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GIS-BASED LAND SUITABILITY ANALYSIS FOR FOOD CROP DEVELOPMENT IN TRENGGALEK REGENCY

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Abstract

This study screens the spatial suitability of land for food-crop development in Trenggalek Regency using Geographic Information System (GIS) overlay analysis with slope as the primary biophysical indicator. The analysis covers the entire regency and classifies slope gradients into five categories using the classification of the Minister of Agriculture Decree No. 837/Kpts/Um/11/1980, followed by raster preparation, slope reclassification, and overlay with the existing land-use layer. In 2025, the prevalence of inadequate food consumption in Trenggalek was 12.07 percent, placing the regency among the five highest values in East Java and indicating a continuing need for place-specific food-system planning. The spatial results show a broad north–south differentiation: lower slopes dominate the northern group, while moderately steep to steep slopes are more prevalent in the southern group. Relative map-cell proportions are approximately 46.7 percent flat, 11.9 percent gently sloping, 21.7 percent moderately steep, 19.5 percent steep, and 0.2 percent very steep. These proportions are derived from the rendered map and are not official hectare statistics. The study does not treat slope suitability as a composite food-resilience index or as proof of crop productivity. The resulting map provides an initial spatial basis for land protection, conservation-oriented management, and further multi-factor suitability assessment.

Kata Kunci:

Analisis Spasial;
GIS;
Kemiringan Lereng;
Kesesuaian Lahan;
Tanaman Pangan;

Abstrak

Penelitian ini melakukan penyaringan spasial kesesuaian lahan untuk pengembangan tanaman pangan di Kabupaten Trenggalek menggunakan *Geographic Information System* (GIS) melalui analisis *overlay* dengan kemiringan lereng sebagai indikator biofisik utama. Analisis mencakup seluruh wilayah kabupaten dan mengelompokkan kemiringan lereng menjadi lima kelas berdasarkan klasifikasi Keputusan Menteri Pertanian No. 837/Kpts/Um/11/1980, kemudian dilanjutkan dengan penyiapan *raster*, reklasifikasi lereng, dan *overlay* dengan penggunaan lahan aktual. Pada 2025, prevalensi ketidakcukupan konsumsi pangan di Trenggalek sebesar 12,07 persen dan termasuk lima nilai tertinggi di Jawa Timur, sehingga perencanaan sistem pangan tetap memerlukan pendekatan spasial yang spesifik wilayah. Hasil menunjukkan pola utara–selatan yang jelas: kelas lereng lebih rendah mendominasi kelompok wilayah utara, sedangkan kelas agak curam hingga curam lebih banyak terdapat di kelompok wilayah selatan. Proporsi relatif sel peta diperkirakan sekitar 46,7 persen datar, 11,9 persen landai, 21,7 persen agak curam, 19,5 persen curam, dan 0,2 persen sangat curam. Proporsi tersebut merupakan estimasi dari peta yang dirender dan bukan statistik luas resmi dalam hektare. Penelitian ini tidak menempatkan kesesuaian berbasis lereng sebagai indeks ketahanan pangan komposit atau bukti produktivitas aktual. Peta digunakan sebagai dasar awal perlindungan lahan, pengelolaan konservasi, dan penilaian kesesuaian lanjutan berbasis banyak faktor.

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INTRODUCTION

Food resilience is a multidimensional development concern because the capacity of a local food system depends not only on food availability, but also on access, affordability, distribution, and the ability to respond to disruptions. In the Indonesian context, food policy therefore needs to be connected with spatial and economic planning so that productive resources can be allocated efficiently and protected from incompatible land uses (Salasa, 2021). Recent research likewise shows that GIS-based spatial assessment can connect land resources, planning interventions, and the resilience of local food systems, although the indicators and weighting schemes differ across study areas (Gu *et al.*, 2024).

Trenggalek Regency provides an important case for such a spatial perspective. The latest Statistics Indonesia data for 2025 record a prevalence of inadequate food consumption of 12.07 percent in Trenggalek, placing the regency among the five highest values in East Java after Situbondo, Jember, and Probolinggo. The figure is lower than Trenggalek's 2024 value of 14.75 percent, indicating improvement but not eliminating the need for spatially targeted planning. Food insecurity is also connected with household welfare and nutritional conditions. Hidayati (2023), for example, documented the relationship between household income, food security, and child nutritional status in Pasuruan. These findings place food access within a broader development context rather than treating food security as a production issue alone.

The spatial challenge is closely related to how agricultural land is allocated and managed. Previous Indonesian studies show that land conversion can reduce the area available for food production and alter the capacity of local farming systems to maintain food supply. Martanto *et al.* (2023) identified clustered land conversion in Bantul and linked sustainable food-land directions with food-security conditions, while Alamsyar (2022) documented substantial paddy-field decline in Sigi and its implications for future rice production. In Sleman, Putri *et al.* (2024) reported clustered conversion of agricultural land associated with food-security, environmental, and agricultural-sustainability concerns. Sudrajat *et al.* (2021) further showed at village level that shrinking rice-land availability around oil-palm expansion weakened household food self-sufficiency. More recently, Dewa and Anggraeni (2026) demonstrated the value of spatial analysis for examining agricultural land conversion in relation to food-security policy. Together, these studies indicate that land availability and land-use direction are relevant to food-system capacity, while also showing that actual conversion, production impacts, and household outcomes require data beyond a single topographic variable.

Table 1.
Prevalence of Inadequate Food Consumption (Percent) by Regency/City in East Java, 2025

Rank	Regency/City	2025 (percent)
1	Situbondo	17.22
2	Jember	13.24
3	Probolinggo	12.99
4	Trenggalek	12.07
5	Blitar	11.99

Source: Statistics Indonesia, 2025

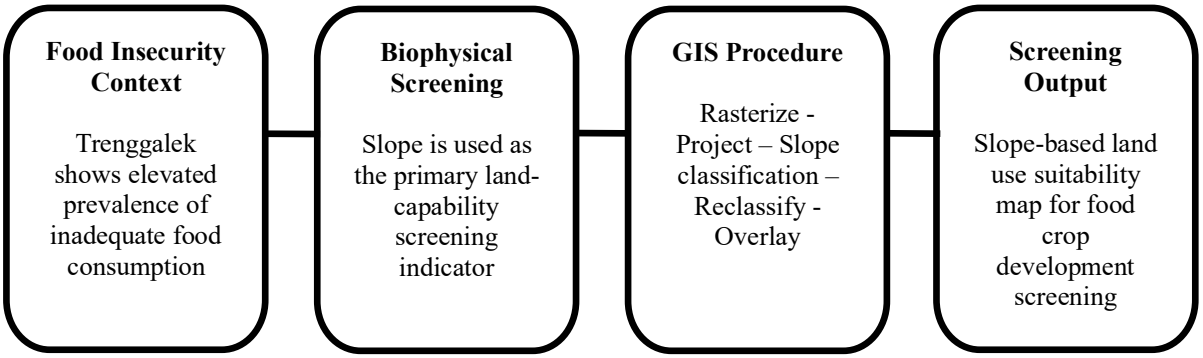
From a regional-development perspective, land suitability is useful because it helps planners distinguish where intensive food-crop cultivation is physically more compatible with the terrain and where conservation demands are likely to be greater. Spatial planning and land use are therefore connected through a feedback relationship: planning establishes the intended allocation and protection of space, while land-use evidence reveals how the physical capability of land can support or constrain those plans. Gu *et al.* (2024) demonstrate how GIS can be integrated into food-resilience assessment, while Baja *et al.* (2026) show that spatial land-suitability information can be linked to farm-income analysis. The economic significance of land suitability therefore lies not in assuming a direct income

effect from slope, but in using spatial evidence to reduce land-use mismatch and guide subsequent assessments of productivity, farm profitability, infrastructure, and market access.

Integrated spatial planning also requires attention to environmental carrying capacity and the spatial distribution of regional economic activities. Previous studies have emphasized spatial coordination in strengthening economic sectors, managing environmental quality, and addressing regional development disparities (Desanty et al., 2026; Puspita, 2025; Ronaldi et al., 2026). For food-related planning, these perspectives are most useful when they are translated into place-specific land information. Thus, the present study uses slope as a first-stage biophysical screening variable rather than as a complete food-security measure.

The objective of this study is to delineate the spatial pattern of slope-based land-use suitability for food-crop development in Trenggalek Regency and to identify the major north–south concentrations of lower and higher slope classes. The analysis is intended to provide an initial spatial reference for regional development planning, land protection, and conservation-oriented agricultural management. The study does not test a statistical hypothesis because its design is descriptive-spatial; instead, it evaluates the spatial proposition that lower slope gradients are generally more compatible with intensive cultivation, whereas steeper gradients require stronger conservation considerations.

The contribution of the study is methodological and planning-oriented. It converts slope information and existing land-use data into a readable GIS-based screening map, while explicitly limiting interpretation to what the available variables can support. The resulting map is therefore not presented as a composite food-resilience index, a measure of crop productivity, or evidence of a causal relationship between slope and household food security. This distinction is important for using the map as a first-stage input to more comprehensive food-system and regional-economic assessment.



Source: Author's Analytical Framework, 2026

Figure 1. Analytical Framework

RESEARCH METHOD

The study uses a quantitative descriptive-spatial design. The study area is Trenggalek Regency, East Java, and the spatial coverage is the entire administrative area represented in the available geospatial layers. The unit of analysis is the rasterized spatial cell or polygon produced during GIS processing; therefore, no human respondents, population sample, or questionnaire survey is involved. Secondary geospatial data consist of a slope/contour layer and an existing land-use or land-typology layer prepared for the 2026 analysis. The statistical food-insecurity context is taken from Statistics Indonesia's 2025 prevalence-of-inadequate-food-consumption data.

Slope is selected as the primary screening variable because terrain gradient affects the physical practicality of cultivation, water movement, erosion exposure, and the conservation effort required to maintain productive land. The variable is intentionally used as a first-stage biophysical indicator rather than a complete land-suitability model. Recent GIS studies support the use of slope together with other

spatial parameters for spatial zoning and land-management assessment (Erfani *et al.*, 2023; Gu *et al.*, 2024; Sukiyah & Nurfadli, 2024).

The GIS procedure was implemented in ArcMap through five sequential steps. First, the land-typology polygons were rasterized so that the land-use layer could be processed in a common grid structure. Second, raster layers were projected into a consistent spatial reference to minimize positional mismatch during overlay. Third, slope was derived from the available elevation or contour information. Fourth, the slope raster was reclassified into five classes using the slope classification of the Minister of Agriculture Decree No. 837/Kpts/Um/11/1980 (Ministry of Agriculture, 1980). In this article, all thresholds are expressed as percentages, not degrees. Fifth, polygon boundaries were smoothed for cartographic presentation only; smoothing does not change the underlying analytical classification. Overlay analysis was then used to compare the spatial arrangement of the slope classes with the existing land-use layer.

The slope thresholds applied are 0–8 percent (Flat), 8–15 percent (Gently Sloping), 15–25 percent (Moderately Steep), 25–45 percent (Steep), and greater than 45 percent (Very Steep). The terminology is interpreted as a screening hierarchy: lower slopes are generally more compatible with intensive annual cultivation, intermediate slopes require progressively stronger soil and water conservation, and the steepest class is treated primarily from a conservation perspective. Because slope alone cannot determine crop performance, no additional weighting is assigned to soil, rainfall, irrigation, market access, farm income, or other food-security dimensions in this study.

The relative share of each slope class was estimated from the classified map by counting the map cells represented by each class colour. These percentages are reported as relative map-cell proportions rather than official area statistics and are used only to describe the spatial predominance of each class.

The methodological logic is consistent with prior overlay-based research. Danoedoro *et al.* (2020) demonstrate the value of integrating landform and land-cover information in detailed land-use mapping. Sukiyah and Nurfadli (2024) and Erfani *et al.* (2023) show how slope can be integrated with other variables in GIS-based spatial zoning, while Sandy (2025) illustrates the use of ArcGIS overlay procedures for flood-distribution mapping. These studies support the analytical workflow, but they do not directly validate food-crop suitability in Trenggalek because their objectives and variables differ from the present study.

RESULT AND DISCUSSION

The GIS overlay produced a slope-based land-use suitability screening map for Trenggalek Regency. The analysis should be interpreted as a biophysical screening exercise: slope identifies where terrain is relatively more or less compatible with cultivation, while the land-use layer shows how those terrain conditions are distributed across the existing landscape. The approach is useful for regional planning because it converts a continuous physical characteristic into spatially explicit classes that can be compared with current land use.

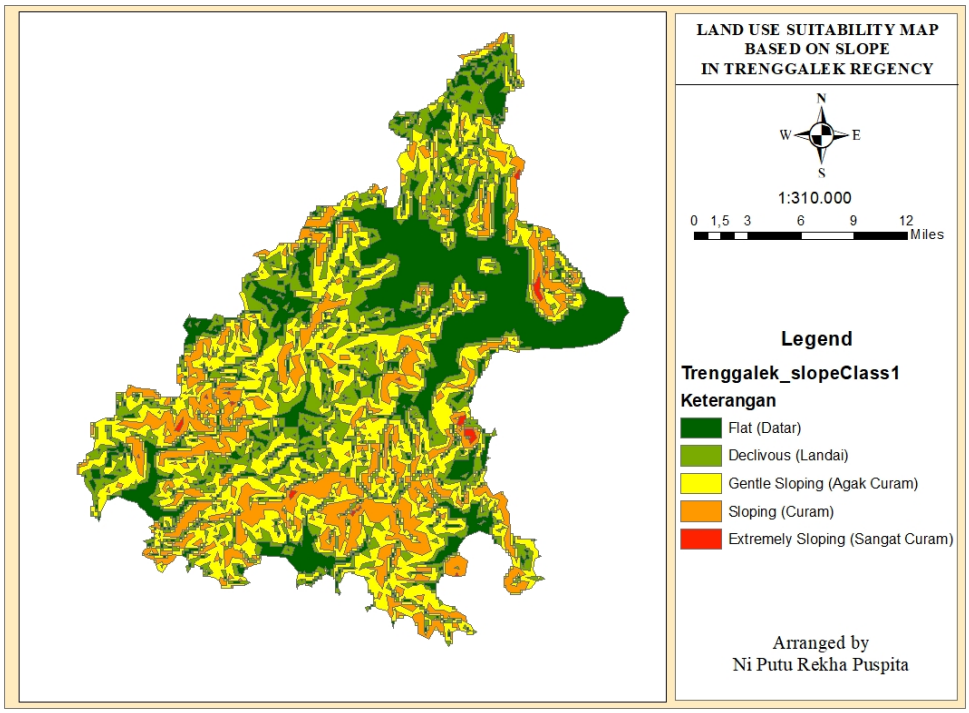
Table 2.
Slope Classification Used in the GIS Screening

Slope Class	Slope Gradient (%)	Interpretation for land-use screening
Flat	0–8	Most compatible with intensive cultivation, irrigation layout, field access, and soil preparation.
Gently Sloping	8–15	Suitable for agriculture with increasing attention to drainage, soil cover, and conservation.
Moderately Steep	15–25	Agricultural use remains possible, but conservation and water-management requirements increase.

Slope Class	Slope Gradient (%)	Interpretation for land-use screening
Steep	25–45	Cultivation is more constrained; conservation-intensive agriculture, perennial use, or grassland systems require careful management.
Very Steep	>45	Primarily a conservation/protection priority; intensive annual cultivation is strongly constrained.

Source: Adapted from Ministry of Agriculture (1980)

Table 2 summarizes the slope classification used throughout the analysis; all thresholds are expressed as slope gradient (percent) rather than degrees. The resulting slope-based land-use suitability map is presented in Figure 2.



Source: Processed Data, 2026

Figure 2. Slope-Based Land Use Suitability Map, Trenggalek Regency

Figure 2 shows a broad north–south differentiation in slope classes. Lower-slope classes (Flat and Gently Sloping) are concentrated in the northern part of the regency, including Bendungan, Trenggalek, Pogalan, Durenan, Gandusari, Tugu, and Karangan, whereas the southern part, represented by Pule, Dongko, Kampak, Watulimo, Munjungan, and Panggul, is dominated by Moderately Steep to Steep terrain. The pattern indicates that the two parts of the regency face different land-management conditions rather than one uniform agricultural environment. Because the classification is slope-based, it should not be read as definitive crop suitability for each sub-district.

For descriptive quantification, the rendered map indicates approximate relative shares of 46.7 percent Flat, 11.9 percent Gently Sloping, 21.7 percent Moderately Steep, 19.5 percent Steep, and 0.2 percent Very Steep. The combined lower-slope classes therefore account for about 58.6 percent of the mapped classified cells, whereas the Moderately Steep to Very Steep classes account for about 41.4 percent. Because these values are derived from the rendered map rather than the original GIS attribute table, they are used to describe spatial dominance and should not be read as official hectare totals.

The northern concentration of lower slopes has an economic interpretation, but that interpretation must remain within the limits of the analysis. In general, lower gradients are more compatible with irrigation layout, field access, soil preparation, and mechanized operations, which can reduce physical constraints on agricultural management. This does not prove higher productivity or

income in the northern area because those outcomes were not measured. Evidence from Wakatobi shows that spatial land-suitability assessment can be connected with net farm income when biophysical and farm-economic data are combined (Baja *et al.*, 2026). Thus, the Trenggalek map is best treated as an upstream spatial input for subsequent productivity, profitability, and infrastructure analysis.

The southern concentration of steeper terrain implies a different management logic. As slope increases, soil-erosion control, water management, access, and conservation requirements generally become more demanding. The appropriate response is therefore not to classify all steep land as unproductive, but to distinguish between areas that can support conservation-oriented agriculture and areas where ecological protection should take precedence. This interpretation is consistent with GIS-based studies that use slope as one component of spatial vulnerability or land-management assessment (Erfani *et al.*, 2023; Sandy, 2025; Sukiyah & Nurfadli, 2024).

The result also clarifies how this study relates to previous research on land conversion and food insecurity. Martanto *et al.* (2023), Alamsyar (2022), Putri *et al.* (2024), Sudrajat *et al.* (2021), and Dewa and Anggraeni (2026) focus on land-use change, conversion pressure, or food-security consequences. Their evidence supports the importance of protecting land resources, but their methods are not directly comparable with the present slope-screening analysis. The present study is complementary because it identifies the physical distribution of terrain classes that should be considered before more detailed assessments of conversion risk, crop suitability, farm productivity, or household outcomes are undertaken.

The broader resilience literature suggests that food systems should be treated as dynamic systems rather than as production spaces alone. Sperling *et al.* (2022) emphasize absorptive, coping, adaptive, and transformative capacities, while Gu *et al.* (2024) demonstrate that food-resilience assessment can be integrated with GIS and spatial planning. Stone *et al.* (2024) further show that spatial visualization can help explore alternative local food-production arrangements. For Trenggalek, these perspectives support using the slope map as one layer within a wider regional food-system framework rather than interpreting the map as a stand-alone resilience score.

The analytical comparison with other spatial studies also explains why the present result is necessarily limited. Danoedoro *et al.* (2020) show that landform context and land-cover interpretation can improve detailed land-use mapping, while Sukiyah and Nurfadli (2024), Erfani *et al.* (2023), and Sandy (2025) combine multiple spatial variables in vulnerability mapping. Rowland and Ebuka (2024) highlight the resilience implications of land-cover change for urban infrastructure, and Nimko (2023) discusses land-use planning as a support for self-sufficiency among displaced populations. These studies collectively indicate that spatial overlays are useful decision-support tools, but they also demonstrate that resilience is multi-factor and cannot be represented by slope alone.

The main contribution of the Trenggalek analysis is therefore the identification of a geographically differentiated first-stage screening pattern. The map is most useful for protecting lower-slope agricultural land from incompatible conversion, prioritizing conservation-oriented management in more inclined terrain, and identifying locations where additional variables should be added before a final crop or food-resilience designation is made. The study does not estimate policy effectiveness, does not establish causality, and does not claim that any specific crop will perform well solely because of its slope class.

A limitation follows directly from the research design. Soil characteristics, rainfall, temperature, water availability, irrigation access, current crop composition, farm size, farmer income, road accessibility, markets, land tenure, and demographic access to food were not included in the overlay. Consequently, the map should be interpreted as a slope-based land-use screening layer. Future work should combine these variables through a transparent multi-criteria framework and, where possible, validate the resulting suitability classes against observed crop productivity and farm-economic outcomes.

Table 3.
Relative Distribution of Mapped Slope Classes

Slope class	Relative mapped-cell share (%)	Spatial interpretation
Flat	46.7	Largest mapped class; concentrated mainly in the lower-slope northern group.
Gently Sloping	11.9	Additional lower-slope area that remains relatively compatible with cultivation subject to conservation.
Moderately Steep	21.7	Intermediate class; agriculture is possible with stronger soil and water management.
Steep	19.5	Substantial area where cultivation is more constrained and conservation demand is higher.
Very Steep	0.2	Very limited mapped share; prioritize ecological protection/conservation interpretation.

Note: percentages are estimated from the rendered classified map and represent relative map-cell proportions, not official hectare totals
Source: Processed Data, 2026

CONCLUSION AND SUGGESTION

The GIS analysis identifies a clear spatial differentiation of slope conditions in Trenggalek Regency. The northern group is dominated by Flat and Gently Sloping terrain, while the southern group is characterized more strongly by Moderately Steep to Steep terrain. The five-class map therefore provides a geographically explicit screening layer for distinguishing areas with relatively lower cultivation constraints from areas where conservation requirements are greater. The central conclusion is not that a particular crop is automatically suitable in one region, but that terrain creates different planning conditions that should be considered in agricultural land management.

The findings support a targeted regional-planning interpretation rather than a claim of complete crop suitability. Lower-slope areas can be prioritized for more intensive assessment of food-producing land, while steeper areas require stronger conservation and land-management safeguards. Because slope alone does not measure productivity, irrigation, soil quality, farm income, market access, or household food access, subsequent planning should combine the slope map with these additional dimensions before designating operational food-development zones. This approach keeps the policy implication consistent with the empirical evidence while strengthening the role of spatial analysis in regional food planning.

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