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Sustainability Status Analysis of Berau's Agriculture Sector: A Multi-Aspect Sustainability Approach (MSA)

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Abstract

This study evaluates the sustainability status of the agricultural sector in Berau Regency, East Kalimantan, using a Multiaspect Sustainability Analysis (MSA) approach supported by EXSIMPRO software. The assessment focuses on three main dimensions: economic, institutional, and technological sustainability. Primary data were obtained from 30 key stakeholders, including farmers, extension officers, cooperatives, and local government representatives, and were complemented by secondary data from official sources. The results show that the economic sustainability index is 42.86%, indicating a low level of sustainability, mainly due to low productivity, fluctuating Farmer Exchange Rates (NTP), and limited market access. The institutional dimension records a borderline sustainability status of approximately 50%, reflecting weak farmer organizations, limited extension intensity, and insufficient regulatory support. The technological dimension performs relatively better, with a sustainability index of 65.8%, driven by partial adoption of agricultural machinery, superior seeds, and basic digital technologies. Leverage sensitivity analysis reveals an equal leverage value of 0.5 across all dimensions, indicating strong interdependence and the need for simultaneous, integrated interventions. Scenario simulations suggest that targeted policies could increase the economic sustainability index to 50% and the technological index to 87.5%. Key structural constraints include long marketing chains, inadequate irrigation, land conversion, labor shortages, and low digital literacy. The study concludes that integrated interventions focusing on technology adoption, institutional strengthening, and market access improvement are essential to enhance the overall sustainability of Berau Regency's agricultural sector.

Keywords: Agricultural Sustainability, Berau Regency, MSA-EXSIMPRO

1. Introduction

Berau Regency has a diverse range of agricultural and livestock commodities with the potential to drive the regional economy, encompassing the subsectors of food crops, horticulture, smallholder plantations, livestock, and capture and aquaculture fisheries, all of which play a strategic role in the rural economic structure. Several leading commodities have been identified as basic sectors with comparative advantages relative to other regions in East Kalimantan, but this potential has not yet been fully translated into optimal economic performance at the level of key business actors and farming households. The agriculture, forestry, and fisheries sectors remain the backbone of rural communities despite facing pressure from the dominant mining sector in the regional GRDP structure, which tends to suppress the relative contribution of the agricultural sector as extractive activities increase.

Various structural issues remain major challenges to improving the efficiency and competitiveness of the agricultural sector in Berau Regency. The long marketing chain, resulting in dependence on intermediaries, volatile agricultural product price fluctuations, minimal processing activities, and local commodity-based agro-industries, and limited access to broad regional and national markets, continues to hamper the creation of optimal economic added value. Furthermore, internal factors such as suboptimal farm productivity, traditional production patterns, limited basic infrastructure, including irrigation networks, farm roads, and reservoirs, and the progressive conversion of agricultural land to oil palm plantations and mining activities further exacerbate these conditions (Tondel et al. 2022). Fluctuating low farmer exchange rates, limited access to capital with high farm interest rates, a declining agricultural workforce due to uncompetitive incomes compared to the mining sector, weak coordination between sectors supporting agricultural development, and the impact of climate change affecting cropping patterns are also critical indicators of the urgency of structural transformation in this sector.

In this context, a sustainability analysis of three key aspects (economic, institutional, and technological) is crucial for describing the current state of the agricultural business system in Berau Regency and identifying the key factors that most influence systematic performance improvement. These three aspects are closely interrelated in shaping the competitiveness and resilience of the agricultural sector: economics determines financial viability and the creation of added value, institutions strengthen business actor coordination, resource access, and bargaining power in the market, while technology is a key lever for increasing productivity, production efficiency, and adaptation to environmental challenges. These three elements collectively address structural constraints, including limited land, climate fluctuations, long supply chains, and increasingly fierce market competition.

The Multiaspect Sustainability Analysis (MSA) approach, combined with leverage sensitivity analysis using EXSIMPRO software, was applied to assess the sustainability of the three aspects simultaneously and to determine the main lever variables to prioritize in an integrated development strategy. This methodology allows for a comprehensive evaluation of the relationships between variables from the three aspects—economic (commodity productivity, NTP, business income, market access), institutional (farmer group strength, extension, regulation, partnerships), and technological (agricultural machinery, superior seeds, digitalization)—as well as the simulation of realistic improvement scenarios that can be implemented gradually to accommodate the characteristics of Berau's 14 diverse sub-districts from the coast to the interior. Through this analytical approach, it is hoped that a strong scientific basis can be established to formulate targeted and integrated policies and strategic interventions, including the simultaneous strengthening of all three aspects to create the maximum multiplier effect. This integrated approach in strengthening the economy, institutions, and technology is not only expected to be able to encourage an increase in the sustainability index towards the highly sustainable category, but also become a catalyst for the comprehensive transformation of Berau's agricultural sector towards a competitive modern agribusiness model, supporting post-mining economic diversification through the optimization of LQ-based commodities, and strengthening the strategic role of Berau Regency in supporting the sustainable food security of the Indonesian Capital City amidst the dynamics of climate change, land conversion, and shifting workforce structures (Aprylasari & Toyibulah, 2025).

2. Research Methods

2.1 Study Area

This study was conducted in Berau Regency, East Kalimantan Province, Indonesia, which comprises 14 sub-districts with diverse agroecological characteristics ranging from coastal areas to inland regions. Berau Regency was selected due to its strategic role in regional food production, the dominance of agriculture-based livelihoods in rural areas, and increasing development pressures from mining, plantation expansion, and land-use change.

2.2 Research Design and Approach

The study applied a descriptive–quantitative approach using Multiaspect Sustainability Analysis (MSA) to assess the sustainability status of the agricultural sector. The MSA framework allows simultaneous evaluation of multiple sustainability dimensions and identification of key leverage variables that influence system performance. Sustainability analysis and scenario simulations were conducted using EXSIMPRO software, which is specifically designed for sensitivity and leverage analysis in complex systems.

2.3 Sustainability Dimensions and Indicators

The sustainability assessment covered three main dimensions, each represented by several key indicators adapted to local agricultural conditions:

1. Economic aspect, including commodity productivity, Farmer Exchange Rate (NTP), farm income, agricultural value-added to GRDP, market access, and export potential.
2. Institutional aspect, comprising farmer group and cooperative strength, intensity of agricultural extension and mentoring, regulatory support and priority programs, and partnerships with off-takers or private actors.
3. Technological aspect, including availability and maintenance of agricultural machinery, adoption of cultivation technology and superior seeds, livestock pest and disease control, and utilization of information and digital technologies.

Each indicator was scored based on current field conditions and expert judgment, then normalized on a scale of 0–100 to generate sustainability indices for each aspect.

2.4 Data Collection

Data were collected using a combination of primary and secondary sources. Primary data were obtained through in-depth interviews, structured questionnaires, and expert judgment involving 30 key stakeholders, including farmers, livestock farmers, extension officers, local government officials, cooperative managers, and agribusiness actors. Secondary data were collected from official reports, regional statistics, policy documents, and relevant publications from local and national institutions.

2.5 Data Analysis

Sustainability indices were calculated using the MSA approach embedded in EXSIMPRO software. The analysis consisted of three main stages:

1. Sustainability status assessment, which classified each aspect into categories ranging from less sustainable to highly sustainable.
2. Leverage sensitivity analysis, used to identify variables with the highest influence on changes in sustainability indices.
3. Scenario simulation, conducted to estimate potential improvements in sustainability indices under targeted intervention scenarios based on key leverage variables.

Leverage values closer to 1.0 indicate stronger influence, while equal leverage values suggest interdependence among variables, requiring integrated interventions.

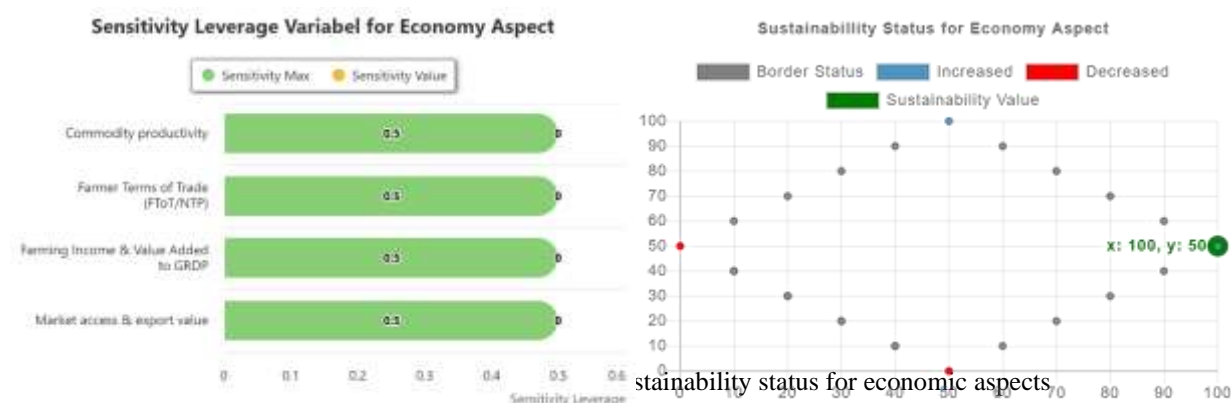
2.6 Interpretation and Validation

The results were interpreted by comparing current and simulated sustainability indices across the three aspects. Validation was conducted through expert discussions and cross-checking with secondary data to ensure consistency and contextual relevance. The analysis emphasizes integrated policy implications rather than isolated interventions, reflecting the systemic nature of agricultural sustainability in Berau Regency.

3. Results and Discussions

Economic Aspects

The economic sustainability index for the agricultural sector in Berau Regency is 42.86%, indicating low sustainability. Simulations of future (leveraged) conditions show an increase in the index value to around 50% (Figure 1), but this achievement is still within the lower limit of sustainability and has not yet reached the sustainable category. This finding reflects that the improvements made are not yet strong enough to drive structural transformation of the agricultural sector, despite Berau Regency's potential natural resources, diverse commodities, and strategic role in the regional economy.



The results of the sensitivity leverage analysis indicate that all analyzed economic variables have the same leverage value (0.5), suggesting that no single variable dominates the economic sustainability of the agricultural sector. This condition indicates that the agricultural economy in Berau Regency is multidimensional and interconnected, so that increasing sustainability cannot be achieved through partial interventions, but rather requires an integrated approach that targets all key variables simultaneously (Koptaeva et al. 2019). The variables of commodity productivity, Farmer Exchange Rate (NTP), farm income, value added to GRDP, as well as market access and export value, exhibit equal sensitivity in determining changes in the economic sustainability index. Low agricultural commodity productivity is one of the main factors hindering improvements in the economic

performance of the agricultural sector in Berau Regency. The production system, which is still dominated by traditional patterns with limited technology adoption, results in relatively low yields per unit of land and business efficiency. Dependence on natural and seasonal factors, limited irrigation facilities, and minimal post-harvest management make agricultural production vulnerable to climate fluctuations and yield losses, which ultimately impact low farmer incomes and unstable market supply (Shahbazi et al. 2025).

The Farmer's Exchange Rate (NTP), which fluctuates between 95 and 102, reflects weak farmer purchasing power due to rising input costs that are not offset by increases in agricultural product prices. Rising prices for fertilizer, feed, seeds, and energy directly suppress farm profit margins, while a marketing structure that remains reliant on intermediaries weakens farmers' bargaining position. As a result, farmers are vulnerable to price fluctuations and lack adequate economic incentives to scale up and improve the quality of their businesses. Farm income and the agricultural sector's value-added contribution to Berau Regency's GRDP remain relatively low, primarily due to the dominance of raw material sales. The limited processing of products and the agro-industry based on local commodities mean that economic value-added is primarily enjoyed by actors outside the production area (Ahmad, 2022). This situation indicates that the agricultural sector has not been optimally integrated with the supporting industrial and service sectors, thus limiting its role as a primary driver of regional economic growth.

Market access and export opportunities for agricultural products in Berau Regency face various obstacles, primarily related to limited transportation, logistics, and distribution infrastructure in rural areas and production centers. Farmer economic institutions, such as cooperatives and Village-Owned Enterprises (BUMDes), have not yet functioned optimally in strengthening the marketing chain and improving producers' bargaining position. Furthermore, limited quality standardization, packaging, and supply continuity are major obstacles to expanding market reach, both regionally and nationally. Overall, the analysis shows that the economic sustainability of the agricultural sector in Berau Regency requires a comprehensive strengthening approach that includes increasing productivity through the application of appropriate technology, stabilizing the NTP through production cost efficiency, improving marketing systems, developing agro-industry and downstream MSMEs to increase added value, and strengthening market access through improvements in infrastructure and farmer economic institutions. This integrated approach is a key prerequisite for increasing the agricultural sector's economic sustainability index toward the sustainable category and strengthening its contribution to sustainable regional economic development.

Institutional Aspects

The sustainability index for the Berau Regency agricultural sector in terms of institutions is around 50, indicating a borderline or less sustainable condition (Figure 2). This position indicates that institutions' support for agricultural sustainability has not been optimal, despite the structural availability of supporting institutions such as farmer groups, agricultural extension services, and local government policies and programs. Simulation results indicate that institutional improvements have the potential to enhance sustainability, but this strengthening remains partial and has not been fully integrated into the regional agricultural development system. The results of the leverage sensitivity analysis show that all institutional variables have a relatively similar maximum leverage value (0.5), indicating that no single variable dominates changes in the sustainability index. However, differences emerge in the actual sensitivity values, with the variables of extension and mentoring intensity, as well as regulations and priority programs, showing higher sensitivity than the other variables. This indicates that the effectiveness of agricultural institutions in Berau Regency is highly dependent on policy consistency and the continuity of mentoring processes that directly impact farmers.

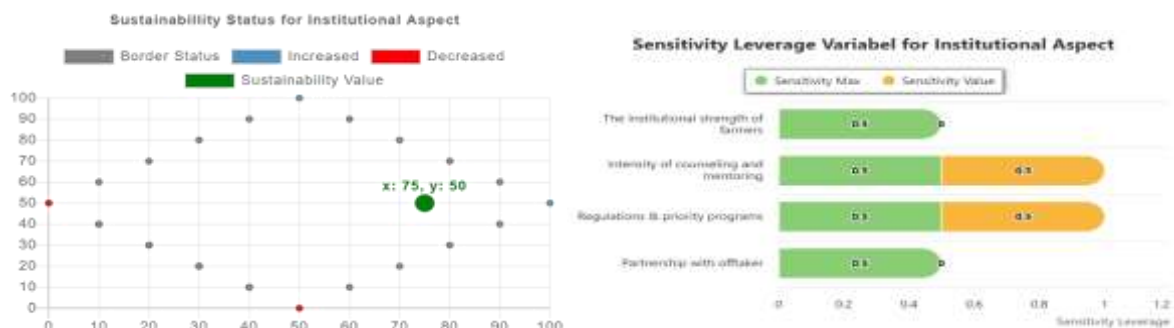


Figure 2. Sensitivity lever variables and sustainability status for institutional aspects

The institutional strength of farmers remains relatively limited, as reflected in the suboptimal performance of farmer groups (gapoktan), cooperatives, and village-owned enterprises (BUMDes) in fulfilling their economic and social roles. Most farmer institutions still function primarily as administrative bodies and program recipients, but have not yet developed into economic institutions capable of improving farmers' bargaining power, managing joint ventures, and establishing sustainable partnerships. This situation leads farmers to operate individually and to be highly dependent on external parties, particularly for access to capital, production inputs, and marketing agricultural products (Shiferaw et al., 2011). The intensity of extension and mentoring is the institutional variable most sensitive to changes in the sustainability index, indicating that the quality and continuity of extension services play a strategic role in increasing farmer capacity. The limited number of extension workers, the vast working areas, and the extension approach, which is still oriented towards one-way technology transfer, have resulted in the process of increasing farmer capacity being less than optimal. Yet, ongoing mentoring is essential to encourage the adoption of innovation, strengthen business management, and transform farmer institutions toward a more modern and competitive agribusiness system.

Regulatory variables and priority programs also exhibit high sensitivity, indicating that policy direction and consistency of local government programs significantly determine the effectiveness of agricultural institutions (Lencucha et al. 2020). Sectoral, short-term, and poorly integrated programs across agencies often fail to create sustainable institutional impacts (Clark et al, 2018). The disconnect between program planning, implementation, and evaluation results in slow institutional strengthening and a lack of responsiveness to farmers' real needs on the ground. Meanwhile, partnerships with offtakers have not yet developed optimally and have not significantly impacted sustainability. Existing partnerships are generally informal and short-term, with no clear contractual arrangements for price, quality, or the continuity of supply. As a result, farmers remain in a weak bargaining position and lack market certainty that could encourage increased production and investment in agricultural businesses (Ncube et al. 2020).

Overall, the analysis shows that improving the sustainability of the institutional aspects of the agricultural sector in Berau Regency requires integrated strengthening, including revitalizing farmer institutions to function as economic institutions, increasing the intensity and quality of extension services based on local needs, establishing consistent and cross-sectoral regulations and priority programs, and developing fair and sustainable business partnerships. This institutional strengthening lays a crucial foundation for the overall economic, social, and environmental sustainability of the agricultural sector.

Technological Aspects

The agricultural sector sustainability index in Berau Regency, based on technology, is at 65.8%, indicating a moderately sustainable condition. Simulation results for future (leveraged) conditions show an increase in the index value to 87.5% (Figure 3), which places it in the highly sustainable category, but it still requires strengthening basic infrastructure to maintain the momentum of sustainable technological transformation. These findings indicate that the adoption of agricultural technology has significantly increased the productivity of key subsectors, despite challenges of unstable electricity access in eight remote sub-districts, limited internet access, and low digital literacy among farmers/livestock farmers.

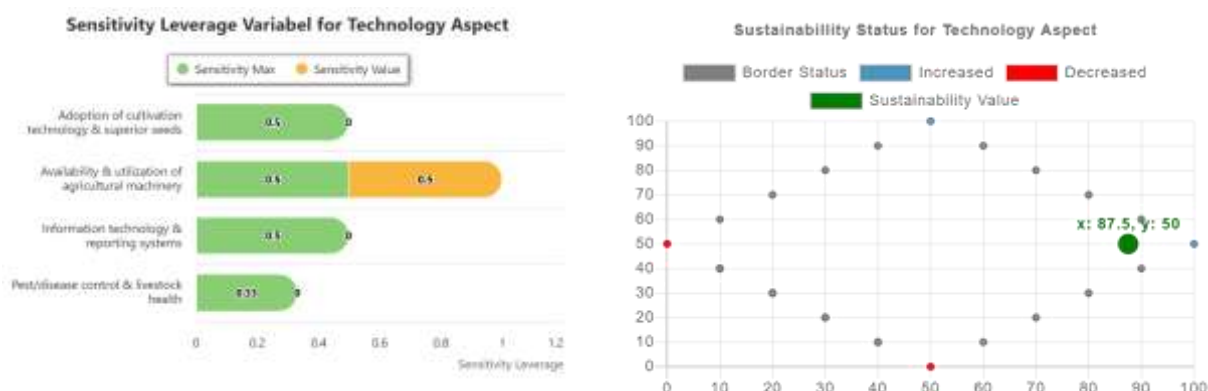


Figure 3. Sensitivity lever variables and sustainability status for technology aspects

The results of the sensitivity leverage analysis show that all technology variables have a maximum sensitivity of 1.0, with the highest leverage on the availability & maintenance of tools (0.5), followed by the adoption of cultivation technology & superior seeds (0.5), information technology & reporting systems (0.5), and livestock pest/disease control (0.33). This condition indicates that aspects of Berau's agricultural technology are closely interconnected with physical infrastructure as the main lever, so that increasing sustainability cannot be achieved through a single intervention but requires a holistic approach that includes agricultural machinery, genetics, digitalization, and sanitation simultaneously (Hollaus et al. 2022). The availability & maintenance of tools are the most critical factor that limits the optimization of agricultural technology in Berau. Only 30% of farmer/breeder groups have access to mini tractors/hedgehogs and 15% semi-permanent cattle pens with mechanical ventilation, while 85% of production still relies on traditional manual tools (hoes, sickles, saws). Damage to agricultural machinery due to muddy terrain in Biatan/Segah District and repair costs of Rp2-5 million/year are beyond the reach of small farmers with land <2 ha. Adoption of cultivation technology & superior seeds is limited to 25% of farmers using BISI-2 hybrid corn seeds/Ciherang rice and Ongole Artificial Insemination (1,000 doses/year Distanak), with 75% still using low-productivity local varieties (corn: 4.5 tons/ha vs. hybrid: 7 tons/ha).

The state of information technology & reporting systems is still very limited, with only 10% of farmer groups actively using WhatsApp market coordination groups and 0% using e-traceability systems for export commodities (beef cattle, LQ=1.18; cayenne pepper). 2G/3G internet connections in Segah/Talisayan District (speed <2 Mbps) and farmers' digital literacy <20% hinder the adoption of agricultural applications such as e-farming Kaltim and market price monitoring. Livestock pest/disease control is weak, with only 5% of farmers routinely vaccinating against FMD/HS, and cayenne pepper pest control remains 80% chemical, without integrated IPM, leading to pesticide residues exceeding export thresholds and increasing thrips pest resistance. Overall, the analysis results show that the sustainability of Berau's agricultural sector technology requires a gradual and integrated strengthening approach that includes: distribution of integrated agricultural machinery packages (mini tractors + level 3 ventilation cages), mass subsidized superior seeds (BISI-2 corn hybrid + Ongole IB 5,000 doses/year), farmer group digitalization training (Tokopedia e-marketplace + blockchain traceability), and an inter-district mobile IPM/veterinary program with land monitoring drones. This holistic approach is the main prerequisite for maintaining an index of >85% (very sustainable), supporting Berau's smart farming transformation based on LQ of superior commodities (beef cattle, cayenne pepper, corn), and strengthening the strategic role of the agricultural sector in food security for the Indonesian Capital City (IKN Nusantara) and sustainable regional economic development (Aprylasari, et al. 2025).

4. Conclusion

A Multiaspect Sustainability Analysis (MSA) of the agricultural sector in Berau Regency revealed that the economic sustainability index was at 42.86% (less sustainable), institutional ~50% (borderline), and technological 65.8% (moderately sustainable), indicating an overall condition that is not yet optimal despite the potential for significant transformation through integrated interventions. The results of the sensitivity leverage analysis with a value of 0.5 evenly across all three aspects indicate a multidimensional and interrelated character, where no single variable is dominant, but rather requires a simultaneous, holistic approach to achieve substantial improvements in the sustainability index. Realistic scenario simulations show the potential for economic growth of up to 50%, while technology has the potential to reach 87.5% (very sustainable), underscoring the urgency of strengthening technology as the main lever followed by NTP stabilization and institutional revitalization. Key structural challenges include long marketing chains, fluctuating NTP of 95-102, limited access to agricultural machinery (30%), minimal extension services, and low digital infrastructure, which collectively hinder the conversion of basic commodity LQ into real economic added value.

Reference

1. Ahmad, A. Y. (2022). Unlocking the potentials of Micro and Small Enterprises (MSEs) in building local technological capabilities in agro-processing industry. *Innovation and development*, 12(2), 279-303.
2. Aprylasari, D., & Toyibulah, Y. (2025). Spatial-Based Livestock Development Strategy in Berau Regency: An Integration of Location Quotient (LQ) and GIS Analysis. *RIGGS: Journal of Artificial Intelligence and Digital Business*, 4(3), 7396-7403.
3. Aprylasari, D., Safitri, A., & Toyibulah, Y. (2025). Beef Cattle Farming Area Planning Based on LQ and GIS Analysis in West Kutai Regency. *Mikroba: Jurnal Ilmu Tanaman, Sains Dan Teknologi Pertanian*, 2(3), 43-57.
4. Ayalew, N. A., & Lema, A. T. (2025). Conflict Risk Monitoring for Conflict Prevention in Ethiopia: The Case of Ataye Townen, North Shewa, Amhara Region. *International Journal of Disaster Risk Management*, 7(1), 177-202.
5. Clark, R., Reed, J., & Sunderland, T. (2018). Bridging funding gaps for climate and sustainable development: Pitfalls, progress and potential of private finance. *Land use policy*, 71, 335-346.

6. Fauré, E., Arushanyan, Y., Ekener, E., Miliutenko, S., & Finnveden, G. (2017). Methods for assessing future scenarios from a sustainability perspective. *European Journal of Futures Research*, 5(1), 17.
7. Grimm, V., Augustiak, J., Focks, A., Frank, B. M., Gabsi, F., Johnston, A. S., ... & Railsback, S. F. (2014). Towards better modelling and decision support: Documenting model development, testing, and analysis using TRACE. *Ecological Modelling*, 280, 129-139.
8. Habiyaemye, A. D., Maziya, M., Chaminuka, P. D., & Mdlulwa, Z. (2017). Smallholder livestock farmers' knowledge, attitudes, practices and perceptions towards vaccinations: The case of five provinces in South Africa.
9. Hollaus, A., Schunko, C., Weissshaidinger, R., Bala, P., & Vogl, C. R. (2022). Indigenous farmers' perceptions of problems in the rice field agroecosystems in the upper Baram, Malaysia. *Journal of Ethnobiology and Ethnomedicine*, 18(1), 26.
10. Koptaeva, G. P., Shinet, G. G., & Agabekova, G. N. (2019). Agricultural economy: development of crop production and its competitiveness. *OF SOCIAL AND HUMAN SCIENCES*, 91.
11. Lencucha, R., Pal, N. E., Appau, A., Thow, A. M., & Drope, J. (2020). Government policy and agricultural production: a scoping review to inform research and policy on healthy agricultural commodities. *Globalization and Health*, 16(1), 11.
12. Ncube, D. (2020). The importance of contract farming to small-scale farmers in Africa and the implications for policy: A review scenario. *The Open Agriculture Journal*, 14(1).
13. Paulus, C. A., Adar, D., Hotty, R. M., Rusdiyanto, E., & Firmansyah, I. (2023). Multi-Aspect Sustainability Analysis of Freshwater Fish Aquaculture In Kupang City of East Nusa Tenggara Province, Indonesia. *Russian Journal of Agricultural and Socio-Economic Sciences*, 140(8), 173-186.
14. Shahbazi, F., Shahbazi, S., & Zare, D. (2025). Losses in Agricultural Produce: Causes and Effects on Food Security. *Food and Energy Security*, 14(3), e70086.
15. Shiferaw, B., Hellin, J., & Muricho, G. (2011). Improving market access and agricultural productivity growth in Africa: what role for producer organizations and collective action institutions?. *Food security*, 3(4), 475-489.
16. Sia, R., Darma, R., Salman, D., & Riwu, M. (2025). Sustainability Assessment of the Arabica Coffee Agribusiness in North Toraja: Insight from a Multidimensional Approach. *Sustainability*, 17(5), 2167.
17. Tondel, F., D'Alessandro, C., & Dekeyser, K. (2022). The effects of major economies' policies on climate action, food security and water in developing countries. *The Netherlands: ECDPM: Maastricht*.