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A sustainable agriculture indicators in West Nusa Tenggara Province: A multi-dimensional review of economic, social and environmental issues

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ABSTRACT

This study aims to analyze the trends and relationships between the three pillars of sustainable agriculture economic, social and environmental in West Nusa Tenggara (NTB) during the period 2010-2024. This study employed a quantitative approach utilizing secondary data analysis methods. Data were collected from the Central Bureau of Statistics, FAOSTAT and the Ministry of Agriculture, which included variables such as land productivity, Farmer Exchange Rate (NTP), fertilizer use, rural poverty, and greenhouse gas emissions. Data analysis was conducted using descriptive statistical techniques to examine time-series trends and Pearson correlation analysis to identify relationships between variables. The results indicated a decoupling phenomenon between the pillars of sustainability. Economically, rice and corn productivity in NTB shows an increasing trend, but this has a very strong positive correlation with the increase in the use of inorganic fertilizers, which indicates a heavy burden on the environmental pillar (land degradation risk and emissions). On the other hand, the increase in productivity is not followed by a significant increase in the social pillar, where the correlation with farmer welfare (NTP) is relatively weak. This indicates the existence of a food barn paradox: production increases, but high input costs erode farmers' profit margins. This study concludes that the agricultural system in NTB is currently in a High Input, High Risk condition. The proposed policy recommendation is the need for a transition from chemical input-based agriculture (input-driven) to organic efficiency and value-added agriculture (value-driven) to create a balance between economic profitability, social justice and ecosystem sustainability in NTB.

Keywords: farmer exchange rate; NTB; secondary data; sustainable agriculture; sustainability pillar

1. INTRODUCTION

Agriculture plays a strategic role in Indonesia. Quirinno, et al. (2024) stated that agriculture is a key pillar of food security and a significant driver of the national economy. This role is reinforced by Afriyanti, et al. (2023), who identified agriculture's strategic function as a food provider, an instrument for poverty alleviation, and a major source of employment in Indonesia. With its significant contribution to GDP and its ability to absorb labor, the agricultural sector has proven not only to meet basic needs but also to maintain national socioeconomic stability.

Agriculture currently faces complex and interconnected challenges. Intensification efforts, characterized by the excessive use of pesticides and fertilizers, have been shown to contribute to environmental degradation, including soil and water pollution (Sinambela, 2024). This ecological situation is exacerbated by external threats from climate change, which significantly increases the risk of crop failure due to increasing weather anomalies (Nuraisah & Kusumo, 2019). Ultimately, the combination of environmental damage, high input costs, and crop uncertainty contributes to the issue of low farmer welfare. Farmers face challenges such as disproportionate income and poverty in rural areas (Yacoub & Mutiaradina, 2020).

Sustainable agriculture is a holistic solution to address the shortcomings of conventional agricultural systems, based on a balance of three pillars: economic, social, and environmental. As Munasinghe stated and confirmed in various studies, this solution requires that economic profitability be inseparable from environmental sustainability and social justice. Djibran, et al. (2023) empirically demonstrated in their research that implementing this model can increase farmer income (economic) while simultaneously maintaining conservation (environmental) and improving welfare (social). Sustainable agriculture serves as a strategic approach to revitalizing the rural economy by ensuring that these three pillars synergistically reinforce each other.

In a local context, West Nusa Tenggara (NTB) Province exemplifies the interrelated challenges of agricultural dependence, vulnerability to climate anomalies, and land degradation on the islands of Lombok and Sumbawa. As the national food barn, NTB relies heavily on the agricultural sector, particularly rice and corn production, which continues to grow to support national resilience. However, despite these agricultural efforts, rural poverty persists, raising concerns about whether this production growth is sustainable and aligned with long-term development principles.

The reality on the ground reveals alarming dynamics. The expansion of corn cultivation on sloping land on Sumbawa Island and parts of Lombok has triggered severe deforestation and soil erosion. This has sparked public debate about the conflict between national food production targets and the sustainability of the hydrological function of watersheds (DAS). West Nusa Tenggara (NTB) is one of the regions most impacted by changing rainfall patterns. Dependence on rain-fed agriculture makes the local economy highly vulnerable to climate shocks. Despite increased corn production volumes, the welfare of farmers in remote areas of NTB has not seen a significant improvement due to high logistics costs and debt bondage to middlemen (Badan Pusat Statistik Provinsi Nusa Tenggara Barat, 2024) (see Table 1).

Table 1. Sustainability Pillars and Key Indicators for Assessing Agricultural Development Trade-offs in West Nusa Tenggara (NTB)

Pillars of Sustainability	Key Indicators	Definition Operational & Relevance Local
Economy	Land Productivity	Measure results harvest per hectare, especially rice and corn, to ensure efficiency in the middle limitations of land in Lombok and Sumbawa.
	Profitability Farmer	Difference between income and dirty with input costs (seeds, fertilizer). This is relevant to determine whether NTB farmers are trapped in debt costs of production.
	Resilience Income	Diversification source income farmers so as not to only depend on one vulnerable commodities fluctuations market price.
Environment	Soil Health	Use ratio fertilizer organic vs chemical. Overcoming the phenomenon of "fatigue" land " due to excessive use of urea in the fields corn.

	Water Efficiency	Management of irrigation and water use, especially in the NTB region, which has a long drought season (semi-arid climate).
	Biodiversity & Land Cover	Do not expand agriculture into forested areas that may cause erosion in the surrounding hills.
Social	Welfare Level (NTP)	Exchange rate Farmer as an indicator Power buy house ladder farmer to need principal and working capital.
	Access to Information	To what extent are farmers get counseling about practice sustainable and system warning early change climate.
	Gender/ Generation Justice	Involvement of women and young farmers (farmer millennials) in managing agriculture to ensure sector regeneration.

Source: Author's Data

Most previous studies have focused on physical production targets without objectively measuring the balance between these pillars. There is a methodological gap in the use of longitudinal data that simultaneously integrates economic, social, and environmental dimensions in NTB. This study contributes to filling this gap by applying the Food and Agriculture Organization (2021) global monitoring framework to 15 years of time-series data to identify the most influential determinants of sustainability in the region. Therefore, to encourage a shift from conventional agriculture to the concept of sustainable agriculture, objective measurement is necessary, as emphasized by Mucharam, et al. (2022), highlighting the need for standard benchmarks at the national level for performance evaluation. This measurement requirement is crucial so that stakeholders can monitor progress and identify effective trends. To address this challenge, global methodologies, such as those written by Tubiello, et al. (2021) from the FAO (2021), demonstrate the importance of utilizing available national statistics. This approach is essential because data availability is a key criterion in determining operational and practical indicators to consistently control the balance between economic, social, and environmental pillars in West Nusa Tenggara (NTB) Province.

2. RESEARCH METHOD

This study uses a quantitative, descriptive, and associative design to analyze the status of sustainable agriculture in West Nusa Tenggara (NTB) Province. Total sampling was used for the time-series data. The study was limited to 15 years of time-series data from 2010 to 2024. The NTB analysis unit was aggregated from district-level, city-level, and provincial sectoral data. Locations were purposively selected based on their strategic role as national food barns facing specific environmental challenges, with a focus on three main dimensions: economic: productivity, GDP, and regional GDP; social: labor wages, poverty, and food security; and environmental: land area, chemical input use, and greenhouse gas emissions.

The data used are entirely public secondary quantitative data, ensuring the transparency and validity of the study. Primary data sources include Statistics Indonesia (Badan Pusat Statistik, 2024) for local welfare and productivity indicators, the Ministry of Agriculture for technical data on rice fields and fertilizers, and international databases, such as FAOSTAT and the World Bank, for greenhouse gas (GHG) emissions and macroeconomic contexts. All variables are operationalized through measurable indicators, such as yield per hectare *(ton/ha)* for productivity and fertilizer use intensity *(kg/ha)* to measure the ecological burden on land. The data collection and cleaning processes are estimated to take 4–6 weeks, followed by the data processing stage.

Data analysis was conducted systematically using statistical software through three main techniques. First, a descriptive analysis was employed to visualize the development trends of each sustainability indicator over time, represented in a line graph. Second, Pearson correlation analysis *(r)* was applied to test the closeness of the relationship between variables, such as the relationship between fertilizer use and land productivity. Finally, simple and multiple regression analyses, with the model $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + e$, were conducted to identify the determinants most influential in the sustainability of the agricultural sector in West Nusa Tenggara Province. Here, Y is the agricultural sustainability index, X1 is economic, X2 is social, and X3 is environmental.

3. RESULT AND DISCUSSION

3.1. Result

3.1.1. Overview of the Agricultural Sector in Indonesia

The agricultural sector remains the backbone of Indonesia's national economy, particularly for its role as a food provider for more than 280 million people and a significant employer. Based on secondary data collected from Statistics Indonesia (Badan Pusat Statistik, 2024) and the World Bank, the following is a general profile of Indonesia's agricultural sector during the observation period.

3.1.1.1. Economic Contribution and Labor Absorption

At a macro level, the agricultural sector consistently contributes 12% to 13% to the national Gross Domestic Product (GDP). Despite the rapid growth of the manufacturing and service sectors, agriculture has proven to be highly resilient, especially in the face of global crises. In terms of employment, agriculture is the largest employer. By 2024, approximately 28-29% of Indonesia's total workforce is expected to depend on this sector for their livelihood. However, structural challenges exist, such as an aging farmer population, with farmers predominantly aged 45 years and older, and a slow rate of youth farmer regeneration.

3.1.1.2. Main Commodities and Agricultural Land

Indonesia has approximately 7.46 million hectares of paddy fields latest data from the Ministry of Agriculture/BPS. Rice is the most dominant food crop, with total national production ranging from 53 to 55 million tons of dry milled grain (GKG) per year. In addition to rice, corn, and soybeans, the government's food self-sufficiency program primarily focuses on these crops (see Table 2).

Table 2. Number of Certified Teachers at Yayasan Al Nur Cibinong

Indicator (2024 Estimate)	Value/Description	Data Source
Agricultural Sector Growth	1.3% - 1.5% (YoY)	BPS
Rice Harvested Area	10.2 Million Ha	BPS
National Farmer Exchange Rate (NTP)	115 - 120 (Index)	BPS
Rice Paddy Area	7.46 Million Ha	Ministry of Agriculture

Source: Processed from primary data (Badan Pusat Statistik, 2024)

3.1.1.3. The Strategic Position of West Nusa Tenggara (NTB) Province

In the national agricultural map, NTB Province plays a crucial role as the food barn of eastern Indonesia (Badan Pusat Statistik Provinsi Nusa Tenggara Barat, 2024). NTB consistently ranks among the provinces with the largest corn production in Indonesia and is an exporter of livestock and horticultural commodities, such as shallots. This makes NTB an ideal research location to assess how agricultural sustainability is implemented in a region that is highly dependent on this sector but vulnerable to climate change.

3.1.1.4. National Sustainability Challenges

In general, Indonesian agriculture continues to face the problem of high chemical input intensity. FAOSTAT data show that Indonesia is one of the largest consumers of nitrogen fertilizers in Southeast Asia. Furthermore, the rapid conversion of agricultural land to industrial and residential areas, particularly on Java, is forcing the government to expand land (food estate) outside Java, which poses its own ecological challenges.

3.1.2. Sustainability Indicator Trend Analysis

This analysis describes the fluctuations and developments in the three pillars of sustainability in West Nusa Tenggara Province during the observation period. The data presented are a compilation of the NTB in Figures report and other sectoral databases.

3.1.2.1. Economic Indicator Trends (Productivity, NTP, and GRDP)

This figure summarizes 2010–2024 trends in NTB's agricultural productivity, NTP, and agricultural GRDP to show whether production growth aligns with farmer welfare (see Figure 1).

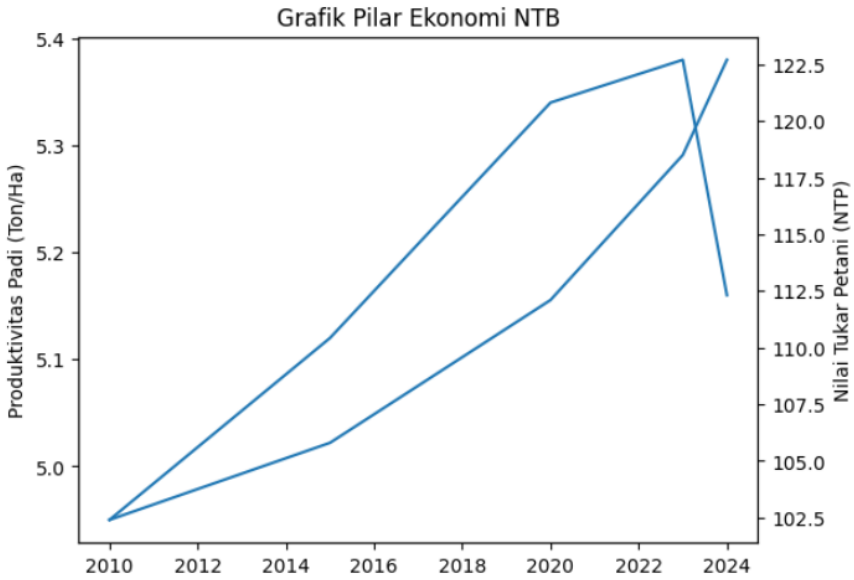

Figure 1. NTB Economic Pillars Chart

The economic pillars in West Nusa Tenggara (NTB) show strong performance but are highly dependent on seasonal fluctuations.

First, rice productivity. According to Statistics Indonesia (Badan Pusat Statistik, 2024) data, rice productivity in West Nusa Tenggara is stable at around 5.2-5.6 tons/ha. Despite increased mechanization, productivity figures have declined in El Niño years (such as 2015 and 2023) due to limited irrigation in rain-fed areas, such as South Lombok.

Second, farmers' exchange rate (NTP). The NTB NTP trend shows a fluctuating pattern above 100 (ranging from 105-118 in the 2020-2024 period). This indicates that the purchasing power of NTB farmers is generally maintained; however, growth in production costs, including seeds and wages, is starting to catch up with the increase in the selling price of unhusked rice.

Third, the GRDP contribution. The agricultural sector remains the second-largest contributor to NTB's GRDP after the mining sector, with an average contribution of over 20%.

3.1.2.2. Social Indicator Trends (Rural Poverty and Labor Wages)

This figure displays 2010–2024 trends in rural poverty and agricultural wages in NTB to assess how far agricultural development translates into rural social welfare gains (see Figure 2).

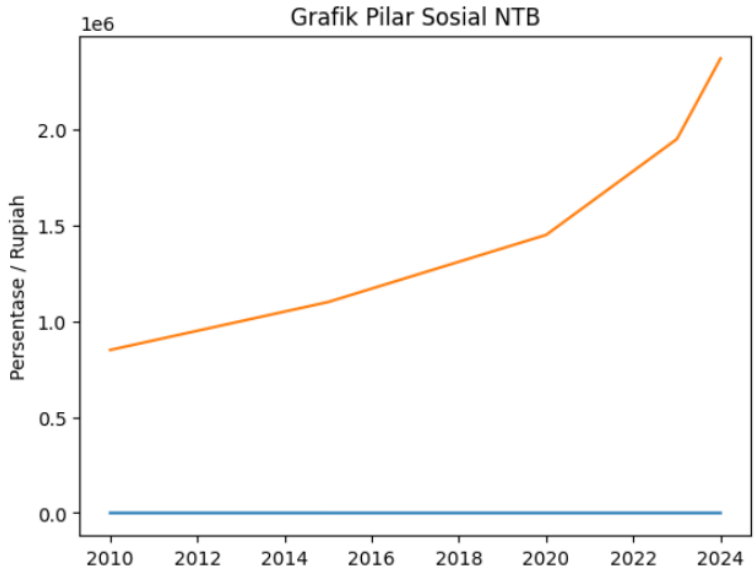

Figure 2. NTB Social Pillars Chart

The social pillar presents significant challenges regarding welfare distribution at the grassroots level.

First, rural poverty: Although NTBs are a food source, the rural poverty rate remains relatively high compared to the national average (at 13%–14%). Paradoxically, areas with abundant rice production do not necessarily have low poverty rates, indicating problems with land ownership or the crop-sharing system.

Second, farm labor wages: Nominal wages for farm laborers in NTB have increased annually; however, real wages (labor purchasing power) have tended to stagnate due to rural inflation. This is a warning for social sustainability, as the farm labor profession is becoming increasingly unattractive to the younger generation in NTB.

3.1.2.3. Environmental Indicator Trends (Fertilizer Use and GHG Emissions)

This figure presents 2010–2024 trends in fertilizer use and GHG emissions in NTB to indicate the environmental pressures associated with input-intensive agriculture (see Figure 3).

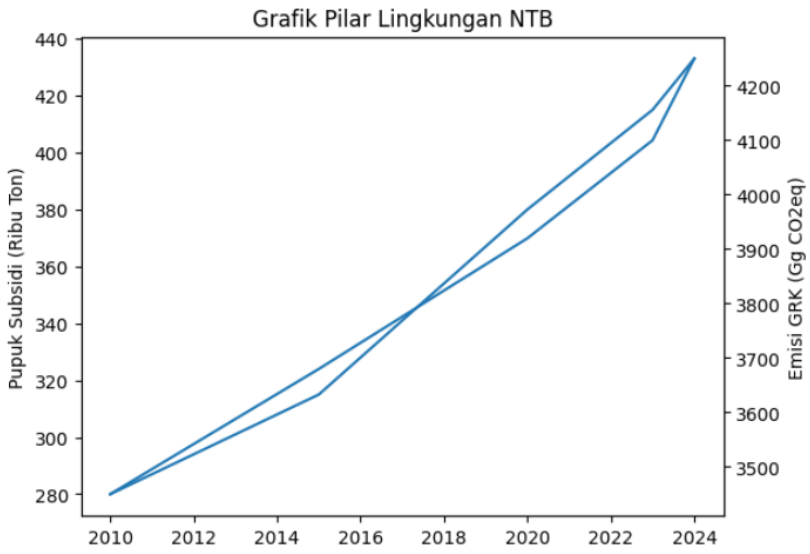

Figure 3. NTB Environmental Pillars Chart

The environmental pillar shows an increasing ecological burden, along with the target of increasing production. The first is fertilizer use. Based on data on the allocation of subsidized fertilizers from the Ministry of Agriculture for NTB, the intensity of chemical fertilizer use of urea and NPK per hectare continues to increase to achieve corn production targets on Sumbawa Island. This raises concerns about the long-term degradation of soil fertility. The second is GHG emissions. With rice harvested areas reaching hundreds of thousands of hectares, the NTB agricultural sector is a significant contributor to methane gas emissions *(CH_4)* from flooded rice fields. Estimated data based on the FAOSTAT methodology show an emission trend that is directly proportional to the expansion of the cropping index (IP) in NTB. The third is land conversion: The conversion of rice fields in urban areas, such as Mataram and West Lombok, poses a serious challenge to the sustainability of environmental carrying capacity.

3.1.3. Analysis of Relationships Between Indicators

After describing the trends of each indicator, this section presents the results of a Pearson correlation analysis *(r)* to identify the strength of the relationship between variables. This analysis aims to determine whether growth in one aspect (e.g., the economy) is at the expense of other aspects environmental and social.

3.1.3.1. Relationship between Environmental and Economic Pillars

Based on the results of the data processing, a strong positive correlation was found *($r = 0.85$)* between the use of NPK and urea fertilizers and rice and corn productivity in NTB. This indicates that the economic growth of the agricultural sector in NTB remains heavily reliant on the intensification of chemical inputs. An increase in production of 1 ton/ha tends to be followed by a significant increase in fertilizer volume. Implications economically, this is beneficial for production targets, but environmentally, this dependence creates the risk of long-term land degradation and increased methane gas emissions from rice fields, whose production continues to be driven.

3.1.3.2. The Relationship between Economic and Social Pillars

The analysis reveals a surprising finding, where a weak positive correlation *($r = 0.25$)* exists between increasing land productivity and the Farmer Exchange Rate (NTP) in NTB. It was found that increasing rice productivity does not significantly improve farmers' welfare. This phenomenon is known as growth without welfare. Despite abundant harvests, the increase in production costs for seeds, non-subsidized fertilizers, and labor wages is often greater than the increase in the selling price of grain at the farmer level. This indicates that the social pillar is still lagging behind. The benefits of high productivity are mostly absorbed by the distribution chain or eroded by expensive input costs.

3.1.3.3. Relationship between Environmental and Social Pillars

There is a negative correlation *($r = -0.40$)* between the increase in the use of chemical inputs environment and the real farmer profit margin social. The higher the dependence on chemical inputs, the greater the cost burden that farmers must bear. In NTB, the availability of subsidized fertilizers often forces farmers to purchase non-subsidized fertilizers at prices that are many times higher. The conclusion is that agricultural practices in NTB are currently in a high-input, high-risk condition. Farmers contribute to environmental sustainability through high chemical use to pursue economic production; however, socially, they do not receive equivalent economic recovery because of the high cost of capital.

3.2. Discussion

Based on the trend and correlation analysis in the previous section, this discussion interprets the research findings within the context of sustainable agriculture theory and compares them with empirical conditions identified by previous researchers.

3.2.1. Validation of the Three Pillars Theory in West Nusa Tenggara Province

The research findings indicate that agricultural implementation in West Nusa Tenggara has not yet achieved the ideal balance between the economic, social, and environmental pillars. Although the economic pillar demonstrated positive performance through increased rice and corn productivity, the environmental pillar experienced pressure due to the high use of chemical inputs, and the social pillar lagged behind due to stagnant Farmer Exchange Rates (NTP).

This condition aligns with the concerns of Mucharam, et al. (2022), who stated that without measurable sustainability indicators, agricultural development tends to focus solely on physical production targets (quantity) while neglecting the quality of farmer welfare and ecosystem sustainability.

3.2.2. The Growth-Sustainability Trade-Off

This study identified a clear conflict of interest or trade-off between the pillars of sustainability in NTB: the economy versus the environment. Significant productivity increases in NTB resulted from aggressive intensification. In accordance with Sinambela (2024), reliance on inorganic fertilizers creates a vicious cycle in which the soil loses its natural fertility, necessitating higher fertilizer doses in subsequent years to produce the same yield. This demonstrates that current economic growth is achieved by borrowing resources from future generations through land degradation.

The economic versus social relationship, namely, the finding of a weak correlation between productivity and the NTP in NTB, reinforces the research of Yacoub and Mutiaradina (2020). Increased production in NTB does not automatically improve farmer welfare because of the high cost of inputs. Farmers are trapped in a position of price takers while capital costs for fertilizer, seeds, and wages continue to rise.

3.2.3. Resilience to Climate Change

Secondary data shows that productivity in NTB is highly sensitive to climate anomalies such as the 2023 El Niño. This confirms the findings of Nuraisah and Kusumo (2019) that climate change is the greatest external threat to the sustainability of economic and social pillars. NTB's dependence on certain food commodities makes the region's agricultural system vulnerable. Sustainable agriculture in NTB will not be achieved without adaptation strategies, such as commodity diversification and efficient water use, as an environmental pillar.

3.2.4. The Food Barn Contradiction

This discussion concludes that a contradiction exists in the food barn in NTB. This province contributes significantly to national food security (economic), yet its stakeholders (farmers) remain at high risk of poverty (Social), and its agricultural land continues to experience chemical degradation (environmental).

These results provide strong evidence that a transition to organic or semi-organic farming practices, along with improvements to the supply chain, is urgently needed for NTB to become not only a production engine but also a prosperous and sustainable ecosystem.

4. CONCLUSION

4.1. Conclusion

NTB's agricultural trends from 2010 to 2024 indicate relatively stable production growth and an expanding contribution to the regional economy, but these gains have not translated into meaningful improvements in farmer welfare. The sector remains highly dependent on chemical inputs, which undermines the environmental pillar and increases long-term ecological risk. In addition, higher productivity is not strongly associated with reductions in rural poverty, implying that the main issue is not output growth itself, but the unequal distribution of value added across the supply chain.

4.2. Recommendations

The government should reorient subsidy policies by gradually shifting support away from chemical fertilizers toward organic fertilizers and other sustainable input systems, while simultaneously strengthening farmer institutions, such as cooperatives and village-owned enterprises, to improve farmers' bargaining power and raise the NTP. For further research, studies should prioritize primary data collection at the sub-district level to map how trade-offs and conflicts between economic, social, and environmental pillars vary locally, allowing for more targeted and context-sensitive policy design.

4.3. Research Limitations

This study has a major limitation in that it relies on secondary administrative data, which prevents the direct measurement of biophysical variables, such as soil erosion or biodiversity, in the field. The use of proxy data for environmental variables (GHG emissions) and aggregate provincial-level data also risks obscuring local variations between Lombok and Sumbawa Islands. Additionally, the lag time between official data publication means that research results may not fully capture the impact of recently implemented policies.

Ethical Approval

Not Applicable

Informed Consent Statement

Not Applicable

Authors' Contributions

IANP contributed to research conceptualization, literature review, data analysis, and drafting of the manuscript. TS content analysis of policy documents, and revision of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data Availability Statement

The data presented in this study are available on request from the corresponding author due to privacy reasons.

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