwhile, the marketing subsystem suffers from lengthy, fragmented supply chains that diminish farmer incomes and bargaining power through multiple intermediaries. The findings indicate that isolated improvements within individual subsystems are insufficient for sustainable agricultural development. Instead, an integrated approach combining technological innovation, post-harvest infrastructure investment, market access enhancement through digital platforms and cooperatives, and inclusive institutional governance is essential. These integrated strategies align with national modernization goals and are critical for ensuring food security, improving farmer livelihoods, and promoting resilient agricultural growth in the Philippines.

Keywords: Agriculture; Food Security; Production; Processing; Marketing; Sustainable Agricultural Development

1. Introduction

Agriculture is a vital part of the Philippine economy. It supports rural livelihoods and food security while playing a role in national development. It accounts for about 8.6% to 10% of the national gross domestic product and employs over 25% of the total labor force (Mopera, 2016; Taer & Taer, 2024; Philippine Statistics Authority, 2024). Even with its declining share of the gross domestic product, the sector still provides jobs for a large portion of the population and supplies key raw materials to various industries (Cruz, 2022; Orzales, 2025). Additionally, interconnected activities in agriculture, fisheries, and forestry create significant job opportunities and help reduce poverty in developing countries like the Philippines (Domaob et al., 2025).

Modern agricultural analysis focuses on an integrated agribusiness or value chain approach. This method highlights the connections between production, processing, and marketing subsystems. The production subsystem involves growing crops and raising livestock affected by climate change, technological advancements and socio-economic factors (Espino et al., 2021). Currently, the production subsystem is transitioning to "Agriculture 4.0." This approach stresses digitalization and data-driven innovation to deal with high input costs and climate-related risks (Vijayakumar et al.,

* Corresponding author: Moseb H. Mamasao

2025). Although farm mechanization has improved to about 2.679 hp/ha, production is still limited by small landholdings and smallholder farmers' restricted access to credit (Valiente et al., 2025). Meanwhile, the processing subsystem adds value to agricultural products through preservation, packaging, and manufacturing. This improves product quality and cuts down on post-harvest losses (Ambor et al., 2025). However, a lack of modern infrastructure, such as integrated cold chains and efficient mechanical dryers, leads to post-harvest losses of up to 50% for perishable horticultural crops. These losses significantly reduce the available marketable surplus and lower the overall value added within the chain (Mopera, 2016; Aguilar et al., 2020). Developing this subsystem is crucial for improving shelf life, cutting waste and raising local farmers' incomes. Additionally, the marketing subsystem connects producers with consumers. It is characterized by multiple assessments that create large price gaps between farm-gate and retail prices (Aguinaldo et al., 2016; Quintana et al., 2022). Smallholder farmers often struggle with limited infrastructure and weak bargaining power (Domaob et al., 2025).

These subsystems work within a larger framework of food system drivers including globalization, urbanization, policy frameworks and climate variability. These factors influence the efficiency and resilience of the agricultural sector (Espino et al., 2021). Despite their interconnections, studies often look at these components separately leaving a gap in understanding their combined impact on agricultural development. This review brings together existing literature on the production, processing, and marketing subsystems of agriculture in the Philippines. It aims to highlight their interconnections, identify key challenges and explore how their integration can boost agricultural growth, ensure food security and promote economic development.

2. Research Methodology

This study employed a systematic literature review (SLR) approach to analyze existing research on agricultural production, processing and marketing subsystems in the Philippines. The SLR method enables the structured identification, evaluation and synthesis of relevant studies to ensure transparency and minimize bias in the review process. This approach is particularly useful for determining research trends, consolidating existing knowledge and identifying gaps within a specific field. Through this method, the study examined scholarly literature to provide a comprehensive understanding of how agricultural subsystems operate and interact within the Philippine agricultural sector. A comprehensive search for relevant and reliable literature was conducted across multiple academic and professional databases. These included Scopus-indexed journals, Web of Science, ResearchGate, ScienceDirect, JSTOR and Google Scholar. Additional sources such as institutional publications, peer-reviewed journal articles, conference proceedings and government reports were also reviewed. To ensure local relevance, the search further included Philippine-based repositories, such as Philippine E-Journals and official government publications. These sources were selected to capture a broad range of studies addressing agricultural production, processing and marketing subsystems to ensure the inclusion of both international and Philippine-focused research.

3. Literature Review

3.1. Agricultural Value Chain Coordination and Climate Resilience

Recent studies highlight the importance of integrated approaches to agribusiness value chains. A systematic review found that competitive advantage in agribusiness value chains depends on sustainability, digital transformation and supply chain management but these are only supported by innovation and collaborative institutional structures. However, most studies are still fragmented and limited to examining individual components within a value chain rather than the value chain system as a whole (Andrea et al., 2025). Evidence from Zimbabwe demonstrated that poor coordination across value chain components especially among production and marketing entities along with inadequate access to inputs and low bargaining power among farmers, adversely affected value chain performance despite strong potential for international trade and high profitability in export markets (Bandason et al., 2021). In the Philippine context, low productivity in taro production was attributed to limited inputs, insufficient technology adoption, as well the lack of sufficient support from government agencies which highlighted inefficiencies in the production subsystem (Onsay et al., 2022). Similarly, a study on consumer preferences also revealed mismatches between production practices and market expectations, indicating the need for improved post-harvest handling and marketing strategies (Gerance et al., 2020).

Studies on crop production systems in the Philippines reveal that environmental performance is affected by production and post-harvest practices. A study by Dait, (2023) employed panel data and an augmented Cobb-Douglas model from 2006–2019 to demonstrate that while increased land area and urea fertilizer boost Philippine rice production, higher rainfall and temperatures significantly reduce yields necessitating long-term strategies to expand irrigation, diversify

inputs and implement climate adaptation measures to ensure national rice security. In corn production systems, those utilizing sun drying and manual harvesting demonstrated lower energy inputs, higher energy and carbon efficiency, and lower greenhouse gas emissions compared to those using mechanical drying, predominantly due to reduced energy reliance on non-renewable fuels such as kerosene (Flores et al., 2016). Similarly, a life cycle assessment of conventional and organic vegetable farming systems in Tayabas, Quezon indicated that conventional systems generated higher global warming, acidification and human toxicity impacts compared to organic systems because of chemical inputs while organic systems showed lower emissions but a higher eutrophication potential. Overall, both studies established that the reduction in fossil fuel dependence and synthetic agrochemicals improves the environmental sustainability of agricultural production systems (Oliquino-Abasolo & Zamora, 2016).

3.2. Supply Chain Fragmentation in Agricultural Systems

Agricultural marketing and supply chain management are crucial in ensuring the efficient and profitable movement of farm products through various stages from production to consumers. Studies highlight that marketing functions such as post-harvest handling, processing, storage, transportation, pricing, and distribution directly impact farmers' income and consumers' satisfaction, while robust logistics infrastructure and technological innovations help in reducing losses and improving market access (Singh et al., 2025). A qualitative study employing triangulation and inductive analysis studied by Andriani et al, (2025) reveals that raw material supply chains in Indonesia (Specifically in Madiun Regency) and the Philippines both involve multiple flow of supply chain from producers to consumers through intermediaries including collectors, processors, and distributors, rather than direct channels from producers to consumers.

Evidence from horticulture and tea value chains in India further demonstrates how inadequate cold storage, poor transport systems and price volatility weaken the performance of the value chain, whereas collective action and value addition empower farmers to bypass intermediaries and strengthen their role across the production, processing and marketing subsystems (Saha, 2020; Kumar & Chandel, 2024). The significant post-harvest losses in India, estimated to be 7–10% of food grains, further reveal the inefficiency in storage, handling and distribution systems, highlighting a need for improved marketing and supply chain management and infrastructure (Somashekhar et al., 2014). Similarly, inefficient marketing systems in Bangladesh, including poor transportation, inadequate storage and dominance by middlemen limit farmers' profitability despite strong production potential (Singha & Maezawa, 2019). Studies from the lemongrass supply in the Caraga Region of the Philippines highlight the high profitability and value-adding potential of lemongrass but limited support, weak logistics infrastructure and underdevelopments in export linkages hinder its expansion (balanay & Guinancias, 2025).

3.3. Challenge across the Agricultural Value Chain in the Philippines

The agricultural sector in the Philippines depends on essential crops which serve as its main agricultural backbone. Rice is regarded by the country as its key staple food, because it occupies most farmland and the government carries out extensive support programs to boost its production (David, 1999; Mohapatra, 2025). The country has achieved its highest rice production output when it reached more than 20 million metric tons in recent years. However, aiming for complete self-sufficiency for the country was still in progress (Department of Agriculture, 2024). Corn, Coconut, Banana and Sugarcane were among the most produced and important food supply sectors in the Philippines throughout the generation. However, several studies suggest that the importance of improved varieties, proper fertilization, integrated pest management and land utilization of these crops is highly significant in order to maintain its productivity and continuous supply across the world (Nyberg, 1968; Gerpacio et al., 2004; Nozawa, 2012; Pongao-ponio, 2026)

Research and development in agricultural value chains have highlighted the significant impact of inefficiencies in the production, processing and marketing subsystems on farmer incomes and sectoral performance. Specifically, an integrative review on boundary drivers and market-centered expansion in agribusiness (2015–2025) by Candontol et al., (2025) demonstrates that the sector's transformation toward an integrated, sustainability-oriented framework depends from the strategic convergence of technological innovation (such the adoption of Artificial Intelligence, blockchain and the circular economies), market globalization and institutional governance while simultaneously highlighting persistent challenges in the inclusion of smallholders and identifying the critical opportunities posed by eco-innovation, the digital transformation and participation of the woman and youth in ensuring long-term food system resilience. In line with this, market-centered agribusiness strategies utilizing cooperatives, vertical integration and the digital platforms offer opportunities in improving the competitiveness and access to markets but necessitate more equitable policy frameworks to address differences in technology adopted and bargaining positions among smallholder farmers (Alimoden & Bandera, 2025). For instance, in the Philippine rice industry, high production costs due to low yields, costly inputs and labor-intensive farming practices and limited access to irrigation highlight the need for mechanization, improved access to high-quality seed and public investment in irrigation infrastructure (Mataia et al., 2020). Moreover, studies on marketing channels have also underscored the importance of shorter channels, like direct

sales to millers in achieving higher profits although limited infrastructure, access to credit, storage facilities and market information often require smallholders to rely on intermediaries reducing their profitability and bargaining power (Soe & Maezawa, 2019; Mgale & Yunxian, 2020). Similar concerns are evident in the Philippine coffee supply chain where risks in the production, processing and distribution phases such as climate change, inadequate postharvest facilities, poor transportation infrastructure and limited access to postharvest resources highlight the need for a coordinated policy and institutional approach (Fuerzas et al., 2025). In addition, the role of climate-resilient technologies, such as efficient irrigation systems, improved crop varieties and information systems has been identified as a key strategy in stabilizing agricultural productivity under changing environmental conditions (Slater, 2019). Similarly, findings also show that integrated agribusiness subsystems units that also cover input supply, production, processing, marketing and support services may provide opportunities for the improvement and sustainability of farmer group performance in Chili–Tobacco intercropping systems (Adnyana et al., 2020).

The processing subsystem currently stands as the weakest link in the Philippine agricultural value chain because it lacks proper infrastructure and experiences excessive post-production losses (Mataia et al., 2020). The lack of infrastructure for modern drying and milling facilities burdens local farmers due to high operation cost and leads to mills to be poorly utilized. Many of these processing activities remain manual and the absence of transparency in quality assessment often caused by a lack of moisture meters prevents farmers from realizing the true value of their commodities. The Philippine Center for Postharvest Development and Mechanization has started to implement small-scale processing equipment across government agencies however, these efforts have not yet achieved the required national capacity to update processing operations. While there has been some introduction of small-scale processing tools by several government agencies such as the Philippine Center for Postharvest Development Mechanization, scale of these intervention has not yet reach with the national demand for modernization of the processing stage (Mataia et al., 2020). Additionally in terms of value addition and processing, it is critical for any agricultural development. Although there are economic opportunities that come with the production of virgin coconut oil, the adoption of some technologies has been limited leading to the constrained income improvements among farmers (Soetikno, 2019). In Laguna (Philippines), the rubber industry has been able to capitalize on its economic potential as there are local processing facilities and formal marketing agreements in place, although growth has been limited due to limited skilled labor and low production scale in their industry (Castillo et al., 2014). A study by Tripathy et al. (2022) demonstrates that Zero Energy Cool Chambers (ZECC), evaporative cooling systems, solar dryers, clay pot refrigeration and underground storage systems decrease post-harvest losses while extending product shelf life, increasing farmers' market access and income potential. The wider implementation of these technologies requires improved policy support and public knowledge about their benefits. Locally, Postharvest losses in the Philippines go as high as 55% around the supply chain based on perishability, poor infrastructure, inefficient handling and distribution systems across the supply chain which greatly affect the overall efficiency and value of agricultural production (Mopera, 2016). Similarly, Faqeerzada et al. (2018), found that Postharvest losses of fruits or vegetables in the Southeast Asian countries including Philippines remains high (about 20%–50%) leading to reduce food availability, lower income for farmers and lower nutritional quality of the produce.

In the marketing subsystem, the Philippine agricultural supply chain is often characterized by its length, fragmentation, & inefficiency (Aguilar, 2019). Produce often moves through several layers of intermediaries like traders, wholesalers, & retailers, which leads to increase losses and reduced profit for the primary producers (Gardas et al., 2018). This fragmented structure perpetuated asymmetric price transmission, with retailers benefiting from real-time price monitoring in markets like those for onions, while farmers are often forced to sell at lower prices to wholesalers due to high perishability in the crops and a lack of direct feedback from consumers (Cavaye et al., 2016; Hinlo & Lee, 2025). In addition, logistical barriers like poor farm-to-market roads and high transportation cost increase domestic prices (Cavaye et al., 2016; Mataia et al., 2020). Additionally, many smallholders also find themselves trapped in debt cycles, with no significant marketing options and no power to bargain due to the high-interest-loans they receive from the wholesalers to fund their business (Cavaye et al., 2016).

It is only by integrating these three subsystems that the Philippine agricultural system can proceed towards the path of modernization. The National Agriculture and Fisheries Modernization and Industrialization Plan 2021-2030's main objective is the doubling of smallholder's incomes which will only be possible if research efforts are decentralized to include the Visayas and Mindanao investments in post-harvest infrastructure are prioritized to reduce the 20-30% post-producing loss and digital marketing platforms are utilized to shorten supply chains and enhance price transparency (Mataia et al.,2020; Taer & Taer, 2024; Ugpat et al., 2025).

3.4. Agricultural Mechanization and Technology Adoption

The evolution of agricultural mechanization and technology adoption in the Philippines is characterized by an ongoing strategic shift from traditional manual labor practices towards a more technologically advanced model, often referred to as "Agriculture 4.0" and data-driven innovation (Valiente et al., 2025). Despite being an agricultural country where 10% of the total National Gross Domestic Product (GDP) comes from the agriculture sector, the country faces ongoing challenges with low levels of mechanization and productivity (Taer & Taer, 2024). The local government unit decentralization and limited funding pose challenges for extension services that deliver essential technology transfer and farmer education services. Norton and Alwang (2020) examined agricultural extension approaches which revealed that decentralized extension models face challenges in offering comprehensive support and sustaining high-quality service to farmers. Digital extension services have emerged as a promising alternative solution although adoption by smallholders were still limited (Phanith et al., 2023).

The adoption of mechanization has shown a positive correlation with the rise of farmer income and labor productivity (Arbes et al. 2024). Although there are concerns regarding the displacement due to mechanization among farm laborers, most studies suggests that in recent years, mechanized farming is a necessity in the country in order to survive in a liberalized trade market (Tado & Bautista, 2022). Moreover, for a sustainable transformation, findings from the literature suggest that in order to improve agricultural technological adoption, there must be an accompanying push on inclusive innovation, coordinated policymaking and improved agricultural extension services to narrow down the difference between technological availability and the ability of farmers to utilize such technologies (Inutan et al., 2025; Custudio, 2025).

3.5. Agricultural Mechanization Progress in the Philippines

Agricultural mechanization in the Philippines saw significant growth over the past ten years. Not only did the country's mechanization level which was reported at the 2010 survey baseline (1.23 horsepower per hectare [hp/ha]) increase to 2.31 hp/ha in 2013, but it is enhanced to around 2.679 hp/ha in 2025 (De Jesus & Leyesa, 2023; Taer & Taer, 2024; Valiente et al., 2025). The rise in mechanization correlates with the enhanced efforts of the government to transform the rice industry. The push to be more competitive with the decrease of rice imports at significantly lower prices from neighboring Southeast Asian countries has been one of the primary reasons for this (Tado & Bautista, 2022).

Most innovations and developments in the Philippines revolve around staple crops, particularly rice, which makes up for 33.33% of the total category identified in the past years (Taer &Taer,2024). A noticeable trend of technological integration is the increase of image analysis and sustainable farming systems innovations, making up 26% and 23% of the total categories respectively (Taer &Taer, 2024). However, there's a clear gap in terms of productivity of rice compared to neighboring countries like Vietnam which produces 5.82 tons/ha of rice compared to the Philippines that produces about 4.04 tons/ha. The difference mainly because of higher production costs and slower adoption of climate-resilient seeds and advanced smart farming technologies in the Philippines (Go, 2022; Ugpat et al., 2025). Furthermore, Geographic bias is also observed in terms of agricultural researches and innovations within agriculture, with 69.23% of these focused mainly in Luzon underscoring agricultural potential of Visayas and Mindanao (Taer & Taer, 2024).

3.6. Government Policies and Legislative Framework

Legislative measures have played a critical role in promoting farm mechanization development throughout the Philippines. The Agricultural and Fisheries Mechanization Law of 2013 established the foundational commitment to modernizing agricultural operations nationwide. The Rice Tariffication Law of 2019 established a permanent framework which strengthened the Rice Competitiveness Enhancement Fund (RCEF) program (Tado & Bautista, 2022). The government through the RCEF program spends 10 billion pesos each year for six years while dedicating 5 billion pesos to purchase rice farm equipment via the Philippine Center for Postharvest Development and Mechanization (PhilMech). The capital investment aims to achieve two main objectives which include reducing rice production costs by two pesos to three pesos per kilogram and decreasing postharvest losses by 3% to 5% through the deployment of efficient machinery (De Jesus & Leyesa, 2023).

Data-driven innovation is also seen as a potential pathway to address climate change impacts and resource limitations. These technologies allow for tailored crop cultivation recommendations to a region and predictive intelligence to optimizes agricultural input usage (Taer &Taer,2024). However, the adoption of more advanced technologies such as automated irrigation systems and high-level decision support systems technologies continue to remain in development or experimental stages despite the availability in the online market (Briones et al., 2023).

4. Results and Discussion

The Philippine agricultural sector, which generates 8.6 to 10% of GDP and provides employment to more than 25% of workers faces operational challenges because its agricultural operations and product manufacturing and sales activities all experience inefficient performance (Mopera, 2016; Philippine Statistics Authority, 2024). Production has achieved notable mechanization progress rising from 1.23 hp/ha in 2010 to 2.679 hp/ha in 2025, yet productivity gaps persist because Philippine rice yields average 4.04 tons/ha whereas Vietnam's yields reach 5.82 tons/ha due to higher input expenses and delayed implementation of climate-adaptive technologies (De Jesus & Leyesa, 2023; Go, 2022; Ugpat et al., 2025). The effects of climate change create additional stability risks because rising precipitation and temperature levels reduce agricultural output which requires farmers to expand irrigation systems and implement various solutions (Dait, 2023). Agricultural research shows a strong tendency to favor specific geographical areas because it generates 69.23% of its innovations from Luzon while excluding Visayas and Mindanao (Taer & Taer, 2024). Sustainable intensification needs to establish inclusive innovation together with collaborative policymaking because existing technological resources do not match the needs of smallholder farmers (Inutan et al., 2025; Custudio, 2025).

The processing subsystem represents the weakest link of the value chain because it lacks proper infrastructure and suffers from excessive post-harvest losses which reach 20% to 55% due to the perishable nature of products and their substandard handling practices and the absence of advanced technology (Mopera, 2016; Faqeerzada et al., 2018; Mataia et al., 2020). The absence of modern drying and milling equipment forces farmers to spend excessive operational expenses while operating equipment inefficiently because they lack proper quality assessment instruments which would enable them to determine commodity values accurately (Mataia et al., 2020). The Philippine Center for Postharvest Development and Mechanization has developed small-scale equipment yet these solutions fail to fulfill the complete national needs dedicated to modernization (Mataia et al., 2020). Businesses can use the emerging technologies of Zero Energy Cool Chambers, evaporative cooling and solar dryers to reduce product losses and lengthen product shelf life but these technologies need better policy support and public awareness before they can achieve widespread usage (Tripathy et al., 2022). Sector-specific studies show identical constraints because virgin coconut oil production generates economic benefits which force businesses to adopt new technologies that restrict revenue expansion (Soetikno, 2019), while the Laguna rubber industry relies on local processing centers and official marketing partnerships yet faces operational challenges due to insufficient skilled workers and restricted production capabilities (Castillo et al., 2014).

The problems become worse because marketing inefficiencies create challenges which need to be solved in supply chains that operate through multiple disconnected sections which need to deliver commodities from collectors to traders to wholesalers and finally to retail stores until the product reaches end customers (Gardas et al., 2018; Aguilar, 2019; Andriani et al., 2025). Retailers gain advantages through continuous price tracking while farmers who experience product loss and do not know market prices receive lower prices from wholesalers (Cavaye et al., 2016; Hinlo & Lee, 2025). The combination of inadequate farm-to-market roads and expensive transportation services drives up domestic price levels because smallholders who acquire high-interest loans from wholesalers lose their ability to negotiate better terms and choose different marketing methods (Cavaye et al., 2016; Mataia et al., 2020). The lemongrass supply chains in Caraga Region and coffee sector analyses show that weak infrastructure for logistics and insufficient export connections combined with climate-related production hazards need comprehensive policy solutions with institutional support (Balanay & Guinancias, 2025; Fuerzas et al., 2025). The direct sales system to millers provides better profit margins through shorter marketing channels but smallholders need to work with intermediaries because they lack essential resources for infrastructure development, credit facilities and market knowledge (Soe & Maezawa, 2019; Mgale & Yunxian, 2020). The market-centered approach which uses cooperatives and vertical integration and digital platforms to improve competitiveness requires fair policies which must address technology adoption issues and the distribution of power in negotiations (Alimoden & Bandera, 2025).

The advancement of integrated agricultural systems which focus on sustainability depends on three elements which include technological progress, global market expansion and institutional governance systems (Candontol et al., 2025). The National Agriculture and Fisheries Modernization and Industrialization Plan 2021-2030 targets doubling smallholder incomes through decentralized research which includes prioritized post-harvest infrastructure investment to achieve 20-30 percent production loss reduction and digital marketing platforms that enable shorter supply chains which improve price transparency (Mataia et al., 2020; Taer & Taer, 2024; Ugpat et al., 2025). The Agricultural and Fisheries Mechanization Law of 2013 established modernization foundations while the Rice Tariffication Law of 2019 strengthened the Rice Competitiveness Enhancement Fund which dedicated 10 billion pesos annually and allocated 5 billion pesos for equipment procurement through PhilMech to achieve production cost reductions between 2.00 pesos and 3.00 pesos per kilogram and decrease postharvest losses between 3% and 5% (Tado & Bautista, 2022; De Jesus & Leyesa, 2023). Data-driven innovations provide customized farming guidance together with predictive analytics that

enable efficient resource management, yet automated irrigation systems remain mostly untested despite their presence in the market (Briones et al., 2023; Taer & Taer,2024). The establishment of food security together with comprehensive agricultural development needs more than the implementation of technological solutions because it requires the complete integration of all production components together with processing and marketing systems through innovative solutions, coordinated policy development and fair institutional systems which enable smallholder farmers to build sustainable resilience.

5. Conclusion

This systematic review reveals that Philippine agricultural development is fundamentally constrained by the fragmentation and weak integration of its production, processing and marketing subsystems. The agricultural sector achieved slight progress in mechanization and technology usage. But various factors including climate change impacts, research focus on specific areas, restricted land access and insufficient financial resources continue to prevent agricultural output from reaching its maximum potential in the region. The processing subsystem represents the primary challenge for the system because it experiences extreme post-harvest losses because of insufficient infrastructure and outdated processing technology. The marketing system creates multiple barriers through its complex intermediary networks which restrict farmers from accessing their full financial potential and bargaining power.

The evidence shows that agricultural development needs more than single system improvements because they do not create the necessary changes. The system requires integrated solutions which will combine the three activities of production increase, post-harvest infrastructure development, and market access improvements through digital platforms and cooperative organizations. The combination of technological innovation with institutional governance reforms and inclusive policymaking which focuses on including smallholders and achieving gender equity and engaging youth provides the best solution for reaching the goals of the National Agriculture and Fisheries Modernization and Industrialization Plan 2021-2030. The system needs immediate attention to three areas of processing infrastructure and technology transfer and supply chain development which will create transparent systems that give primary producers fair value for their goods.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no competing interests.

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