

Sustainable Development Strategy for Moringa (*Moringa oleifera* Lam.) Agribusiness on Drylands in North Lombok Regency

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Received: May 7, 2026

Revised: September 6, 2026

Accepted: September 29, 2026

Published: September 30, 2026

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DOI: [10.29303/jppipa.v12i9.15203](https://doi.org/10.29303/jppipa.v12i9.15203)

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Abstract: North Lombok Regency is an emerging center of moringa cultivation in West Nusa Tenggara Province, where dryland agroecology dominates, yet its agribusiness remains suboptimal across the four sustainability dimensions. This study analyzed the sustainability status of moringa agribusiness, identified leverage attributes, and formulated development strategies through an integrated subsystem approach. Data were gathered from 48 respondents, comprising 40 moringa farmers in three sample villages (Gondang, Salut, and Akar-akar) and 8 key informants (extension officers, academics, small enterprises, and local government), using structured surveys with a 0-3 Likert scale, in-depth interviews, and field observation from October 2025 to February 2026. Multiaspect Sustainability Analysis (MSA) was run in Exsimpro software on four dimensions and five agribusiness subsystems, followed by leverage analysis and SMART-based GAP analysis. Moringa agribusiness was classified as Less Sustainable, with a composite index of 49.86. The environmental dimension scored highest (58.50), followed by social (50.00), institutional (46.60), and economic (44.33). Nineteen sensitive leverage indicators were identified, dominated by production and institutional attributes. Priority strategies covered seedling nurseries, Good Agricultural Practices dissemination, certified processing units, a moringa cooperative, and local regulation.

Keywords: Dryland; Leverage analysis; Moringa; MSA; Sustainability

Introduction

Sustainable agribusiness is a holistic approach to agricultural development that integrates economic, social, environmental, and institutional aspects synergistically in order to achieve long-term welfare. The economic dimension focuses on increasing product value added and value chain efficiency; the social dimension emphasizes human resource capacity and the welfare of farming households; the environmental dimension concerns environmentally friendly cultivation practices and ecosystem conservation; while the institutional dimension covers the strengthening of farmer organizations, coordination among stakeholders, and supportive policies. Indonesia possesses vast dryland areas that require specific

development strategies based on a sustainable agribusiness approach in order to optimize their productive potential (Blundo-Canto et al., 2025).

Moringa (*Moringa oleifera* Lam.) is an adaptive commodity with substantial potential for development in dryland agroecosystems. Moringa is known as The Miracle Tree because of its high nutritional content, comprising 18-20.9 g protein/100 g and 738.9 mg calcium/100 g of dry matter, which gives it highly prospective economic and functional value (Pareek et al., 2023). The global market for moringa products is projected to reach USD 6 billion in 2025, with leaf powder priced at USD 10-25 per kilogram in export markets (Rahman et al., 2024). Moringa grows optimally within a rainfall range of 250-3,000 mm per year and a soil pH of 5-9, including marginal soils of

How to Cite:

Example: Susilawati, S., Doyan, A., Muliyadi, L., & Hakim, S. (2019). Growth of tin oxide thin film by aluminum and fluorine doping using spin coating Sol-Gel techniques. *Jurnal Penelitian Pendidikan IPA*, 1(1), 1-4. <https://doi.org/10.29303/jppipa.v1i1.264>

low fertility (Jattan et al., 2021). Its deep and extensive root system allows the plant to access water and nutrients from deeper soil layers, making it efficient in water use, while the first harvest only 2-3 months after planting makes it highly attractive to dryland farmers (Salsi et al., 2025). El Bilali et al. (2024) further note that the versatility of moringa makes it particularly relevant for developing countries pursuing resilient food systems.

Despite this potential, the development of moringa agribusiness in North Lombok Regency faces problems that constrain sustainability across the four dimensions simultaneously. In the economic dimension, farmers face low productivity, limited capital and processing technology, inefficient value chains, and value added that is largely captured by downstream actors. In the social dimension, the human resource capacity of farmers remains limited, farmer regeneration is low with a predominance of older farmers, and access to market information and technology is still minimal. In the environmental dimension, dryland degradation occurs as a result of inappropriate cultivation practices, while the use of moringa as a conservation crop has not been optimized. In the institutional dimension, farmer organizations such as farmer groups remain weak, coordination among stakeholders is not yet optimal, and no specific policy on moringa development exists at the regional level (Riptanti et al., 2020).

A similar study by (Jasmawadi et al., 2022) in Jerowaru District, East Lombok, using a Multi-Dimensional Scaling (MDS) approach, showed that the sustainability status of the economic dimension had an index of 46.3 and the ecological dimension 39.08, both falling within the less sustainable category. E. S. Yusuf et al. (2022) also applied an MSA approach to assess the sustainability of Arabica coffee agribusiness in West Java and found that the institutional and technological dimensions had the highest leverage values. M. Yusuf et al. (2024) offered an ontological perspective on sustainable dryland agricultural development through the integration of crops and Bali cattle in North Lombok Regency, but did not specifically examine the sustainability of moringa agribusiness through a multi-dimensional approach. The present study differs from previous work in four respects: (1) a specific focus on moringa as an adaptive dryland crop; (2) the use of the MSA method to measure sustainability status quantitatively; (3) a comprehensive analysis of four sustainability dimensions simultaneously; and (4) the formulation of strategies based on integrated development interventions across five agribusiness subsystems.

Based on the complexity of the problems and the development potential described above, this study aimed to: (1) analyze the sustainability status of

moringa agribusiness in North Lombok Regency in the economic, social, environmental, and institutional dimensions using the MSA method; (2) identify the sensitive attributes (leverage factors) that influence sustainability in each dimension in order to determine intervention priorities; and (3) formulate strategies for sustainable moringa agribusiness development through program interventions in five subsystems (input, on-farm, agro-industry, marketing, and supporting) in order to increase the income of dryland farmers in North Lombok Regency.

Method

Research Site and Period

The research was conducted in North Lombok Regency, West Nusa Tenggara Province, from October 2025 to February 2026. The location was selected by purposive sampling on the consideration that North Lombok Regency has representative dryland agroecological conditions with low rainfall and high drought intensity, and is one of the centers of moringa development in West Nusa Tenggara Province. Of the five districts in North Lombok Regency, three districts with moringa development potential were selected on the basis of 2024 data from the Agriculture Office of North Lombok Regency, using the criteria: (1) the presence of active farmers or farmer groups cultivating moringa for at least one year; (2) a significant moringa planting area; (3) representation of the variation in dryland agroecological characteristics; and (4) accessibility that allows intensive data collection. Based on these criteria, Gondang Village (Gangga District), Akar-akar Village (Bayan District), and Salut Village (Kayangan District) were selected as sampling sites.

Unit of Analysis and Determination of Respondents

The unit of analysis was the moringa agribusiness system in North Lombok Regency, covering five subsystems: input (upstream), on-farm, agro-industry (downstream), marketing, and supporting. The population comprised all active moringa farmers in North Lombok Regency, estimated at 100 people. The number of farmer samples was determined using the Slovin formula with a margin of error of 10%, yielding a minimum of 50 farmers. However, considering the limited number of active moringa farmers identified in the field, the farmer sample was set at 40 people selected by purposive sampling with the criteria: (1) actively cultivating moringa for at least one year; (2) owning at least 0.25 hectares of land or 50 productive moringa trees; and (3) willingness to participate as a respondent. In addition to farmers, the study involved 8 key informants selected by snowball sampling for in-depth interviews and expert judgment, consisting of

field agricultural extension officers, academics/researchers in agriculture, moringa processing micro and small enterprise actors, and representatives of the Agriculture Office of North Lombok Regency. The total number of respondents was 48. The distribution of the surveyed farmer respondents is presented in Table 1.

Table 1. Distribution of moringa farmer respondents in the sample villages of North Lombok Regency

Sample Village	District	Number (people)	Sampling Technique
Gondang	Gangga	21	Purposive sampling
Salut	Kayang	10	Purposive sampling
Akar-akar	Bayan	9	Purposive sampling
Total		40	

Source: Agriculture Office of North Lombok Regency (2024) and Irawan et al. (2025)

Types, Sources, and Techniques of Data Collection

The data collected comprised qualitative and quantitative data. Qualitative data covered farmers' perceptions of the sustainability of moringa enterprises, descriptions of cultivation practices, identification of development constraints and opportunities, institutional conditions and government support, and stakeholder views on development strategies. Quantitative data included technical farm data (land area, production, prices), economic data (income, costs, business efficiency), farmer demographic data, and the scores of sustainability indicators in the four dimensions measured on a 0-3 ordinal scale. Primary data were obtained directly from respondents through structured questionnaires, in-depth interviews with key informants, and field observation. Secondary data were obtained from Statistics Indonesia of North Lombok Regency, the Agriculture Office of North Lombok Regency, and relevant scientific literature.

Sustainability Variables and Indicators

Sustainability variables were measured in each agribusiness subsystem using four dimensions (economic, social, environmental, and institutional) with one to two indicators per dimension in each subsystem, resulting in a total of 37 indicators (9 economic, 10 social, 8 environmental, and 10 institutional). The indicators were assessed on a 0-3 ordinal scale (0 = Poor, 1 = Fair, 2 = Good, 3 = Very Good). Indicator selection was synthesized from a literature review (Blundo-Canto et al., 2025; Hidayanto & Fiana, 2024; Jasmawadi et al., 2022; Riyanto et al., 2025; Rosmalah et al., 2025; E. S. Yusuf et al., 2022; Zarei et al., 2021) using the criteria: (1) easy to measure objectively; (2) not overlapping between dimensions;

(3) logical and simple; and (4) relevant to the context of moringa agribusiness on drylands. The economic indicators in each subsystem cover availability, price, productivity, value added, and economic continuity; the social indicators cover ease of access, self-reliance, group participation, and labor involvement; the environmental indicators focus on the suitability of inputs for drylands, conservation practices, resource efficiency, and waste management; while the institutional indicators cover the role of government and extension officers, access to training, support from financial institutions, and the consistency of regional policy.

Data Analysis

Data analysis was carried out in three integrated stages. The first stage was descriptive analysis to describe respondent characteristics (age, sex, education, experience, land area) and the condition of moringa agribusiness in each subsystem, presented as tabulations, frequency distributions, and descriptive statistics. The second stage was Multiaspect Sustainability Analysis (MSA) using Exsimpro software with the Multi-Dimensional Scaling (MDS) ordination technique to compute the sustainability index per dimension and in aggregate, together with leverage analysis to identify sensitive attributes. The sustainability index was calculated as Sustainability Index = (Actual Score/Maximum Score) × 100, while the aggregate index is the arithmetic mean of the indices of the four dimensions. Index values were classified into four classes: 0-25 (Not Sustainable), >25-50 (Less Sustainable), >50-75 (Moderately Sustainable), and >75-100 (Highly Sustainable), following E. S. Yusuf et al. (2022). Indicators with a Sensitivity Value ≥ 0.67 were designated as sensitive indicators and became intervention priorities. Validation of the MSA results used an uncertainty error of less than 20% through Monte Carlo simulation. The third stage was development strategy analysis based on the SMART framework (Specific, Measurable, Achievable, Relevant, Time-bound) through GAP analysis between existing and ideal conditions in each subsystem, producing an intervention strategy matrix that maps leverage attributes, forms of intervention, related subsystems, and targets.

Result and Discussion

Respondent Characteristics

The study involved 48 respondents consisting of 40 moringa farmers (83.33%) and 8 key informants (16.67%), with the key informants comprising 3 field agricultural extension officers, 2 academics/researchers, 2 moringa processing

enterprise actors, and 1 representative of the Agriculture Office. This multi-stakeholder approach is consistent with the principle of MSA, which emphasizes the participation of various stakeholders in assessing the sustainability of a system (E. S. Yusuf et al., 2022). The distribution by sex was dominated by women, with 33 people (68.75%), which reflects the central role of women in the moringa agribusiness value chain in North Lombok Regency, particularly through Women Farmer Groups (*Kelompok Wanita Tani, KWT*) that drive harvesting, post-harvest processing, and the marketing of moringa products. Blundo-Canto et al. (2025) affirm that the participation of women is one of the important indicators in the social dimension of agribusiness sustainability.

The majority of respondents were in the middle productive age group (26-45 years) at 75.00%, the older productive age group (46-65 years) at 20.83%, while the young age group (15-25 years) accounted for only 4.17%. The low participation of the younger generation indicates a farmer regeneration challenge that needs to be anticipated. The education level of respondents was dominated by junior high school graduates (27.08%), primary school graduates (25.00%), and senior high school graduates (22.92%), while higher education graduates accounted for only 12.50%. The relatively low level of education among farmers has implications for the capacity to adopt technology and to manage moringa farming, so that mentoring programs need to be adjusted to the cognitive capacity and empirical experience of farmers. Experience in moringa farming was mostly in the range of 2-5 years (80.00%) and no respondent had more than 5 years of experience, which is consistent with the launch of the West Nusa Tenggara Moringa Flagship Program in 2019. As many as 57.50% of farmers owned less than 0.5 hectares of land and all farmers held self-owned land status (100%), which provides business security and an incentive for long-term investment.

Condition of Moringa Agribusiness by Subsystem

Assessment of the existing condition of moringa agribusiness was carried out in five subsystems using a 0-3 ordinal score, which was then summarized into subsystem scores as input for Exsimpro MSA. A summary of these scores is presented in Table 2.

Table 2. Summary of Exsimpro MSA scores by subsystem and sustainability dimension									
Subsystem	E1	E2	S1	S2	L1	L2	K1	K2	
Input	1	1	2	1	2	2	1	2	
On-farm	1	1	2	1	2	2	1	2	
Agro-industry	1	1	2	1	2	2	1	2	
Marketing	2	2	1	2	1	2	1	1	
Supporting	2	2	1	2	1	1	1	2	

Source: Conversion of tabulated data for Exsimpro MSA input, 2026

Table 2 shows that a score of 1 (low, indicating intervention priority) dominates the economic indicators in the input, on-farm, and agro-industry subsystems (E1 = 1, E2 = 1), as well as the institutional indicator K1, which is consistently valued at 1 across all five subsystems. This pattern indicates that economic weaknesses are concentrated in the upstream and middle segments of the value chain, whereas institutional weaknesses are systemic and evenly spread across all subsystems. Relatively better scores are seen in the environmental indicators (L1, L2), which obtained a value of 2 in the input, on-farm, and agro-industry subsystems, reflecting the natural suitability of moringa to the dryland agroecological conditions of North Lombok Regency. This finding is in line with Duffy et al. (2021), who state that agroforestry systems integrating trees such as moringa are able to increase environmental sustainability significantly on Indonesian drylands through the ecosystem services they generate.

Sustainability Status of Moringa Agribusiness

MSA analysis using Exsimpro software with the MDS ordination technique produced sustainability indices for the four dimensions. The position of the sustainability status of each dimension is visualized in the Exsimpro scatter plots (Figure 1 to Figure 4).

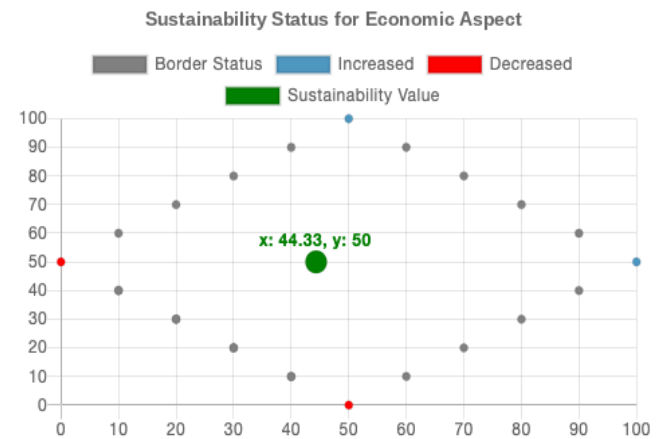


Figure 1. Sustainability status of the economic dimension (MSA Index = 44.33)

Figure 1 presents the scatter plot of the sustainability status of the economic dimension, in which the green point at the coordinates (44.33; 50) shows the position of the economic dimension index within the Less Sustainable quadrant. This value is the lowest index among the four dimensions, which indicates that the economic aspect is the most serious challenge to the sustainability of moringa agribusiness

in North Lombok Regency. The low economic index is caused by several interrelated key factors, namely low moringa leaf productivity in the on-farm subsystem ($E1 = 1$), minimal value added of processed products in the agro-industry subsystem ($E1 = 1$), and limited availability of seedlings and production facilities in the input subsystem ($E1 = 1$; $E2 = 1$). The relative strength of the economic dimension lies only in the marketing subsystem, which shows price stability ($E1 = 2$) and sustained market demand ($E2 = 2$), yet this downstream strength is unable to compensate for the massive weaknesses upstream and in the middle of the value chain. Riyanto et al. (2025) found a similar pattern in the sustainability analysis of rice agribusiness, in which the economic dimension tended to obtain a lower index for commodities managed by smallholders.

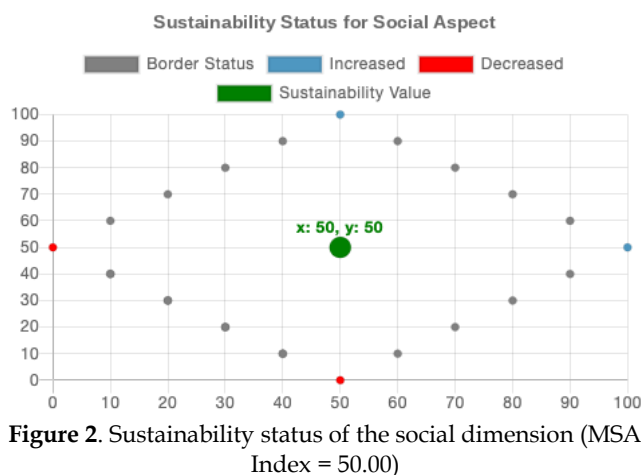


Figure 2 shows the position of the MSA index of the social dimension at the point (50.00; 50), which places it at the lower boundary of the Moderately Sustainable category. Although numerically it has entered the moderately sustainable zone, its position exactly at 50 indicates a fragile condition that could easily fall back into the less sustainable category. The strength of the social dimension lies in the involvement of family labor and the dominance of women along the moringa value chain, from leaf harvesting and drying through to processing and marketing. Weaknesses in the social dimension were identified in the weak participation of farmer groups ($S2$ On-farm = 1), the low role of KWT and small enterprises in processing ($S2$ Agro-industry = 1), and the very low intensity of extension services in the supporting subsystem ($S1 = 1$).

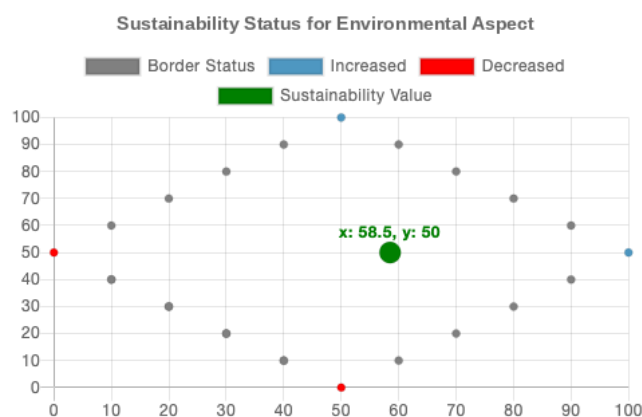


Figure 3. Sustainability status of the environmental dimension (MSA Index = 58.50)

Figure 3 shows the position of the MSA index of the environmental dimension at the point (58.50; 50), which is the furthest to the right compared with the other dimensions and places it in the Moderately Sustainable category. The strength of the environmental dimension is driven by the suitability of moringa to dryland conditions ($L1$ Input = 2; $L1$ On-farm = 2), the good application of soil and water conservation practices ($L1$ On-farm = 2), and the efficiency of water use in cultivation ($L2 = 2$). Salsi et al. (2025) state that moringa inherently supports environmental sustainability in semi-arid regions because of its capacity for soil conservation and water use efficiency, an argument reinforced by Abdoun et al. (2022), who describe moringa as a species that performs well under low input and low rainfall conditions. Weaknesses in the environmental dimension were identified in the use of packaging that is not yet environmentally friendly in the marketing subsystem ($L1 = 1$) and the limited number of government programs related to sustainable agriculture in the supporting subsystem ($L1 = 1$).

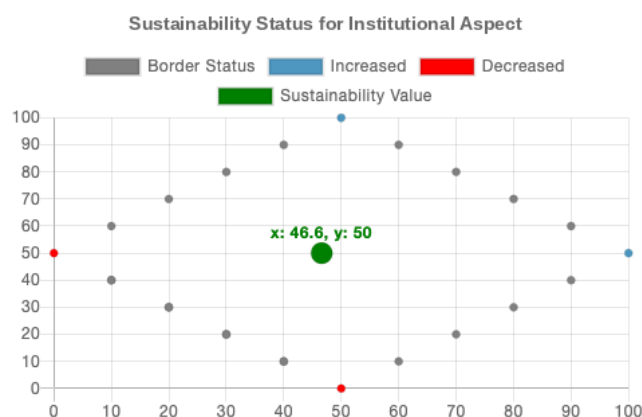


Figure 4. Sustainability status of the institutional dimension (MSA Index = 46.60)

Figure 4 presents the position of the MSA index of the institutional dimension at the point (46.60; 50), which lies in the Less Sustainable quadrant and makes it the second weakest dimension after the economic dimension. The weakness of the institutional dimension is evenly distributed across all subsystems, in which indicator K1 (the active role of government and institutions) consistently obtained a score of 1 in all five subsystems without exception. This consistent pattern of low scores is of serious concern because it shows that institutional weakness is not a partial problem but a structural one that is rooted throughout the moringa agribusiness value chain. (Supriatna et al., 2024) found that institutional weakness is the structural barrier most difficult to overcome in improving the sustainability of smallholder plantations in Indonesia, because it involves governance reform that requires political commitment and a long-time horizon.

The aggregate sustainability status of moringa agribusiness was calculated as the arithmetic mean of the MSA indices of the four dimensions, which produced an index of 49.86. This value places moringa agribusiness in North Lombok Regency in the Less Sustainable category, although it is very close to the threshold of 50 that marks the lower boundary of the Moderately Sustainable zone. A summary of the MSA indices per dimension is presented in Table 3, and the multi-dimensional sustainability profile is visualized in the kite diagram in Figure 5.

Table 3. Summary of MSA indices by dimension and sustainability status

Dimension	MSA Index	Sustainability Status	Rank
Economic	44.33	Less Sustainable	4 (Weakest)
Social	50.00	Moderately Sustainable	2
Environmental	58.50	Moderately Sustainable	1 (Strongest)
Institutional	46.60	Less Sustainable	3
Aggregate	49.86	Less Sustainable	-

Source: Results of Exsimpro MSA analysis, 2026

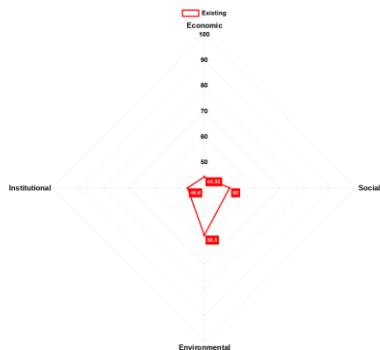


Figure 5. Kite diagram of the sustainability indices of the four dimensions of moringa agribusiness in North Lombok Regency

Figure 5 presents the kite diagram that describes the overall sustainability profile, in which the wider the polygon area, the better the sustainability status of the system. The asymmetric shape of the kite diagram indicates an imbalance between dimensions that needs to be corrected, particularly on the Economic and Institutional axes that pull the polygon inwards. The order of dimensional strength from highest to lowest is: Environmental (58.50) > Social (50.00) > Institutional (46.60) > Economic (44.33). Arias et al. (2024) emphasize that in multidimensional sustainability analysis, improvement in the weakest dimension has a more significant impact on the aggregate index than improvement in dimensions that are already relatively good. Intervention priorities therefore need to be focused on the Economic and Institutional dimensions in order to push the aggregate index beyond the threshold of 50 and to transform the sustainability status of moringa agribusiness in North Lombok Regency from Less Sustainable to Moderately Sustainable.

Sensitive Attributes (Leverage Indicators) by Dimension

The identification of sensitive attributes or leverage indicators is a crucial step in answering the second objective of this research. Leverage analysis was conducted through sensitivity analysis in the Exsimpro MSA tool, in which the Sensitivity Value shows how much the MSA index changes when an indicator is improved. Indicators with a Sensitivity Value ≥ 0.67 were designated as sensitive indicators that become intervention priorities, whereas indicators with a value of 0.33 are not sensitive. Amni et al. (2025) affirm that the identification of leverage indicators is a key step in determining the priority allocation of development resources, a view supported by Rachman et al. (2022), who used sensitive and key factors to direct rice production policy in Indonesia.

Sensitivity Leverage Variables for Economic Aspect

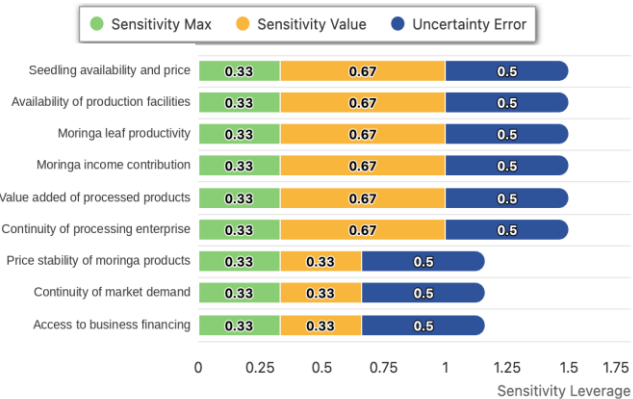


Figure 6. Sensitivity leverage of variables for the economic dimension

Figure 6 presents the sensitivity leverage graph for the economic dimension produced by Exsimpro, in which each horizontal bar shows three components: Sensitivity Max (green), Sensitivity Value (orange), and Uncertainty Error (blue). The results show that 6 of the 9 economic indicators are sensitive with a Sensitivity Value = 0.67, namely: availability and affordability of seedlings (E1 Input), availability of production facilities (E2 Input), moringa leaf productivity (E1 On-farm), the contribution of moringa to household income (E2 On-farm), value added of processed products (E1 Agro-industry), and continuity of the processing enterprise (E2 Agro-industry). A very prominent pattern is that all sensitive indicators are concentrated on the production and processing side (Input, On-farm, and Agro-industry subsystems), whereas the indicators on the marketing and supporting side are not sensitive (0.33). This finding indicates that an increase in the economic index is most effectively achieved through interventions upstream and in the middle of the value chain. (Harisudin & Wida Riptanti, 2024) found that increasing the value added of moringa agro-industry provides a greater economic impact than increasing the marketing volume of fresh products.

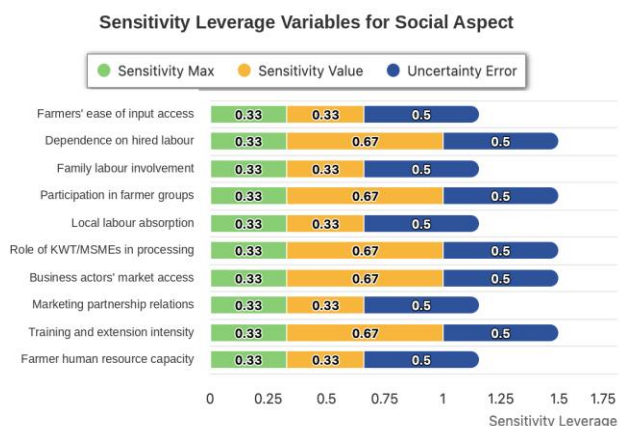


Figure 7. Sensitivity leverage of variables for the social dimension

Figure 7 shows that 5 of the 10 social indicators are sensitive. The sensitive indicators comprise: the level of dependence on hired labor (S2 Input), participation in farmer groups (S2 On-farm), the role of KWT and small enterprises in processing (S1 Agro-industry), access of business actors to markets (S1 Marketing), and the intensity of training and extension (S1 Supporting). These five sensitive indicators point to two main themes: the strengthening of social institutions (participation in farmer groups and the role of KWT) and the widening of access (market access and training intensity). Puspita Anggraeni et al. (2025) state that integrating multidimensional analysis with a

participatory approach can produce development strategies that are more responsive to the needs of farming communities.

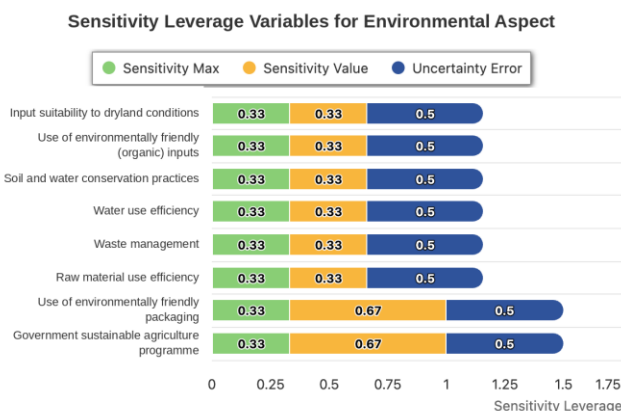


Figure 8. Sensitivity leverage of variables for the environmental dimension

Figure 8 shows that only 2 of the 8 environmental indicators are sensitive, namely the use of environmentally friendly packaging (L1 Marketing) and government programs on sustainable agriculture (L1 Supporting). The small number of sensitive indicators in the environmental dimension reflects that this dimension is already relatively good by nature, in which six indicators directly related to moringa cultivation and processing practices are already in a reasonably adequate condition. Duffy et al. (2021) affirm that agroforestry systems integrating trees such as moringa are able to increase environmental sustainability significantly on Indonesian drylands through the ecosystem services they generate, while El Bilali et al. (2024) note the contribution of moringa to farming system resilience and climate change adaptation. The interventions required in the environmental dimension are minimal but strategic, namely the introduction of environmentally friendly packaging and advocacy for integrating moringa into local government sustainable agriculture programs.

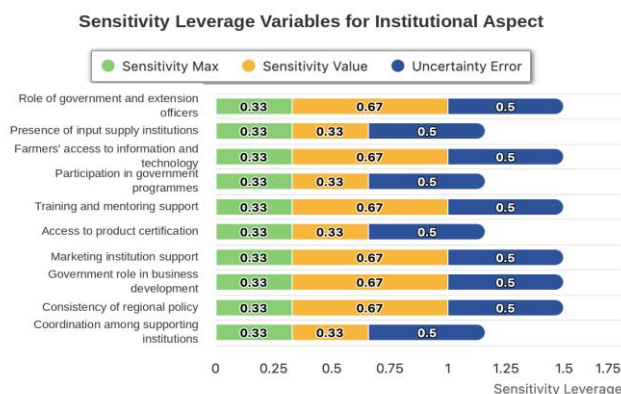


Figure 9. Sensitivity leverage of variables for the institutional dimension

Figure 9 shows that 6 of the 10 institutional indicators are sensitive, with a very prominent pattern in which almost all sensitive indicators are directly related to the active role of government. The sensitive indicators cover: the role of government and extension officers in providing inputs (K1 Input), farmers' access to information and technology (K1 On-farm), support for training and mentoring (K1 Agro-industry), support from financial institutions (K2 Agro-industry), the role of government in market development (K1 Marketing), and the consistency of regional policy (K2 Marketing). Supriatna et al. (2024) emphasize that institutional reform and the strengthening of the capacity of agricultural extension officers are the keys to transforming smallholder plantations from a subsistence condition into sustainable agribusiness. This finding conveys a clear message that without consistent policy support and an active role of local government officials, the institutional dimension of

moringa agribusiness in North Lombok Regency will be difficult to improve significantly.

Sustainable Moringa Agribusiness Development Strategy

The formulation of the sustainable moringa agribusiness development strategy is based on a synthesis of the MSA results, the identification of sensitive attributes, and GAP analysis between existing and ideal conditions in each subsystem. The SMART approach (Specific, Measurable, Achievable, Relevant, Time-bound) was integrated with a model of agribusiness mentoring based on five subsystems (Blundo-Canto et al., 2025; Rahman et al., 2024). Bhagat et al. (2024) emphasize that the success of agribusiness transformation depends heavily on a holistic approach that integrates all system components synergistically. A summary of the GAP analysis and strategy priorities per subsystem is presented in Table 4.

Table 4. Summary of GAP analysis and strategy priorities by moringa agribusiness subsystem

Subsystem	Critical Indicators (Score <= 1)	Largest Gap	Strategy Priorities
Input	E1=1; E2=1; K1=1	E2 (gap of 2 points)	Local seedling nursery; Moringa farm supply kiosk
On-farm	E1=1; E2=1; K1=1	E1 (gap of 2 points)	GAP Farmer Field School; Moringa demonstration plot
Agro-industry	E1=1; E2=1; K1=1	E1 (gap of 2 points)	KWT processing unit; P-IRT facilitation
Marketing	S1=1; L1=1; K1=1	S1, L1, K1 (gap of 2)	Moringa cooperative; Digital marketing
Supporting	S1=1; L1=1; K1=1	S1, L1, K1 (gap of 2)	Cross-agency integrated team; Regional moringa regulation

Source: Synthesis of MSA results, leverage analysis, and GAP analysis, 2026

The intervention strategy in the input subsystem focuses on developing nurseries for superior local moringa seedlings based on farmer groups, with a target of at least one nursery per district and a reduction in seedling prices of up to 30%. At present, moringa farmers in North Lombok Regency rely on seedlings purchased at relatively high prices or obtained traditionally through branch cuttings without quality selection. Keertana et al. (2025) state that the availability of superior seedlings is the main foundation for increasing moringa productivity. The provision of moringa farm supply kiosks in each target village as an integrated center for the distribution of production facilities, training in the independent production of organic fertilizer to achieve input self-reliance, and facilitation of an active role for agricultural extension officers in input management complete the strategy package for this subsystem.

The main strategy in the on-farm subsystem is the dissemination of Good Agricultural Practices (GAP) for dryland-adaptive moringa through Farmer Field Schools that allow farmers to learn directly in the field through a learning by doing approach. A productivity

increase target of 40% within 18 months is realistic given the very low productivity baseline, in which the majority of farmers even gave a score of 0 (Poor) for the productivity indicator. M. Yusuf et al. (2024) state that sustainable dryland agricultural development in North Lombok requires an approach based on local knowledge reinforced by modern technology. The revitalization of active farmer groups with a target of at least one active farmer group per village and 70% of farmers joining, the establishment of moringa demonstration plots together with agricultural extension officers with a target of one demonstration plot per district, and the integration of moringa-food crop agroforestry practices with a target of 30% of farmers applying agroforestry are supporting strategies that are aligned with the principles of the Integrated Farming System (Bhagat et al., 2024; Paramesh et al., 2022).

In the agro-industry subsystem, the development of processing units based on KWT and micro and small enterprises is targeted to produce five active moringa enterprises with P-IRT (household food industry permit) certification within 12 months, accompanied by

facilitation of product quality standardization through P-IRT, BPOM (National Agency of Drug and Food Control), and halal certification. At present, most processed moringa products in North Lombok Regency have neither a distribution permit nor certification, which is a mandatory requirement for entering modern markets such as supermarkets, hotels, and restaurants. Mastuti et al. (2023) report that moringa agro-industry is able to increase the income of processors significantly compared with selling fresh leaves, while Harisudin & Wida Riptanti (2024) add that diversifying processed moringa products into flour, tea, capsules, and other derivatives is an effective strategy for increasing income while creating local employment. Strengthening the capacity of KWT in processing business management with a target of 70% of KWT members trained, the introduction of environmentally friendly packaging with a target of 60% of products using eco-packaging, and cooperation with the Industry Office and BPOM for the legalization of 10 products within 12 months complete the agro-industry strategy.

In the marketing subsystem, the establishment of a North Lombok Moringa Association or Cooperative as a joint marketing institution is the most fundamental institutional strategy for strengthening the bargaining position of farmers against middlemen, developing a collective brand, and facilitating access to wider markets, including export markets. The development of a digital marketing platform with a target of 20% of products sold through digital channels and the facilitation of partnerships between farmers or KWT and buyers from the HORECA segment and exporters, with a target of two permanent buyer partners per district, complete the marketing strategy. The standardization of environmentally friendly distribution packaging with a target of 60% of products using eco-friendly packaging and advocacy for moringa as a flagship export commodity of West Nusa Tenggara through its integration into the medium-term development plan of North Lombok Regency close the marketing strategy package. Rosmalah et al. (2025) state that successful dryland agricultural business implementation models are always supported by strong marketing institutions and conducive regional policies.

In the supporting subsystem, the establishment of a cross-agency Integrated Moringa Development Team (Agriculture Office, Industry Office, Cooperatives Office, and Tourism Office) is a fundamental strategy for overcoming policy fragmentation between agencies, followed by the proposal of a Regional Regulation or Regent Decree on Moringa Development in North Lombok Regency as a legal umbrella that guarantees program continuity across leadership periods. Facilitating access to People's Business Credit (KUR)

and revolving funds for moringa enterprises with a target of 50% of farmers able to access such credit within 12 months, strengthening the capacity of agricultural extension officers specializing in moringa with a target of five extension cadres per district (Mularahman et al., 2023), and integrating moringa into the sustainable and organic agriculture program of North Lombok Regency with a target of 50 hectares of critical land planted with moringa complete the supporting strategy package. Gebrai et al. (2024) emphasize that the sustainability of moringa products in developing countries depends heavily on government policy commitment and the availability of institutional infrastructure that supports small-scale producers.

Overall, the highest intervention priority is directed at the Economic dimension (index 44.33) and the Institutional dimension (index 46.60), because improvements in these two weakest dimensions will have the greatest impact on raising the aggregate sustainability index from 49.86 towards the threshold of 50 and above. Riyanto *et al.* (2025) affirm that multidimensional diagnostics through MDS must be followed by concrete action targeting the weakest dimensions in order to achieve meaningful sustainability transformation, a conclusion also reached by Hidayanto & Fiana (2024) and Qomariyah & Hayati (2024) for cocoa plantations and agropolitan areas in Indonesia. Implementation of the strategy requires strong commitment from the Regional Government of North Lombok Regency, synergy between related agencies, active participation of stakeholders, and consistent regulatory support in order to guarantee the continuity of the moringa agribusiness development program in the long term.

Conclusion

Moringa agribusiness in North Lombok Regency falls into the Less Sustainable category with a composite index of 49.86, with the order of indices from highest to lowest being: Environmental (58.50), Social (50.00), Institutional (46.60), and Economic (44.33). The environmental dimension is the strongest because moringa is naturally adaptive to dryland conditions, whereas the economic dimension is the weakest as a result of low moringa leaf productivity, minimal value added of processed products, and limited availability of superior seedlings and production facilities. Nineteen sensitive leverage indicators were identified, dominated by attributes on the production and processing side (6 economic indicators, 5 social indicators, 2 environmental indicators, and 6 institutional indicators). The sustainable moringa agribusiness development strategy was formulated

through a SMART approach based on GAP analysis across the five subsystems, with priorities on developing superior local seedling nurseries, disseminating moringa GAP through Farmer Field Schools, developing KWT-based processing units with P-IRT certification, establishing a North Lombok Moringa Cooperative, forming a cross-agency Integrated Moringa Development Team, and enacting regional regulation on moringa development as a legal umbrella that guarantees program continuity.

Acknowledgments

The authors would like to thank the Master Program of Dryland Agriculture, Postgraduate Program, University of Mataram, the Agriculture Office of North Lombok Regency, and all farmers, the Sari Kelor Women Farmer Group, agricultural extension officers, and moringa small enterprise actors in Gondang Village, Salut Village, and Akar-akar Village who participated as respondents in this research.

Author Contributions

Conceptualization, E.I., I.K.B., and T.; methodology, E.I. and I.K.B.; investigation, E.I.; formal analysis, E.I. and I.K.B.; writing-original draft preparation, E.I.; writing-review and editing, I.K.B. and T.; supervision, I.K.B. and T. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding. The APC was funded by the authors.

Conflicts of Interest

The authors declare no conflict of interest.

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