



Evaluation of the Sustainability of the Corn Cultivation System in the Dryland of Bima City, West Nusa Tenggara

Pervitara Arum Dewi^{1*}, Muhamad Husni Idris², Hairil Anwar³
Universitas Mataram, Mataram, Indonesia

Corresponding Author: Pervitara Arum Dewi, pervitara.arum@gmail.com

ARTICLE INFO

Keywords: Maize Cultivation, Sustainability Status, Multi-Aspect Sustainability Analysis

Received : 10, July

Revised : 24, July

Accepted : 26, August

©2025 Dewi, Idris, Anwar: This is an open-access article distributed under the terms of the [Creative Commons Attribution 4.0 International](https://creativecommons.org/licenses/by/4.0/).



ABSTRACT

Maize (*Zea mays* L.) cultivation in Bima City, Indonesia, is a major livelihood in dryland areas, yet its productivity remains unstable due to environmental and management constraints. This study, conducted from May to July 2025, employed a Multi-Aspect Sustainability Analysis (MSA) to assess sustainability status and identify key driving factors. Data were collected from 42 expert respondents, including extension workers, NGO practitioners, and farmer group leaders. Four aspects were analyzed soil fertility and land quality, hydrology and microclimate, crop management, and soil and water conservation – comprising 24 factors assessed using ordinal indicators (0–3). The sustainability status was categorized as critical (quadrant IV), with an overall mean score of 41.47. Sub-district scores ranged from 34.31 to 46.41. Driving factors included phosphorus and potassium content, rainfall and seasonal pattern adaptation, crop rotation, waste utilization, terracing, and degraded land rehabilitation. These results emphasize the urgent need for integrated, multi-aspect interventions to strengthen resilience and sustainability in Bima’s dryland maize systems.

INTRODUCTION

Corn (*Zea mays* L.) is a strategic food crop that has a vital and adaptive role in maintaining food system stability and nutritional fulfillment for the global population (Grote et al., 2021), as well as high adaptation to dryland ecosystems (Bendáková et al., 2024). Corn in Indonesia is also a key commodity that not only supports national food security, but also drives rural economies due to high demand across sectors (Rozi et al., 2023). However, corn cultivation often faces productivity constraints influenced by climatic factors, low soil fertility, land degradation, and pressure from anthropogenic biomes (Bendáková et al., 2024; Hirwa et al., 2022; Reynolds et al., 2007). This challenge is also felt in tropical-arid areas such as Bima City, West Nusa Tenggara. The instability of corn productivity in Bima City can be influenced by changes in land use patterns due to uncontrolled expansion of agricultural land (Oduniyi & Tekana, 2021), degradation of soil fertility due to poor management (Mutuku et al., 2020), as well as traditional agricultural practices so that there is minimal application of data-driven approaches in decision-making (Tantalaki et al., 2019). Based on data from the Bima City Agriculture Office (2025), the corn planting area has increased from 7,872 ha in 2020 to 9,083 ha in 2024, while the agricultural area remains stagnant at 10,959 ha. This indicates that there is pressure on intensive land use. In addition, there is an inequality between planting area and harvest area that continues to recur every year, with differences of 279 ha (2020), 74 ha (2021), 77 ha (2022), 146 ha (2023), and 114 ha (2024), reflecting the inefficiency of the production system and the potential for yield loss.

This problem of productivity instability cannot be solved through a purely technical approach, but requires a holistic and adaptive evaluation framework to ensure the sustainability of the production system. The adaptive dimensions of agroecological cultivation management are rarely integrated into the framework of sustainability evaluation. In fact, corn productivity instability, such as what occurred in Bima City, is not only influenced by biophysical factors, but is also closely related to soil fertility degradation due to less sustainable land management practices, changes in land use patterns, and weak implementation of cultivation innovations that are responsive to dry agroclimatic conditions (Asfaw et al., 2024).

Answering the gap, This research proposes an integrated approach Based Multi-Aspect Sustainability Analysis (MSA) to evaluate the sustainability status of maize cultivation holistically on dry land. MSA is used to determine sustainability status, performance index, or performance evaluation (Anwar et al., 2024). Therefore, the purpose of the study is to evaluate the sustainability status of existing conditions and identify the driving factors for corn cultivation in the drylands of Bima City through MSA. The results of the study are expected to provide a more comprehensive scientific basis in the formulation of adaptation strategies and sustainable management of corn farmland, especially in Bima City which is vulnerable to productivity fluctuations and decreased food self-sufficiency capacity.

THEORETICAL REVIEW

The Role of Corn Cultivation in the Rural Economy

Corn cultivation (*Zea mays* L.) in Bima City is the backbone of the economy of rural communities, especially in dry land. However, unstable productivity indicates an imbalance between agricultural intensification and ecological sustainability. This is in line with the theory of sustainable agricultural development which emphasizes the importance of a balance between productivity, environmental sustainability, and farmers' welfare (Suriadi et al., 2024).

The Importance of a Multi-Faceted Approach in Sustainability Evaluation

This study uses Multi-Aspect Sustainability Analysis (MSA) because this approach allows for a comprehensive assessment of various dimensions of sustainability, such as land conditions, climate, cultivation management, and conservation. MSA is in accordance with the theoretical framework of sustainability assessment which emphasizes the integration of ecological, economic, and social aspects in evaluating agricultural systems (Firmansyah, 2022).

Factors Driving the Sustainability of Corn Cultivation

The results of the study identified several critical factors that affect sustainability, such as the availability of macronutrients (P and K), rainfall, adaptation of planting patterns, crop rotation, and soil conservation techniques. These findings support the theory that the sustainability of dryland agriculture is highly dependent on efficient management of natural resources and adaptation to climate variability (Bahrin et al., 2020).

Low Sustainability Status and the Need for Integrated Interventions

A low sustainability score (41.47) indicates that the corn production system in Bima City is in an "urgent" condition (quadrant IV). This reinforces the theory that conventional agricultural systems in drylands are vulnerable to degradation if not supported by policies that pay attention to ecological aspects. Therefore, integrated interventions, such as soil fertility improvement, planting pattern optimization, and the application of conservation techniques, are needed to achieve long-term sustainability (Firmansyah, 2022).

Theoretical Implications for Sustainable Agriculture Development

This research makes a theoretical contribution by showing that a multi-faceted and participatory approach (involving farmers, extension workers, and NGOs) is needed in designing sustainability strategies. These findings are in line with the principle of adaptive management in sustainable agriculture, where policies must be flexible and based on local conditions (Rohandi & Swestiani, 2020).

METHODOLOGY

Research Time and Location

The research was carried out from May to July 2025, located in Bima City, West Nusa Tenggara. Technique for determining the location of the research with Purposive Sampling. According to Sugiyono (2017), Purposive Sampling is a sampling technique with certain considerations. The basis for determining the research location is: (1) the research area is a dryland agricultural area that is vulnerable to productivity fluctuations and land degradation, so it requires a sustainability strategy; and (2) this area has never been evaluated for the sustainability status of its corn cultivation with an approach Multi-Aspect Sustainability Analysis (MSA) to support adaptive and sustainable land management planning.

Data Types and Sources

The types of data used in this study are primary data and secondary data. Primary data was obtained through filling out a questionnaire (Table 1), which consisted of: 4 aspects, where each aspect had 6 factors. The questionnaire was filled with direct interviews with 42 Expert Respondents, namely: Bima City Extension Coordinator, practitioners of Islamic Relief Non-Governmental Organizations (NGOs), and Farmer Groups in 36 villages of Bima City. The determination of respondents in this study used the Purposive Sampling method. Secondary data. obtained through literature, data processing on Google Earth, the Meteorology, Climatology, and Geophysics Agency (BMKG), the Public Works Office, and the Bima City Agriculture Office.

Table 1. Multi-Aspect Sustainability Analysis (MSA) Questionnaire.

Aspects	Factor	Data Source
Aspects of Soil Fertility and Land Quality	pH H ₂ O, total N (%), P ₂ O ₅ (mg 100g ⁻¹), K (me 100g ⁻¹), Slope (%), and Soil Surface Conditions	Primary data (analysis of soil samples (N, P, K, pH H ₂ O) and Questionnaire by Expert Respondents) and secondary data (Digital Elevation Model / DEM)
Aspects of Hydrology and Microclimate	Altitude (masl), average temperature (°c), humidity (%), rainfall (mm), length of dry period (months), and adaptation of seasonal patterns	Primary data (questionnaire by Expert Respondents) and secondary data (Google Earth data processing and BMKG data processing)
Aspects of Plant Management	Tillage, fertilizer use, agricultural waste utilization, planting distance management, crop rotation, superior seedlings, and pesticide use	Primary data (questionnaire by Expert Respondents)
Aspects of Soil and Water Conservation	Terasing, critical land rehabilitation, ground cover management, erosion-resistant vegetation, watering schedules, and water availability	Primary data (questionnaire by Expert Respondents) and secondary data (Public Works Office data processing)

Data Analysis

Analysis of the sustainability status of dryland corn cultivation in Bima City through the Multi-Aspect Sustainability Analysis (MSA) approach. MSA is

a method to evaluate the sustainability status of various aspects in an entity by combining qualitative and quantitative approaches (Firmansyah, 2022). The MSA method was chosen because it is able to evaluate current conditions while projecting future sustainability scenarios quickly (rapid assessment). The stages of MSA analysis include (Firmansyah, 2022): determination of indicators, ordination of status values, and determining leverage factors.

Indicator Determination

The determination of indicators was carried out based on a literature study on agroecology-based maize cultivation management, as follows (Table 2):

Table 2. Determination of indicators.

Aspects	Factor	Indicator Score			Determination
		Bad	-	Very good	
Soil Fertility and Land Quality	pH H ₂ O	0	-	3	(Djaenudin et al., 2011)
	N total (%)	0	-	3	(Djaenudin et al., 2011)
	P ₂ O ₅ (mg 100g ⁻¹)	0	-	3	(Djaenudin et al., 2011)
	K (May 100G ⁻¹)	0	-	3	(Djaenudin et al., 2011)
	Slope (%)	0	-	3	(Djaenudin et al., 2011)
	Soil Level Condition	0	-	3	(Sefiana et al., 2022)
Hydrology and Microclimate	Temperature rerata (°C)	0	-	3	(Djaenudin et al., 2011)
	Altitude of the place (masl)	0	-	3	(Djaenudin et al., 2011)
	Humidity (%)	0	-	2	(Djaenudin et al., 2011)
	Rainfall (mm)	0	-	3	(Djaenudin et al., 2011)
	Length of dry period (months)	0	-	3	(Djaenudin et al., 2011)
	Adaptation of seasonal patterns	0	-	2	(Elias et al., 2019; Kom et al., 2022)
	Tillage	0	-	3	(Borsato et al., 2018; Phogat et al., 2020)
Plant Management	Fertilizer use	0	-	3	(Raza et al., 2021; Yusuff et al., 2007)
	Utilization of agricultural waste	0	-	2	(Acevedo et al., 2020)
	Planting distance setting	0	-	2	(Maddonni & Bercovich, 2014)
	Crop rotation	0	-	2	(Gikonyo et al., 2022)
	Superior seeds	0	-	2	(Khairati et al., 2023)
	Pesticide use	0	-	2	(Bastakoti et al., 2024)
	Terasing	0	-	3	(Priori et al., 2020; White, 1981)
Soil and Water Conservation	Rehabilitation of critical lands	0	-	3	(Mentis, 2020)
	Ground Cover Management	0	-	3	(Salako et al., 2007)
	Erosion Resistant Vegetation	0	-	3	(Yongcai et al., 2021)

Aspects	Factor	Indicator Score		Determination
		Bad	- Very good	
	Water availability	0	- 3	(Bafdal & Dwiratna, 2018)
	Watering schedule	0	- 2	(Kang et al., 2000; Sepaskhah & Parand, 2006)

Determination of Existing Conditions

Existing conditions sustainability is determined by the MSA method through stages, as follows (Firmansyah, 2022):

1. Status Value Calculation

$$Y = \frac{y_1+y_2+y_3+y_4+\dots+y_n}{n} = \frac{\sum y_n}{n}$$

Where:

Y = Aggregate status value (sustainability/performance).

y = The status value of an aspect.

n = Number of aspects.

2. Status Value Ordination Mapping

Sustainability status values are mapped using the status value ordination quadrant (Figure 1) and the criteria in the status assessment (Table 3). The ordination quadrant of status scores explains the level of urgency of the intervention (Firmansyah, 2022), as follows:

- a. I (Good) : No priority intervention required (x >50; y >50)
- b. II (Priority) : Needs quick handling (x >50; y <50)
- c. III (Important) : Needs improvement, but not yet critical (x <50; >50)
- d. IV (Insist) : Need immediate intervention due to systemic susceptibility (x <50; y <50)
- e. V (Bad) : Critical and degraded indicators (x >50; y >y_{max})
- f. VI-VII (Illogical) : Beyond the systematic limits of evaluation (x <50; y >y_{max})

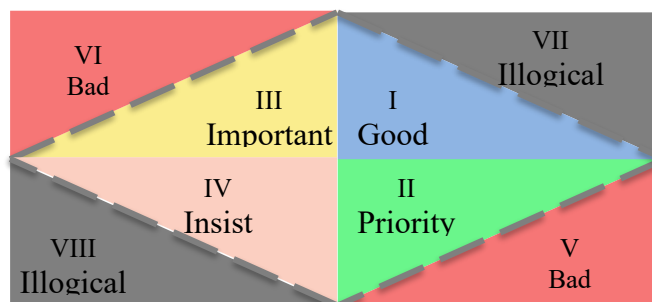


Figure 1. Determination of Conditions by Ordination.

Table 3. Grouping of Criteria in Status Assessment.

Criterion Status Value	Status Naming		Status Color (Map)
	Sustainability	Performance	
0-25	Not Sustainable	Bad	Brown

>25-50	Low Sustainability	Low	Orange
>50-75	Moderate Sustainable	Moderate	Light Green Yellow
>75-100	Highly Sustainable	Excellent	Dark Green

Determination of Driving Factors

The driving factor is the factor that has the greatest influence on the change in status (Firmansyah, 2022). The driving factors were analyzed using Maximum sensitivity and actual sensitivity. After that, the data is validated using random iteration. The driving factors are identified based on sensitivity Value highest, highest maximum sensitivity, random iteration lowest, and error highest. The graph of the driving factors is illustrated in Figure 2.

1. Maximum Sensitivity and Actual Sensitivity

$$L = S_M + S_V$$

Where:

$$S_M = \frac{1}{Gfn}$$

L = Value of the driving factor

BC = Maximum sensitivity

$$S_V = (Gfn - Mofn) \times S_M$$

SV = Sensitivitas Value

2. Validation with Random Iteration

$$P = \frac{fr}{\sum In}$$

Where:

P = Probabilities

Ir = Random interval

In = Indicator value (starting at 0)

fr = Frequency of indicator values

K = Cumulative value

RI = Random iteration

SI_f = Simulation of indicator values

$\overline{SI_f}$ = Random simulation average of indicator values on a factor

$$SI_f = \sum if(A_{rn}, In)$$

$$\overline{SI_f} = \frac{SI_f}{RI_n}$$

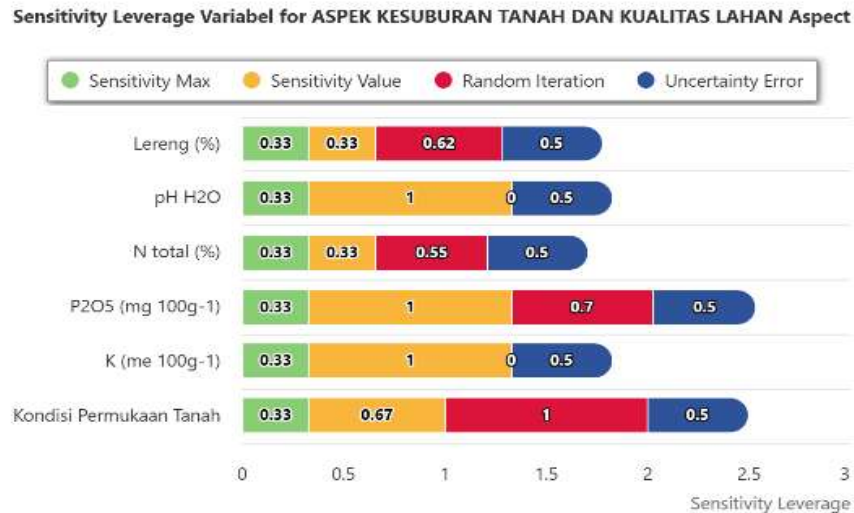


Figure 2. Graph of driving factors.

RESULTS AND DISCUSSION

The Multi-aspect Sustainability Analysis (MSA) produced the existing conditions and driving factors in Bima City in each sub-district, namely: Asakota, Mpunda, West Rasanae, East Rasanae, and Raba, in more detail as follows:

Sustainability Status Of Existing Conditions

The sustainability status of the existing conditions of corn cultivation in Bima City (Table 4) shows that there is a variation in the level of sustainability between sub-districts and the aspects assessed. Based on the results of the assessment on four main aspects, namely fertility and land quality, hydrology and microclimate, aquaculture management, and soil and water conservation, the sustainability status of existing conditions is at the ordination of quadrant IV status (urgent) and is included in the low criteria, with a total average of 41.47. Spatially, Asakota and Mpunda Districts occupy the highest position with an average of 46.41, while West Rasanae District has the lowest score with an average of 34.31. This difference reflects the disparity in resource potential and management effectiveness in each region, which requires specific intervention strategies according to local characteristics.

Table 4. The sustainability status of the existing conditions of corn cultivation in Bima City.

Aspects	District				
	Asakota	Mpunda	See also:	Rasanae Timur	Rasanae Barat
Fertility and land quality	55,67	55,67	38,83	27,83	26,80
Hydrology and microclimate	44,33	44,33	44,33	44,33	44,33
Cultivation management	52,29	52,29	52,29	52,29	52,29
Soil and water conservation	33,33	33,33	27,67	33,33	13,83
Rerata	46,41	46,41	40,78	39,45	34,31
Total Rerata	41,47				

In terms of fertility and land quality, it is the main foundation that determines the effectiveness and efficiency of the long-term production system. Figure 3 presents the existing conditions of fertility and land quality in five sub-districts classified into the ordination quadrant of status values and criteria in the status assessment. Based on the analysis of fertility and land quality aspects between sub-districts, Asakota and Mpunda occupy quadrant II (priority) with a moderate level of sustainability with an index value of 55.67 each. On the other hand, Raba, East Rasanae, and West Rasanae are included in quadrant IV (urgent) with a low level of sustainability and an index value of 38.83 each; 27,83; and 26.80.

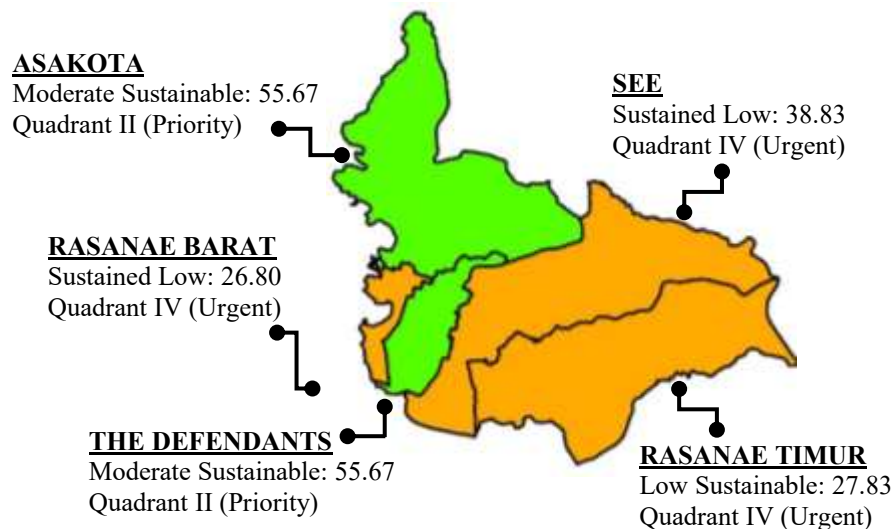


Figure 3. Existing conditions of fertility and land quality.

Hydrological and microclimatic aspects have a central role in determining the stability of production and the resilience of agroecosystem systems to climate change. Figure 4 presents the sustainability status of hydrological and microclimatic aspects in five sub-districts, which show a low level of sustainability and is included in the quadrant IV (urgent) category with an index value of 44.33.



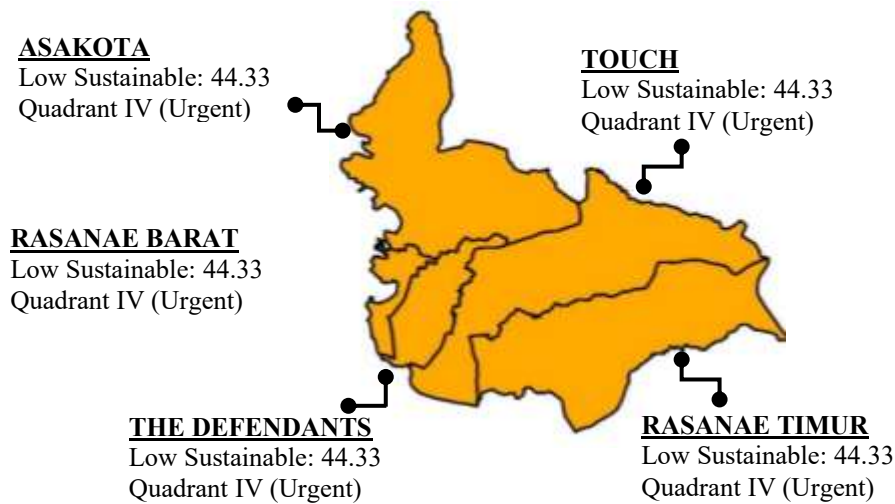


Figure 4. Existing conditions of hydrological and microclimatic aspects.

The management aspect of sustainable corn cultivation involves various technical and managerial dimensions that affect the efficiency and sustainability of the agricultural system. Figure 5 presents the sustainability status of the management aspect of corn cultivation in five sub-districts showing a moderate level of sustainability and is included in the quadrant IV (priority) category with an index value of 52.29.

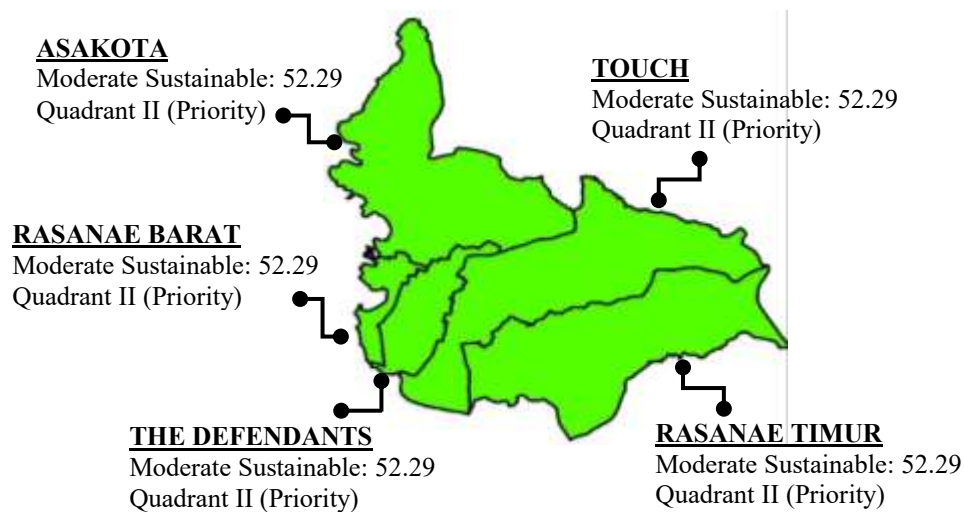


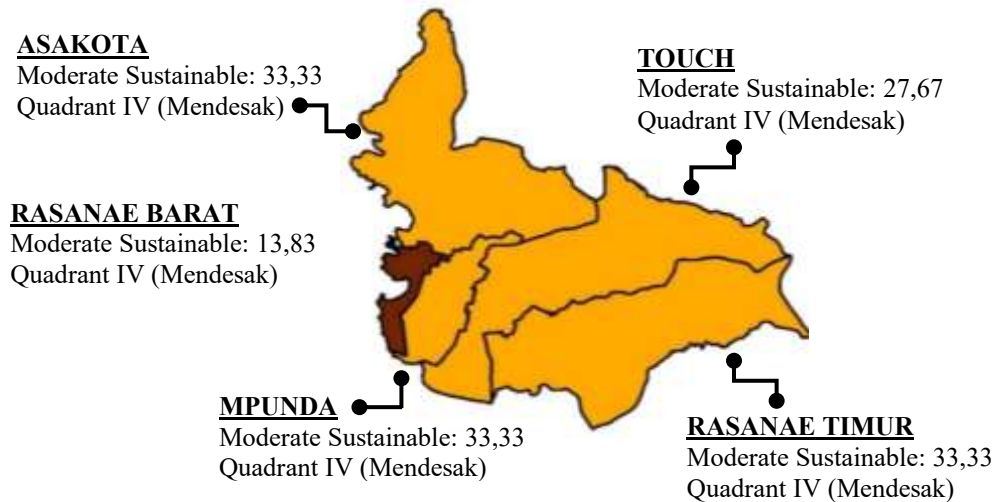
Figure 5. The existing conditions of the management aspect of corn cultivation.

Figure 6. Existing conditions of soil and water conservation aspects.

Driving Factors For Corn Cultivation

The main driving factor that affects the sustainability of corn cultivation in Bima City from the aspect of fertility and land quality is the content of phosphorus (P) nutrients $<7 \text{ mg}/100\text{g}$ and potassium (K) $<0.3(\text{me } 100\text{g}^{-1})$ in poor condition. The low availability of P and K, indicates problems that greatly determine the productivity and sustainability of corn cultivation (Hernawan et al., 2020). Therefore, site-specific land management strategies need to be focused on macronutrient recovery and management, through balanced and test-based fertilization (Nziguheba et al., 2022).

The main driving factors that affect the sustainability of corn cultivation in Bima City from the aspect of hydrology and microclimate, be rainfall $<130 \text{ mm}$ and relatively limited adaptability to seasonal patterns. Adjustments to the



planting calendar are only made if the rainy season recedes, and even that is limited to delaying planting time without other cultivation technical modifications. Access to climate information is mostly obtained passively, both from BMKG forecasts and traditional natural signs, but has not been integrated into medium- or long-term adaptation strategies. Lack of diversification of adaptations, such as the use of drought-tolerant varieties, layered planting (staggered planting), or the use of water conservation technology, makes the production system highly dependent on the suitability of the annual rainy season (Omokaro, 2025). In the long term, this pattern increases the risk of crop failure in years with climate anomalies, while hindering the achievement of optimal productivity (Omokaro, 2025). Therefore, building the capacity of data-based climate adaptation and conservation technologies is key to strengthening the sustainability of maize cultivation in areas with low rainfall.

The management aspect of maize cultivation, with factors driving crop rotation and utilization of agricultural waste, is a crucial element to maintain soil health and long-term productivity (Nugroho et al., 2022). Field facts show that the use of agricultural waste (straw, cobs, corn stalks) for animal feed or compost

already exists but is not routine, is still individual, and without collective management; Meanwhile, crop rotation has not been implemented, with the practice of allowing land to be planted for one season. Reliance on a single planting pattern without rotation accelerates fertility degradation, increases the risk of pest/disease attacks, and decreases nutrient utilization efficiency (Narendra et al., 2021). Optimizing these two factors through increasing farmer capacity, waste management institutions, and policy support is an urgent strategy to strengthen sustainability, resource efficiency, and reduce the environmental impact of the corn production system.

The main driving factors in conservation efforts are the terraces and rehabilitation of critical land. Soil conservation remains an important challenge, and terraces are the main technique to address erosion problems on sloping land (Priori et al., 2020; White, 1981). The existing condition is indicated by the absence of terraces/guludan/contours; no drainage channels; runoff is not managed, then there are no land rehabilitation efforts, and there is no practice of making guludan, contours, or drainage that follows the land channel. Critical land rehabilitation is urgently needed in areas experiencing heavy land degradation (Priori et al., 2020; White, 1981), such as in West Rasanae, to restore soil quality and increase agricultural carrying capacity in a sustainable manner. Therefore, a land management strategy that includes terraces and rehabilitation of critical lands is urgently needed to support more sustainable maize cultivation systems across the region. The disparity between sub-districts confirms that an extensification program without intensification, through improved fertility, climate adaptation, and land conservation, will not be able to significantly increase productivity. Future development strategies need to be directed at conservation-based intensification with location priority.

CONCLUSION AND RECOMMENDATION

The sustainability status of the existing conditions of corn cultivation in Bima City shows that the results of the assessment, the sustainability status of the existing conditions are at the ordinates of the value of quadrant IV status (urgent) and enter the low criteria, with a total average of 41.47. Asakota, Mpunda, Raba, West Rasanae, and East Rasanae districts are 46.41; 46.41; 40.78; 34.31; respectively; 39.45. The driving factors in the aspects of soil fertility and land quality with the driving factors being the content of macronutrients, namely phosphorus (P) and potassium (K), in the hydrological and microclimatic aspects are rainfall and adaptation to seasonal patterns, in the aspect of cultivation management is crop rotation and utilization of agricultural waste, and in the aspect of soil and water conservation is the terraced and rehabilitation of critical land. This emphasizes the need for integrated and multi-faceted interventions to strengthen the sustainability of the corn production system in dry land.

FURTHER STUDY

Further research should focus on developing evidence-based adaptation scenarios that can improve the sustainability of the maize cultivation system in Bima City. Through the application of a multi-faceted integration-based approach, as well as the use of precision agriculture technology, it is hoped that

the corn farming system can transform to be more resilient to climate change, efficient, and environmentally friendly.

REFERENCES

- Acevedo, M. D., Belmonte-Ureña, L., Plaza-Úbeda, J., & Camacho-Ferre, F. (2020). The Management of Agricultural Waste Biomass in the Framework of Circular Economy and Bioeconomy: An Opportunity for Greenhouse Agriculture in Southeast Spain. *Agronomy*, 10(4), 1–22.
- Anwar, M. A., Suprihatin, Sasongko, N. A., Najib, M., Pranoto, B., & Firmansyah, I. (2024). Sustainability Of Multilayer Plastics Waste Management in Indonesia: A Multi-Aspect Sustainability Analysis (MSA) Approach. *Brin*, 1–24.
- Ardianto, A., Zakaria, W. A., Murniati, K., Abidin, Z., & Asmara, S. (2024). Analisis Keberlanjutan Rencana Pengembangan Lahan Sawah Baru: Strategi Peningkatan Produksi Pangan di Kabupaten Lampung Tengah. *Agroteknika*, 7(4), 460–478.
- Asfaw, D. M., Asnakew, Y. W., Sendkie, F. B., Abdulkadr, A. A., Mekonnen, B. A., Tiruneh, H. D., & Ebad, A. M. (2024). Analysis of constraints and opportunities in maize production and marketing in Ethiopia. *Heliyon*, 10(20), 1–9. <https://doi.org/10.1016/j.heliyon.2024.e39606>
- Bafdal, N., & Dwiratna, S. (2018). Water Harvesting System as an Alternative Appropriate Technology to Supply Irrigation on Red Oval Cherry Tomato Production. *International Journal on Advanced Science, Engineering and Information Technology*, 8(2), 561–566. <https://doi.org/10.18517/ijaseit.8.2.5468>
- Bahrún, A., Amin, R., & Alimin, F. (2020). Application of corn cultivation techniques by smallholder farmers. *IOP Conference Series: Earth and Environmental Science*, 575, 1–9.
- Bastakoti, B., Tiwari, S., Subedi, A. P., Giri, D., & Karki, A. (2024). Comparative analysis of knowledge and management practices of insect pests of maize among IPM adopters and non-adopters in Sindhupalchok, Nepal. *Archives of Agriculture and Environmental Science*, 9(1), 168–174. <https://doi.org/10.26832/24566632.2024.0901024>
- Bend'áková, V., Nagy, H., Turčeková, N., Adamičková, I., & Bielik, P. (2024). Assessing the Climate Change Impacts on Maize Production in the Slovak Republic and Their Relevance to . *Sustainability (Switzerland)*, 16(13), 1–21. <https://doi.org/10.3390/su16135573>
- Borsato, E., Galindo, A., Tarolli, P., Sartori, L., & Marinello, F. (2018). Evaluation of the Grey Water Footprint Comparing the Indirect Effects of Different Agricultural Practices. *Sustainability*, 10(11), 1–15. <https://doi.org/10.3390/su10113992>
- Djaenudin, D., Marwan, H., Subagjo, H., & Hidayat, A. (2011). Petunjuk Teknis Evaluasi Lahan untuk Komoditas Pertanian. In *Petunjuk Teknis Evaluasi Lahan untuk Komoditas Pertanian*.
- Elias, E. H., Flynn, R., Idowu, O. J., Reyes, J., Sanogo, S., Schutte, B. J., Smith, R., Steele, C., & Sutherland, C. (2019). Crop Vulnerability to Weather and

- Climate Risk: Analysis of Interacting Systems and Adaptation Efficacy for Sustainable Crop Production. *Sustainability*, 11(23), 1–25. <https://doi.org/10.3390/su11236619>
- Firmansyah, I. (2022). Multiaspect sustainability analysis. *Expert Simulation Program Article.*, 1(1), 1–14.
- Gikonyo, F. N., Dong, X., Mosongo, P. S., Guo, K., & Liu, X. (2022). Long-Term Impacts of Different Cropping Patterns on Soil Physico-Chemical Properties and Enzyme Activities in the Low Land Plain of North China. *Agronomy*, 12(2), 1–18.
- Grote, U., Fasse, A., Nguyen, T. T., & Erenstein, O. (2021). Food Security and the Dynamics of Wheat and Maize Value Chains in Africa and Asia. *Frontiers in Sustainable Food Systems*, 4, 1–17. <https://doi.org/10.3389/fsufs.2020.617009>
- Hernawan, E., Rosmiati, M., Lastini, T., & ... (2020). Agroforestry as a model of sustainable land use of small-scale private forest: a case study in Sumedang, West Java, Indonesia. *International*. <https://doi.org/10.1504/IJBCRM.2020.108506>
- Hirwa, H., Li, F., Qiao, Y., Measho, S., Muhirwa, F., Tian, C., Leng, P., Ingabire, R., Itangishaka, A. C., Chen, G., & Turyasingura, B. (2022). Climate change–drylands–food security nexus in Africa: From the perspective of technical advances, challenges, and opportunities. *Frontiers in Environmental Science*, 10, 1–17. <https://doi.org/10.3389/fenvs.2022.851249>
- Kang, S., Liang, Z., Pan, Y., Shi, P., & Zhang, J. (2000). Alternate furrow irrigation for maize production in an arid area. *Agricultural Water Management*, 45(3), 267–274. [https://doi.org/10.1016/S0378-3774\(00\)00072-X](https://doi.org/10.1016/S0378-3774(00)00072-X)
- Khairati, S., Jusni, & BDR, M. F. (2023). Comparison of financial feasibility between hybrid maize farming for seed production and feed production in Bone District, South Sulawesi. *IOP Conference Series: Earth and Environmental Science*, 1230(1). <https://doi.org/10.1088/1755-1315/1230/1/012222>
- Kom, Z., Nethengwe, N. S., Mpandeli, N. S., & Chikoore, H. (2022). Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal*, 87(2), 677–700. <https://doi.org/10.1007/s10708-020-10272-7>
- Maddonna, G., & Bercovich, J. M. (2014). Row Spacing, Landscape Position, and Maize Grain Yield. *International Journal of Agronomy*, 2014, 1–12.
- Mentis, M. (2020). Environmental rehabilitation of damaged land. *Forest Ecosystems*, 7(1), 1–16. <https://doi.org/10.1186/s40663-020-00233-4>
- Mutuku, E. A., Roobroeck, D., Vanlauwe, B., Boeckx, P., & Cornelis, W. M. (2020). Maize production under combined Conservation Agriculture and Integrated Soil Fertility Management in the sub-humid and semi-arid regions of Kenya. *Field Crops Research*, 254(1–15), 107833. <https://doi.org/10.1016/j.fcr.2020.107833>
- Narendra, B. H., Siregar, C. A., Dharmawan, I. W. S., Sukmana, A., Pratiwi, Pramono, I. B., Basuki, T. M., Nugroho, H. Y. S. H., Supangat, A. B.,

- Purwanto, Setiawan, O., Nandini, R., Ulya, N. A., Arifanti, V. B., & Yuwati, T. W. (2021). A Review on Sustainability of Watershed Management in Indonesia. *Sustainability*, 13(19), 1–29.
<https://doi.org/10.3390/su131911125>
- Nugroho, H. Y. S. H., Indrawati, D. R., Wahyuningrum, N., Adi, R. N., Supangat, A. B., Indrajaya, Y., Putra, P. B., Cahyono, S. A., Nugroho, A. W., Basuki, T. M., Savitri, E., Yuwati, T. W., Narendra, B. H., Sallata, M. K., Allo, M. K., Bisjoe, A. R., Muin, N., Isnani, W., Ansari, F., Hani, A. (2022). Toward Water, Energy, and Food Security in Rural Indonesia: A Review. *Water*, 14(10), 1–25. <https://doi.org/10.3390/w14101645>
- Nziguheba, G., Adewopo, J., Masso, C., Nabahungu, N. L., Six, J., Sseguya, H., Taulya, G., & Vanlauwe, B. (2022). Assessment of sustainable land use: linking land management practices to sustainable land use indicators. *International Journal of Agricultural Sustainability*, 20(3), 265–288. <https://doi.org/10.1080/14735903.2021.1926150>
- Oduniyi, O. S., & Tekana, S. S. (2021). The impact of sustainable land management practices on household welfare and determinants among smallholder maize farmers in South Africa. *Land*, 10(5), 1–16. <https://doi.org/10.3390/land10050508>
- Omokaro, G. O. (2025). Multi-impacts of climate change and mitigation strategies in Nigeria: agricultural production and food security. *Science in One Health*, 4, 1–12. <https://doi.org/10.1016/j.soh.2025.100113>
- Paulus, C. A., Damianus, A., Yahyah, Rayzcha, M. I. H., Eddy, R., & 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*, 8(140), 1–14. <https://doi.org/10.18551/rjoas.2023-08.18>
- Phogat, M., Dahiya, R., Sangwan, P., & Goyal, V. (2020). Zero tillage and water productivity: A review. *International Journal of Chemical Studies*, 8(5), 2529–2533. <https://doi.org/10.22271/chemi.2020.v8.i5ai.10698>
- Priori, S., Pellegrini, S., Vignozzi, N., & Costantini, E. A. C. (2020). Soil Physical-Hydrological Degradation in the Root-Zone of Tree Crops: Problems and Solutions. *Agronomy*, 11(68), 1–27. <https://doi.org/10.3390/agronomy11010068>
- Raza, S. T., Wu, J., Ali, Z., Anjum, R., Bazai, N. A., Feyissa, A., & Chen, Z. (2021). Differential Effects of Organic Amendments on Maize Biomass and Nutrient Availability in Upland Calcareous Soil. *Atmosphere*, 12(8), 1–10. <https://doi.org/10.3390/atmos12081034>
- Reynolds, J. F., Smith, D. M. S., Lambin, E. F., Turner, B. L., Mortimore, M., Batterbury, S. P. J., Downing, T. E., Dowlatabadi, H., Fernández, R. J., Herrick, J. E., Huber-Sannwald, E., Jiang, H., Leemans, R., Lynam, T., Maestre, F. T., Ayarza, M., & Walker, B. (2007). Global Desertification: Building a Science for Dryland Development. *Science*, 316(5826), 847–851. <https://doi.org/10.1126/science.1131634>
- Rohandi, A., & Swestiani, D. (2020). Compatibility of variety and planting pattern of Maize (*Zea mays*) in early Ganitri (*Elaeocarpus ganitrus* Roxb.) based

- agroforestry in dry land. *IOP Conference Series: Earth and Environmental Science*, 449, 1–12.
- Rozi, F., Santoso, A. B., Mahendri, I. G. A. P., Hutapea, R. T. P., Wamaer, D., Siagian, V., Elisabeth, D. A. A., Sugiono, S., Handoko, H., Subagio, H., & Syam, A. (2023). Indonesian market demand patterns for food commodity sources of carbohydrates in facing the global food crisis. *Heliyon*, 9, 1–12. <https://doi.org/10.1016/j.heliyon.2023.e16809>
- Salako, F. K., Olowokere, F. A., Tian, G., Kirchhof, G., & Osiname, O. (2007). Ground cover by three crops cultivated on marginal lands in Southwestern Nigeria and implications for soil erosion. *Spanish Journal of Agricultural Research*, 5(4), 497–505. <https://doi.org/10.5424/sjar/2007054-272>
- Sefiana, R. R., Ma'shum, M., Padusung, & Tejowulan, R. S. (2022). Tingkat Nilai Konsistensi Tanah Pada Berbagai Macam Lahan Terdegradasi Di Daerah Kayangan Kabupaten Lombok Utara. *Journal of Soil Quality and Management*, 1(2), 18–22.
- Sepaskhah, A. R., & Parand, A.-R. (2006). Effects of Alternate Furrow Irrigation with Supplemental Every-Furrow Irrigation at Different Growth Stages on the Yield of Maize (*Zea mays* L.). *Plant Production Science*, 9(4), 415–421. <https://doi.org/10.1626/paps.9.415>
- Sugiyono. (2017). *Metode Penelitian Kuantitatif Kualitatif dan R&D* (Cetakan ke). CV Alfabeta.
- Suriadi, A., Syarifinnur, Mulyati, Sumarsono, J., Hadiawati, L., Khaerana, & Putra, G. (2024). Maize production at phenological stages affected by water irrigation stress in dryland conditions. *IOP Conference Series: Earth and Environmental Science*, 1377(1), 1–9. <https://doi.org/10.1088/1755-1315/1377/1/012016>
- Tantalaki, N., Souravlas, S., & Roumeliotis, M. (2019). Data-Driven Decision Making in Precision Agriculture: The Rise of Big Data in Agricultural Systems. *Journal of Agricultural & Food Information*, 20(4), 344–380. <https://doi.org/10.1080/10496505.2019.1638264>
- White, J. (1981). Choosing Terrace Systems. In *unknown*.
- Yongcai, L., ZhaoLiang, G., Wu, T., & Qi, X. (2021). Effects of Different Inflow Rate Patterns and Distributions of Grass Strips on Runoff and Sediment in an Engineering Accumulation Body. *Unknown*.
- Yusuff, M. T. M., Ahmed, O. H., Yahaya, W. A. W., & Majid, N. M. A. (2007). Effect of Organic and Inorganic Fertilizers on Nitrogen and Potassium Uptake and Yield of Sweet Corn Grown on an Acid Soil. *American Journal of Agricultural and Biological Sciences*, 2(2), 118–122. <https://doi.org/10.3844/ajabssp.2007.118.122>