Research Article

Multidimensional Assessment of Feed Corn Farming Sustainability: Ecological, Technological, Social and Economic Insights from South Sulawesi, Indonesia

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Abstract | Feed corn farming is a critical component of Indonesia's agricultural sector and requires comprehensive sustainability assessments across ecological, technological, social, and economic dimensions. This study evaluates the sustainability of feed corn agriculture in Takalar Regency, South Sulawesi, Indonesia, employing a quantitative descriptive survey methodology. Data from 70 feed corn farmers were analyzed using the Rap-Local Animal Feed Corn Farming ordination technique through Multidimensional Scaling (MDS). Results indicate high ecological sustainability, with a sustainability index of 75.18%, a stress value of 0.15, and an R^2 of 0.94, reflecting reliable model performance. Technologically, the farming practices were highly sustainable, achieving an index of 81.75%, accompanied by a stress value of 0.14 and an R^2 of 0.94, highlighting high technological frameworks. The social dimension emerged as the strongest, with a sustainability score of 83.56%, stress value of 0.14, and R^2 of 0.94, indicating significant strength and resilience within social structures. Conversely, the economic dimension scored moderately sustainable at 69.15%, underscoring critical economic vulnerabilities requiring targeted interventions. The sustainability of feed corn farming in Takalar Regency is affirmed, though strategic economic improvements remain essential for ensuring its sustainability. These findings highlight the need for targeted policy interventions that strengthen agro-industry linkages, improve market access, and promote environmentally sustainable practices. A multidimensional sustainability framework should be integrated into regional planning to support long-term resilience in Indonesia's feed corn sector.

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Introduction

Agriculture plays a pivotal role in global food security and economic stability, with corn (*Zea mays L.*) being one of the most important staple crops worldwide. The agricultural sector in Indonesia plays a strategic role in economic development (Rofik *et al*., 2025; Yamin *et al*., 2025). Corn holds significant importance among the key agricultural commodities due to its potential contribution to food security and economic stability (Grote *et al*., 2021). In Indonesia, corn is the primary secondary crop after rice and plays a crucial role in national food consumption patterns. Indonesia's national demand for feed corn is estimated at approximately 15 million tons annually.

In comparison, domestic production is projected to reach 16–17 million tons, supporting government goals of self-sufficiency and reduced import dependence (Antara News, 2025). In addition, total corn production (including feed and other uses) is forecast to reach around 15.5 million tons by 2025, reflecting a stable upward trend (FAO, 2025). The sustainability of corn farming is increasingly critical due to challenges such as climate change, soil degradation, resource limitations, and socio-economic disparities (Arsyad *et al*., 2023; Dugassa *et al*., 2017). Ensuring sustainable agricultural practices is essential for maintaining long-term productivity and environmental resilience while supporting farmers' welfare and market stability.

Corn production is heavily influenced by ecological, technological, social, and economic factors. The ecological dimension relates to agro-ecosystem stability, water availability, waste management, and biodiversity conservation (Quintero *et al*., 2022). Sustainable farming practices, including crop diversification, precision agriculture, and efficient resource management, are essential for mitigating environmental risks. The technological dimension plays a crucial role in improving productivity through advancements in seed selection, mechanization, production management, and post-harvest processing (Di Bene *et al*., 2022). Adoption of innovative agricultural technologies can enhance efficiency, reduce losses, and increase farmers' adaptability to climate change. The social dimension is fundamental to agricultural sustainability, encompassing labor availability, community participation, farmer collaboration, and social capital development (Ruzzante *et al*., 2021). Empowering farming communities through knowledge transfer, cooperatives, and stakeholder engagement can foster resilience and enhance sustainable farming practices. Meanwhile, the economic dimension significantly impacts farmers' income, market accessibility, production costs, and financial support (Maryono *et al*., 2024). Sustainable feed corn farming requires a stable price structure, improved value chain integration, and investment in agricultural infrastructure to ensure long-term profitability and food security (Viana *et al*., 2022).

Takalar Regency is one of the leading corn-producing regions in South Sulawesi, recognized for its high-quality corn production. Corn farming serves as a key economic driver in the region, particularly in Galesong District, where production reached 23,450 tons in 2016, significantly surpassing other districts that averaged 4,000 tons per year (Statistics Indonesia, 2023). However, in recent years, Takalar's corn production has experienced fluctuations, with 82,228.70 tons produced in 2019, followed by a 19.3% decline in 2020 and an additional 1.7% decrease in 2022 (Statistics of Indonesia, 2023). These fluctuations in production and market prices directly impact farmers' livelihoods, affecting income stability, supply chain dynamics, and overall agricultural economic performance. A comprehensive sustainability assessment is essential to ensure the long-term viability of feed corn farming (Muhie, 2022). This study aims to evaluate the sustainability of feed corn farming by assessing key indicators across four dimensions: ecology, technology, social, and economic, using a quantitative analytical approach. The technological dimension focuses on adopting improved farming techniques, mechanization, seed selection, and post-harvest management, which are crucial for enhancing productivity and resilience. The social dimension explores the role of labor availability, community participation, farmer collaboration, and social well-being. In contrast, the economic dimension assesses factors such as farmer income, market access, pricing stability, and financial support mechanisms.

The use of the Multidimensional Scaling (MDS) approach also strengthens the appropriateness of this study, offering a replicable and robust methodology to assess sustainability in similar agricultural contexts. The findings provide critical insights into the current sustainability status of feed corn farming in Takalar Regency and identify areas that require targeted interventions. This research will offer data-driven recommendations for policy enhancements, agricultural development strategies, and resource management improvements by analyzing sustainability across these dimensions. Strengthening sustainable agricultural practices will contribute to the economic resilience of farming communities and enhance regional and national food security.

Materials and Methods

Study area and duration

This study was conducted in Takalar Regency, South Sulawesi, Indonesia, over a three-month period from February to April 2024. The study sites were Galesong Utara and Polongbangkeng Selatan sub-districts, selected using a purposive sampling approach due to their status as the largest corn-producing areas in Takalar Regency, which itself is a major national corn production center.

Research design and sampling

This study employed a survey research design with a quantitative descriptive approach, which is suitable for analyzing relationships between variables and testing hypotheses (Holton and Burnett, 2005). The respondent sample consisted of 70 feed corn farmers, selected through a random sampling technique. Additionally, nine key informants were identified and interviewed for in-depth insights, comprising two representatives from formal institutions, three from informal institutions, and four farmer group leaders.

Data collection and analysis

Data for this study were collected through structured interviews using a standardized questionnaire designed to assess the sustainability performance of feed corn farming in Takalar Regency. The instrument was developed to capture farmers' experiences, perceptions, and practices across four key sustainability dimensions: ecological, technological, social and economic. Identifying sustainability indicators was grounded in relevant literature and expert validation, resulting in 24 attributes, with six attributes assigned to each dimension.

Ecological dimension: (a) Corn plant suitability with agro-ecosystem, (b) Efficient water availability, (c) Waste reduction, (d) Sustainability improvement through production diversification, (e) Farmer involvement in environmental management, (f) Mixed cropping techniques;

- Technological dimension: (a) Seed selection, (b) Land management, (c) Mechanization, (d) Production management, (e) Technological modifications, (f) Harvesting and processing;
- Social dimension: (a) Labor availability, (b) Family participation, (c) Community participation, (d) Farmer income, (e) Farmer-to-farmer collaboration, (f) Success rate of feed corn farming;
- Economic dimension: (a) Farmer income, (b) Feed corn product prices, (c) Feed corn product quality, (d) Availability of feed/food industries, (e) Market availability, (f) Access to financing.

Statistical analysis

The sustainability data were analyzed using the rapid appraisal for local animal feed corn farming technique, based on the Multidimensional Scaling (MDS) approach. This technique allows for exploring complex relationships among sustainability indicators across four key dimensions: ecological, technological, social, and economic. The following analytical steps and tools were applied:

MDS Method and Statistical Tool: Kruskal's MDS / Non-Metric MDS was employed as the core analytical method. This approach uses ordinal data (ranked attributes) and is especially suited for handling non-linear relationships.

Software: The analysis was performed using the RAP-MDS (Rapid Appraisal for Multidimensional Scaling) platform. Developed using Excel VBA Macros, RAP-MDS is widely used in sustainability assessments, including tools such as Rapfish (fisheries), RapLivestock (animal farming), and Rapgroundwater (water resource management). It is particularly effective for evaluating ecological, social, economic, technological, and institutional dimensions.

Analytical steps

Identification of Attributes: A total of 24 sustainability attributes (6 per dimension) were identified based on literature and field relevance.

Ordination and Sustainability Index Classification: MDS was used to produce sustainability indices for each dimension, ranging from 0 to 100, and classified as:

$0.00 < x \leq 25.00$: Unsustainable
$25.01 < x \leq 50.00$: Less sustainable
$50.01 < x \leq 75.00$: Moderately sustainable
$75.01 < x \leq 100.00$: Highly sustainable

Visualization: Index scores were visualized using kite diagrams to show sustainability performance across the four dimensions.

Euclidean Distance Ordination: The MDS ordination was constructed using Euclidean Distance to plot the relative position of indicators in n-dimensional space. Model Fit and Validation: Stress value (S-Stress): A value below 0.25 ($S < 0.25$) indicated a good fit. Coefficient of determination (R^2): Values close to 1 indicate that the selected attributes explained most of the variation in sustainability scores.

Results

Sustainability of feed corn farming based on the ecological dimension

Figure 1 illustrates the sustainability index of feed corn farming in Takalar Regency based on the ecological dimension, highlighting its relative sustainability level.

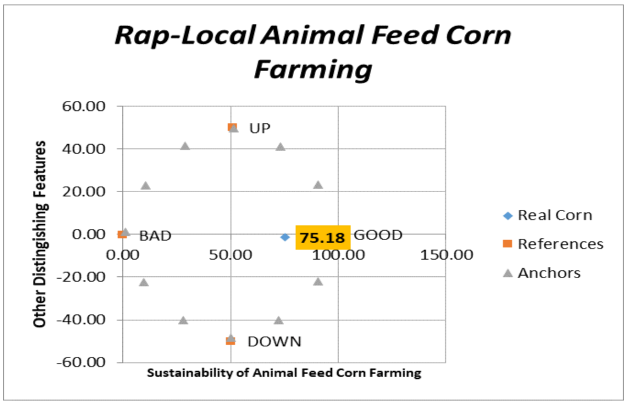

Figure 1: *Sustainability index of feed corn farming based on the ecological dimension*

The analysis using the Rap-Local Animal Feed Corn Farming method indicates that the sustainability index of feed corn farming in Takalar Regency, based on the ecological dimension, is 75.18%. According to the sustainability classification ($75.01 < x \leq 100.00$), this score suggests that the region's ecological sustainability of feed corn farming is highly sustainable. The stress value of the model is 0.15, which is below the acceptable threshold of 0.25.

Figure 2 shows that waste reduction has the highest influence (5.83) on ecological sustainability, indicating that minimizing agricultural waste is crucial for maintaining environmental balance. Production diversification (5.82) and farmer involvement in environmental management (4.98) also play significant roles, suggesting that increasing crop variety and engaging farmers in sustainable practices can enhance ecological sustainability. Meanwhile, efficient water availability (4.79), corn suitability with the agro-ecosystem (2.73), and mixed cropping techniques (2.66) have lower leverage values, implying that while they contribute to sustainability, their impact is not as strong as waste reduction. These results highlight the importance of waste management and diversified farming practices in ensuring sustainable feed corn farming.

Sustainability of feed corn farming based on the technological dimension

Figure 3 presents the sustainability index of feed corn farming based on the technological dimension in Takalar Regency.

The analysis using the Rap-Local Animal Feed Corn Farming method indicates that the sustainability index of feed corn farming in Takalar Regency, based on the technological dimension, is 81.75% ($75.01 < x \leq 100.00$), signifying a highly sustainable level. The stress value obtained is 0.14, which is below the acceptable threshold of 0.25.

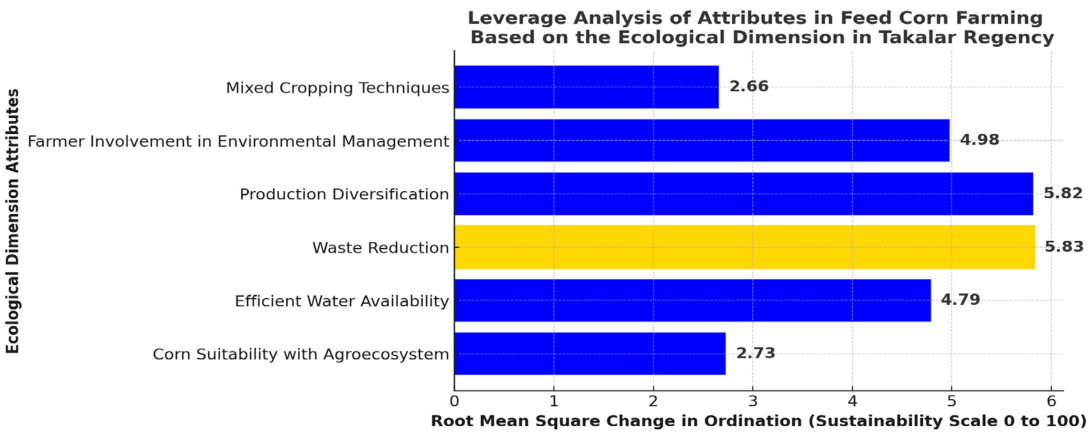

Figure 2: *Leverage analysis of attributes based on the ecological dimension regency*

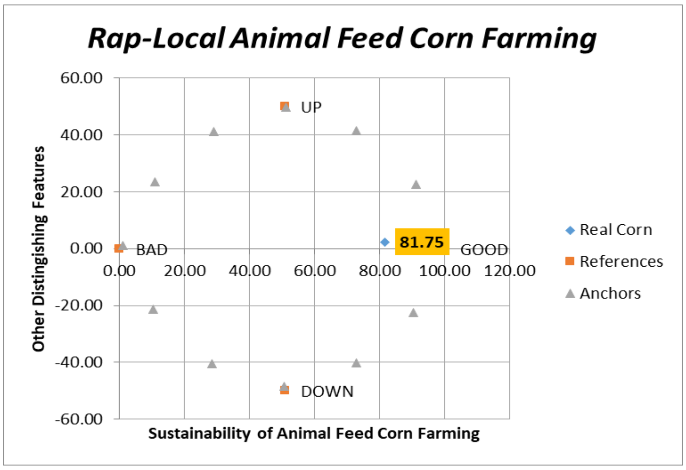

Figure 3: *Sustainability index of feed corn farming based on the technological dimension*

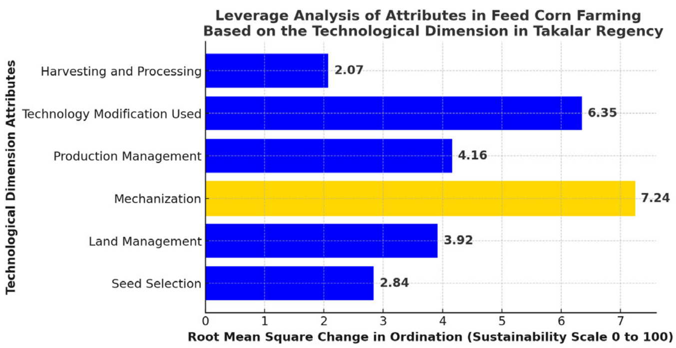

Figure 4: *Leverage analysis of attributes based on the technological dimension*

Figure 4 illustrates that mechanization has the highest influence (7.24) on sustainability, meaning that improving farming equipment and automation is crucial for better productivity. Technology modification (6.35) and production management (4.16) also play important roles in sustainability, indicating the need for modern farming techniques. On the other hand, harvesting and processing (2.07) and seed selection (2.84) have lower impacts, suggesting they are less critical compared to mechanization. These results highlight the importance of investing in advanced technology and better farm management to improve sustainability in feed corn farming.

Sustainability of feed corn farming based on the social dimension

Figure 5 presents the sustainability index of feed corn farming based on the social dimension in Takalar Regency. The analysis using the Rap-Local Animal Feed Corn Farming method indicates that the sustainability index of feed corn farming in Takalar Regency, based on the social dimension, is 83.56% ($75.01 < x \leq 100.00$), signifying a highly sustainable level. The stress value obtained is 0.14, which is below the acceptable threshold of 0.25.

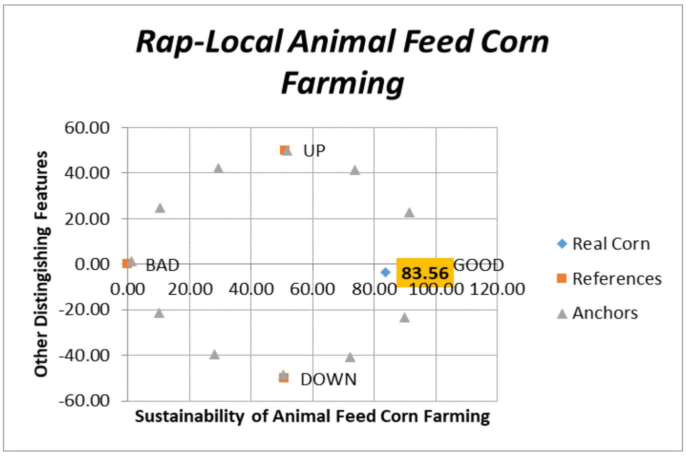

Figure 5: *Sustainability index of feed corn farming based on the social dimension*

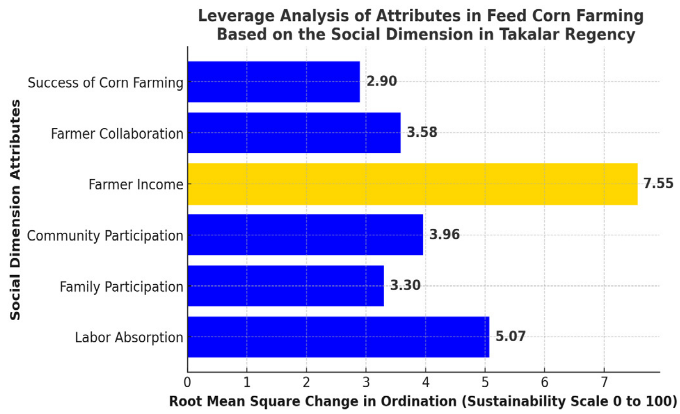

Figure 6: *Leverage analysis of attributes based on the social dimension*

Figure 6 highlights that farmer income has the highest influence (7.55) on the sustainability of feed corn farming, indicating its critical role in the well-being of farmers and the overall agricultural economy. This suggests that improving income stability through better market access, price regulation, and financial support can significantly enhance the social sustainability of farming communities. Additionally, labor absorption (5.07) and community participation (3.96) also play significant roles, emphasizing the importance of job creation and community engagement in sustaining agricultural livelihoods. Farmer collaboration (3.58), family participation (3.30), and the success of corn farming (2.90) have relatively lower leverage values, indicating that while they contribute to social sustainability, their impact is less pronounced compared to farmer income.

Sustainability of feed corn farming based on the economic dimension

Figure 7 presents the sustainability index of feed corn farming based on the social dimension in Takalar Regency.

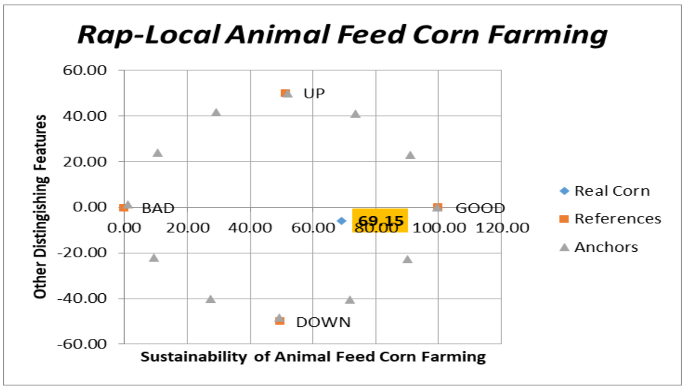

Figure 7: *Sustainability index of feed corn farming based on the economic dimension*

The analysis using the Rap-Local Animal Feed Corn Farming method indicates that the sustainability index of feed corn farming in Takalar Regency, based on the economic dimension, is 69.15% (50.01 < x ≤ 75.00), signifying a moderate level of sustainability. The stress value obtained is 0.15, which is below the acceptable threshold of 0.25.

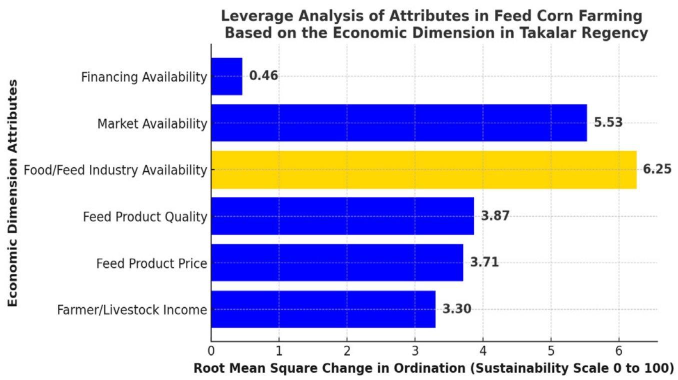

Figure 8: *Leverage analysis of attributes based on the economic dimension*

Figure 8 illustrates the leverage analysis of attributes in feed corn farming based on the economic dimension in Takalar Regency. The results indicate that food/feed industry availability (6.25) is the most influential factor in economic sustainability, highlighting the importance of a strong processing industry to ensure market stability and demand for farmers' produce. Market availability (5.53) also plays a key role, as accessible and competitive markets enhance farmers' economic resilience. Other factors, such as feed product quality (3.87) and feed product price (3.71), contribute to sustainability by ensuring product competitiveness and profitability. Meanwhile, farmer/livestock income (3.30) has a moderate impact, suggesting that broader market and industry conditions shape economic stability. The least influential factor is financing availability (0.46), indicating that financial support plays a minimal role, possibly due to alternative funding sources or self-sufficient farming practices.

Sustainability model of feed corn farming in dimensions

Figure 9 presents the sustainability index of feed corn farming based on ecological, technological, social, and economic dimensions in Takalar Regency.

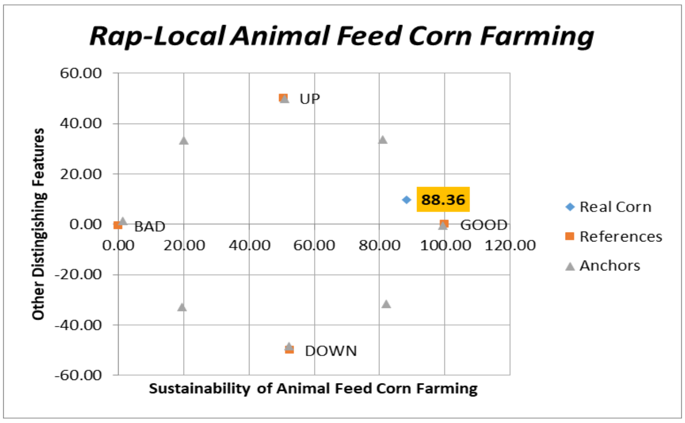

Figure 9: *Sustainability index of feed corn farming based on ecological, technological, social, and economic dimensions*

The analysis conducted using the Rap-Local Animal Feed Corn Farming method indicates that the sustainability index of feed corn farming in Takalar Regency—assessed across ecological, technological, social, and economic dimensions- reached 88.36% (75.01 < x ≤ 100.00), classifying it as highly sustainable. The stress value of 0.16, which falls below the acceptable threshold of 0.25, suggests that the model is reliable, experiences minimal distortion, and can be categorized as robust due to its low stress value.

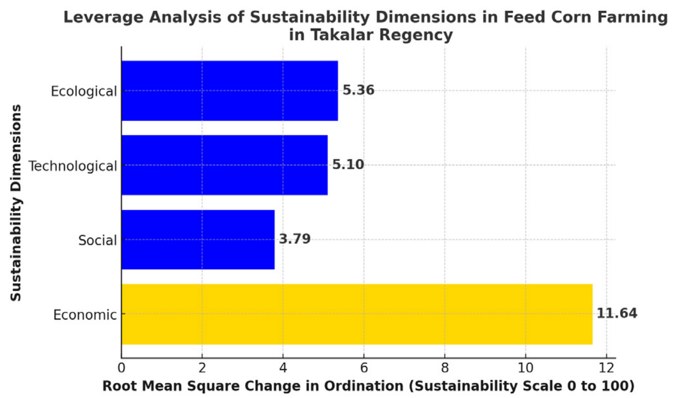

Figure 10: *Leverage analysis of attributes based on ecological, technological, social, and economic dimensions*

Figure 10 illustrates that the economic dimension (11.64) has the highest influence, showing that market access, industry support, and stable pricing are key to sustainability. The ecological (5.36) and technological (5.10) dimensions also play important roles, highlighting the need for better resource management and farming technology. The social dimension (3.79) has the lowest impact, suggesting that while community participation is important, economic and technological factors are more crucial for sustainability.

Discussion

Ecological sustainability of Feed Corn Farming in Takalar Regency, indicating that minimizing agricultural waste is crucial for maintaining environmental balance. One of the most effective strategies for reducing waste is the utilization of corn residues. Corn leaves can also serve as animal feed (Mujnisa *et al*., 2019) or be converted into organic compost to improve soil fertility. Meanwhile, corn cobs, which are often discarded, have potential uses in biogas production, as an alternative energy source, or as materials for handicrafts and biodegradable products (Lee *et al*., 2022). Another essential approach is adopting waste processing technologies, such as composting, biogas production, and livestock feed processing. Composting organic waste enriches soil quality and serves as a natural fertilizer for subsequent planting seasons (Hasan *et al*., 2019). Similarly, biogas production from corn stalks and cobs provides an alternative energy source while reducing methane emissions.

Additionally, drying and processing corn plant residues into animal feed enhances livestock nutrition and reduces agricultural waste (Kukwa *et al*., 2022). Reducing chemical inputs is a further step in sustainability (Hasan *et al*., 2019; Syaiful *et al*., 2025; Utamy *et al*., 2025). Limiting the excessive use of chemical fertilizers and pesticides helps mitigate chemical waste accumulation in the environment.

Implementing organic farming practices and biological pest control methods promotes a more sustainable agricultural system with minimal environmental impact (Gamage *et al*., 2023). Integrating corn cultivation with other crops in an agroforestry system is another important method for enhancing soil health and reducing agricultural waste. Implementing cover crops and soil-protecting plants minimizes soil erosion and optimizes nutrient retention, ensuring long-term sustainability (Fahad *et al*., 2022). Lastly, waste processing for commercial products offers opportunities for sustainable economic development. Corn waste can be repurposed into commercially valuable products, such as bioplastics or eco-friendly packaging materials, reducing reliance on fossil-based plastics. These innovations contribute to waste reduction and create economic opportunities for farmers and agribusinesses (Forfora *et al*., 2024). A study by Liew *et al*. (2021) on agricultural waste management in maize farming highlighted that effective utilization of corn residues significantly reduces environmental pollution while increasing economic benefits for smallholder farmers. Similarly, research by Ingrao (2019) emphasized that integrated biogas systems using corn biomass enhance farm sustainability and provide alternative energy sources for rural communities. These findings align with the current study, suggesting that sustainable waste management strategies can lead to environmental conservation and economic gains for farmers. With these techniques, waste from the maize crop can be minimized and create opportunities to increase added value for farmers and communities (Halliru *et al*., 2020; Widiayani *et al*., 2025). The results indicate that effective waste management in feed corn farming is essential for enhancing ecological sustainability. Implementing waste reduction strategies, sustainable farming practices, and technological innovations can significantly improve resource efficiency, minimize environmental degradation, and support long-term agricultural sustainability in Takalar Regency.

Mechanization is the most sensitive attribute affecting the sustainability of corn farming in Takalar Regency. Implementing mechanization allows farmers to reduce labor dependency, optimize agricultural operations, and improve crop yields (Olatunji *et al*., 2022). The various mechanization techniques adopted in feed corn farming include land preparation, planting, fertilization, irrigation, weed control, harvesting, drying, and transportation. Tractors, plows, cultivators, and rotavators improve soil preparation and aeration, ensuring optimal conditions for plant growth. Similarly, mechanized planters and seed drills enable precise and uniform seed distribution, reducing seed wastage and increasing efficiency in large-scale farming operations. In fertilization, fertilizer spreaders ensure even nutrient distribution, preventing overuse and enhancing soil fertility. In addition to improving productivity, mechanized irrigation systems, such as drip and pump systems, enhance water-use efficiency, conserving water resources while maintaining optimal soil moisture levels (Liang *et al*., 2023).

Furthermore, weed control technologies, including weed cutters and herbicide sprayers, help reduce weed competition, ensuring healthier crop growth (Hasan *et al*., 2019). Mechanization also plays a crucial role in harvesting and post-harvest processing, with corn harvesters and shellers streamlining operations, minimizing labor dependency, and reducing post-harvest losses. Corn dryers facilitate efficient moisture reduction, preventing spoilage and ensuring more extended storage. At the same time, tractors and trailers improve supply chain logistics by efficiently transporting harvested corn to markets or storage facilities (Nath *et al*., 2024). A study by Emami *et al*. (2018) emphasized that agricultural mechanization increases land and labor productivity, leading to greater food security and economic stability in developing regions. Similarly, Sun *et al*. (2024) demonstrated that mechanization significantly reduces production costs while increasing yield stability, aligning with the observed benefits in Takalar Regency.

Furthermore, Getahun *et al*. (2024) highlighted that precision agriculture technologies improve farm sustainability and resilience to climate variability, supporting the role of technological advancements in sustainable agriculture. The findings highlight that mechanization significantly enhances productivity, reduces resource waste, and improves agricultural output. Mechanized farming reduces post-harvest losses, optimizes resource use, and minimizes labor shortages, contributing to a more resilient and economically viable agricultural system.

The social sustainability of feed corn farming in Takalar Regency is significantly affected by income stability, which impacts other social factors, including labor availability, community participation, and farmer collaboration. This aligns with previous studies conducted by Hoàng (2021), which emphasize that stable income sources enable farmers to invest in better agricultural practices, enhance productivity, and improve overall livelihood conditions. Low and unstable incomes may lead to increased vulnerability, reduced agricultural investments, and a higher dependency on external support. The role of labor absorption and community participation suggests that feed corn farming is not only an economic activity but also a social mechanism that supports employment and community resilience (Mursidin and Suarda, 2020). Davis *et al*. (2017) argued that agricultural employment is vital for rural economies, especially in developing regions with limited job diversification. Enhancing labor opportunities through mechanization, skills training, and rural infrastructure development can further improve sustainability (Rasyid *et al*., 2019). Farmer collaboration and family participation also contribute to sustaining agriculture, though their impact is comparatively lower. Sarie *et al*. (2024) highlighted that farmer networks improve market access and technology adoption, yet the effectiveness of these collaborations often depends on institutional support and resource availability. Similarly, family-based farming, while essential, is gradually declining due to modernization and labor migration trends. The success of family farming does not lie in "specialization" or profit maximization but rather in agricultural practices that fulfill the diverse needs of the household, rather than solely responding to market opportunities (Chao, 2024). The relatively lower leverage value of the success of corn farming indicates that farming success alone does not directly determine social sustainability. Instead, external factors such as market conditions, weather variability, and government policies significantly influence farming outcomes. Sanyaolu and Sadowski, (2024) suggest that agricultural sustainability depends on external support systems, including price stabilization policies and credit access for farmers. This result highlights that income stability, employment generation, and social participation are key factors in ensuring the social sustainability of feed corn farming. Policies to improve market access, financial support, cooperative farming structures, and rural job creation are essential for enhancing long-term agricultural sustainability in Takalar Regency.

The economic sustainability of feed corn farming in Takalar Regency is significantly influenced by industry and market-related factors. The leverage analysis results indicate that food/feed industry availability plays the most crucial role, suggesting that a well-established processing industry enhances economic stability by providing consistent demand and value addition for farmers. A strong agro-processing industry ensures that corn production remains viable and profitable, reducing reliance on fluctuating raw commodity markets (Agus and Widi, 2018). This finding aligns with previous research by Diao *et al.* (2019), emphasizing that integrating agricultural production with agro-industrial processing boosts profitability and reduces post-harvest losses. Farmers may face market saturation during peak harvest seasons without proper processing infrastructure, leading to price declines and increased spoilage rates (Urugo *et al*., 2024). Similarly, market availability emerged as a key factor, reinforcing the importance of accessible and competitive markets in ensuring stable income for farmers (Mulia and Suarda, 2019). Strong market linkages allow farmers to sell their produce at fair prices and reduce their dependency on intermediaries, often reducing farmers' bargaining power (Ibikoule *et al*., 2024). This aligns with the findings of Saikanth *et al*. (2024), which highlighted that well-functioning supply chains and strong market linkages enhance agricultural sustainability. Ensuring efficient market accessibility can help stabilize farm incomes and encourage investment in better farming practices. The study also identified feed product quality and price as relevant factors, emphasizing that product competitiveness directly impacts profitability. High-quality feed products are essential for maintaining demand in the livestock industry, where buyers prioritize nutrient-rich, contamination-free feed (Suarda *et al*., 2020). Pratomo (2023) suggested that maintaining high feed quality enhances long-term market demand and farmer income and ensures compliance with industry standards that can facilitate exports and broader market access. Similarly, competitive pricing remains a determining factor in the economic success of corn farming, as price fluctuations can significantly impact profitability, particularly for smallholder farmers.

In contrast, farmer/livestock income had a relatively lower leverage effect, indicating that income stability largely depends on external factors such as industry support, supply chain efficiency, and market access rather than individual productivity. This is consistent with studies by Choi and Lee (2023), which found that improving market structures and industry collaboration is more effective in increasing farm incomes than direct financial aid. When farmers have access to well-organized value chains, they are more likely to receive fair prices and benefit from long-term economic stability (Vroegindewey and Hodbod, 2018). Interestingly, financing availability was the least influential factor, suggesting that access to formal credit has a minimal impact on economic sustainability (Suarda *et al*., 2024). This may indicate that farmers rely more on traditional financial resources, informal lending, or reinvestment from farm revenues rather than external financial assistance. Smallholder farmers often prioritize practical support, such as subsidies and training, over financial aid to improve farm productivity and resilience (Tofu and Wolka, 2023). This finding suggests that policymakers should focus more on improving production efficiency and strengthening industry connections rather than simply increasing credit access. This study emphasizes that strengthening agro-industrial linkages, ensuring stable market access, and maintaining competitive feed product quality are crucial strategies for enhancing the economic sustainability of feed corn farming in Takalar Regency. Future policies should improve supply chain efficiency, foster industry partnerships, and develop infrastructure to support value-added processing. Developing localized feed processing units, investing in transportation networks, and expanding digital market access platforms can further strengthen economic sustainability and ensure long-term resilience for farmers in the region.

The findings indicate that the economic dimension significantly impacts the sustainability of feed corn farming in Takalar Regency. This suggests that factors such as market access, industry support, and pricing stability are essential in ensuring the long-term viability of corn farming. A strong agro-industry can create consistent demand and value addition for farmers, enhancing profitability and reducing financial risks. This aligns with previous research by Urugo *et al*. (2024), highlighting that integrating agricultural production with agro-industrial processing significantly improves farm profitability and minimizes post-harvest losses. The technological and ecological dimensions also play crucial roles in sustainability (Bhambri and Bajdor, 2025). Mechanization and improved agricultural technologies contribute to increased productivity and efficiency, while sustainable land and water management practices ensure long-term resource availability (Cao *et al*, 2024; Huang and Wang, 2024). Agricultural mechanization enhances land and labor productivity, leading to greater food security and economic stability. Similarly, Sanyaolu & Sadowski (2024) found that precision agriculture technologies improve farm resilience to climate variability, supporting the role of technological advancements in sustainable farming. The social dimension had the least impact, suggesting that while community engagement and farmer collaboration are important, economic and technological improvements drive sustainability more effectively. Smallholder farmers benefit more from structured market systems and industrial support rather than direct financial assistance, reinforcing the importance of economic infrastructure over social factors (Fan and Rue, 2020) Additionally, financing availability was found to be the least influential factor, implying that farmers in Takalar rely more on traditional financial systems, reinvestment, or informal lending rather than formal credit. Ibikoule *et al.* (2024) similarly observed that smallholder farmers prioritize practical support such as subsidies and technical training over financial aid to improve farm productivity and resilience.

Although this study was conducted in Takalar Regency, its findings have broader significance for feed corn farming across Indonesia. Feed corn is an essential component of the national livestock sector, and many of the challenges identified in Takalar, such as limited mechanization, unstable market access, and inefficient use of agricultural waste, are also experienced by farmers in other regions. As a result, the insights gained from this research can help inform sustainability efforts beyond the local level. The study applies a multidimensional approach by evaluating ecological, technological, social, and economic factors using the Multidimensional Scaling (MDS) method. This approach provides a structured and practical framework for other districts or provinces to assess their feed corn sustainability. It offers local findings and a model that can support national-level planning and policy development in agriculture. In line with Indonesia's goals for sustainable farming and rural development, this research highlights strategies that can be adopted more widely. These include promoting better waste management, improving access to agricultural technology, strengthening connections with processing industries, and ensuring stable markets. In this way, the study contributes to a larger conversation about building a more sustainable and resilient feed corn sector throughout the country.

Conclusions and Recommendations

Economic and technological factors strongly influence the sustainability of feed corn farming in Takalar Regency. The economic dimension, particularly the availability of agro-industrial support and market access, emerged as the most critical driver of sustainability, followed by mechanization under the technological domain. Ecological practices, especially waste reduction, further support long-term viability. In contrast, social aspects and financing access showed relatively lower influence. Strengthening value chains, advancing farm technology, and promoting sustainable environmental practices are essential to enhancing the region's resilience and sustainability of feed corn farming systems. The integration of agro-industry, efficient mechanization, and environmentally conscious practices positions Takalar Regency as a model for sustainable agricultural development. Continued investment in market infrastructure, technological advancements, and ecological management will be key to maintaining and enhancing the long-term sustainability of feed corn farming. Based on the findings of this study, the following policy recommendations are proposed:

Strengthen agro-industrial linkages by establishing local feed processing units and encouraging partnerships between farmers and agro-industrial actors. This will enhance value addition, stabilize prices, and reduce post-harvest losses.

Promote the adoption of agricultural mechanization and innovative technologies through targeted subsidies, farmer capacity-building programs, and improved access to machinery. Mechanization should prioritize critical stages such as land preparation, planting, irrigation, and post-harvest handling.

Support environmentally sustainable practices by investing in waste management technologies such as composting and biogas production. Utilizing corn residues as organic inputs or alternative energy sources will reduce environmental degradation and improve soil fertility.

Improve rural market infrastructure and supply chain efficiency by expanding storage facilities, transportation networks, and digital trading platforms. Strengthening market access will reduce dependence on intermediaries and ensure fairer returns for farmers.

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Novelty Statement

The study provides original insights into the dominant role of economic and technological dimensions in shaping sustainability outcomes and highlights the limited impact of social and financial factors. These findings contribute new empirical evidence for sustainable agriculture and development of more targeted policies and interventions for resilience-building in smallholder farming systems.

Author's Contribution

Andi Suarda: Conceived, design the research work and write the manuscript.
Apiaty Kamaluddin: Assisted in the experimental design, data interpretation.
Annisar Dzati Iffah: contributed to data compilation, data analysis, and manuscript formatting.
All authors read and approved the final version of the manuscript.

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Generative AI or AI assisted technology statement
The authors declare that no generative artificial intelligence (AI) or AI-assisted tools were used in the writing, data analysis, or preparation of this manuscript. All content, interpretations, and conclusions presented in this article are entirely the work of the authors.

Conflict of interest
The authors declare that there is no conflict of interest among the authors of the manuscript.

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