ISSN: 2623-1662 (online), 2460-092X (printed)
DOI: https://doi.org/10.19109/jusifo.v10i2.24830
Vol. 10, No. 2 (2024), p.107-116

JUSIFO
JURNAL SISTEM INFORMASI

Research Article [OPEN ACCESS]

# GIS-Based Spatial Analysis for Land Suitability and Community Quality of Life Development in Nabire Regency

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## ABSTRACT

This study evaluates land suitability in Nabire Regency, Indonesia, employing geographic information systems (GIS) and spatial analysis to enhance community quality of life. Rapid urbanization and increasing land use pressures have resulted in significant environmental challenges, including deforestation, loss of agricultural land, and reduced access to green spaces. By integrating criteria such as land cover, soil quality, water availability, and socio-economic data, the research identifies optimal locations for housing, agriculture, and conservation areas. Results demonstrate disparities in infrastructure and living standards, emphasizing the need for balanced spatial planning. The proposed land suitability map offers actionable insights for policymakers to foster sustainable development, improve resource allocation, and enhance urban and rural livability. This work underscores the critical role of GIS-based spatial analysis in addressing urbanization challenges and guiding equitable development strategies.

**Keyword:** Geographic information systems, land suitability, sustainable development

Received: October 11, 2024; Revised: December 15, 2024; Accepted: December 30, 2024

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## 1. INTRODUCTION

Land suitability evaluation is a fundamental process in determining the optimal use of land for specific purposes. As a critical methodological tool, spatial analysis evaluates land characteristics and their potential to support community development (I'anah et al., 2019). This approach integrates diverse factors, including physical, economic, social, and environmental conditions, to identify areas most suitable for various activities (Mansyur, 2021). Spatial analysis is indispensable in environmental studies and regional planning as it interprets geographical data, enabling comprehensive assessments of land characteristics, potentials, and limitations. Such evaluations support informed decision-making and environmentally sustainable development strategies (Harahap et al., 2020). Urban quality of life, a vital aspect of public welfare and health improvement, is influenced by several factors, such as access to essential services, environmental conditions, economic opportunities, and community participation in development initiatives (Novian & Machdum, 2021). Nabire City, the capital of Nabire Regency in Central Papua Province, Indonesia, offers a case study of these dynamics. This region, endowed with abundant natural resources, including agriculture, forestry, and marine areas, holds significant potential for enhancing community welfare. However, challenges such as economic inequality, limited access to basic services, and environmental degradation remain pressing concerns.

The rapid urbanization and population growth in Nabire Regency have heightened pressure on urban land use. The increasing demand for land to accommodate housing, infrastructure, and economic activities

threatens agricultural and forest lands, impacting environmental quality and the land's carrying capacity to sustain communities (Dalulia et al., 2022). Recent trends reveal substantial land use changes, where agricultural and forested areas have been converted to residential and industrial zones, reducing productive land and diminishing environmental quality (Purba et al., 2023). This conversion has exacerbated issues such as reduced green spaces, pollution, and declining agricultural output, threatening food security. Key indicators of quality of life in Nabire Regency include access to clean water and sanitation, healthcare, adequate housing, poverty levels, unemployment rates, and the availability of green open spaces and agricultural land. Spatial analysis highlights disparities within the region, showing that urban centers enjoy superior infrastructure and services, while suburban and slum areas suffer from inadequate clean water, poor sanitation, and higher poverty rates (Ramadhani et al., 2021). These inequalities underline uneven development and the need for balanced resource distribution.

Spatial planning grounded in land suitability analysis provides a strategic approach to addressing these challenges and enhancing the quality of life in Nabire Regency. This method identifies the most appropriate land uses for housing, agriculture, green spaces, and health infrastructure, promoting balanced development while ensuring environmental sustainability (Hamzens & Moestopo, 2018). Furthermore, spatial planning can enhance community well-being by integrating land tenure analysis and optimizing the location of transportation infrastructure, including roads, bridges, and public transit systems (Prasetya & Anisia, 2021). Improved accessibility to services such as education, healthcare, and employment fosters social and economic development (Hamas & Salahudin, 2021). A nuanced understanding of land suitability allows planners to create more organized, livable settlements and mitigate risks in disaster-prone areas, such as those vulnerable to floods and landslides (Firdaus & Yuliani, 2022).

This study evaluates land suitability in Nabire Regency using geographic information systems (GIS) and spatial analysis to support activities that improve community well-being. It emphasizes developing affordable, livable settlements and explores opportunities for urban farming to enhance food security and income. Additionally, the study identifies areas for conservation and green spaces to maintain ecological balance and enhance environmental quality in urban settings (Kirana et al., 2020).

## 2. MATERIALS AND METHODS

### 2.1 Materials

Several previous studies have explored spatial analysis for land suitability and its implications for regional development. For instance, I'anah et al. (2019) analyzed land-use inconsistencies in the Cisadane Watershed Protected Area. Their findings revealed that factors such as inadequate public awareness, weak law enforcement, and increasing land demand contribute to deviations from spatial planning. Similarly, Hidayati et al. (2017) examined rice field conversion in Bogor City, utilizing a spatial analysis approach to identify suitable locations for housing development in Bandung while considering environmental quality and transportation accessibility.

Although these studies provide valuable insights into land-use inconsistencies and policy implications, they predominantly focus on the policy and regulatory aspects of spatial planning. A notable research gap exists in linking land suitability analysis to community quality of life improvements, particularly in the context of Nabire Regency. Previous studies have not sufficiently addressed the spatial disparities in quality of life or their connection to land use patterns in this region.

This study addresses the identified research gap by conducting a detailed spatial analysis of land suitability in Nabire Regency. It emphasizes the development of strategies to enhance community quality of life through the identification of spatial disparities and their relationship with existing land use. The study aims to provide actionable recommendations for spatial planning that align with land suitability assessments, ensuring equitable development and sustainable improvements in community welfare. These recommendations serve as a critical input for local government efforts to optimize land use and improve living standards across the region.

## 2.2 Methods

This study employs a quantitative approach utilizing spatial analysis based on geographic information systems (GIS) to evaluate land suitability. Spatial analysis is conducted to assess various criteria, including land cover conditions, soil quality, and water availability, which are crucial for determining land potential for agriculture and protected areas. Additionally, factors such as land slope and elevation are examined to evaluate their feasibility for settlements and agricultural purposes. Relevant data, including climate, existing land use, and socio-economic conditions, are also integrated into the analysis (Achmadi et al., 2023).

The methodology involves overlay and weighting techniques, combining multiple data layers to produce a comprehensive land suitability map. The weighting process assigns priority values to factors based on their influence on land suitability. For this purpose, ArcGIS, the latest version of GIS software, is utilized due to its advanced capabilities in spatial analysis. The software's overlay and weighting tools enable high-precision processing of complex geospatial data. Furthermore, ArcGIS provides an extensive range of analytical tools that support effective management and visualization of geographic information, enhancing the accuracy and applicability of the results.

## 2.3 Data Collection

The initial stage of this study emphasizes data collection as a critical step to ensure the quality and completeness of information for spatial analysis (Wubie et al., 2020). The data collected includes various geospatial information relevant to the research objectives, such as land cover, soil quality, land slope, elevation, and water availability. These datasets are sourced from satellite imagery, topographic maps, field surveys, and secondary data provided by government agencies and other institutions that manage geospatial data for Nabire Regency. A key resource is the spatial planning map for nabire regency 2008–2028, which offers information on spatial planning, including land use zoning, planned infrastructure, and protected areas, serving as a primary reference for understanding the region's land management potential and constraints.

Satellite imagery proves invaluable for analyzing land cover and detecting changes within the region, while topographic maps and field surveys provide more detailed data on slope, elevation, and soil conditions. Beyond physical data, this research also integrates socio-economic information to examine the relationship between land use and community quality of life. Socio-economic data includes population density, educational levels, and per capita income, as well as infrastructure-related data such as accessibility to markets, healthcare facilities, and educational institutions (Chen et al., 2020).

The data collection process is conducted systematically, including field verification to ensure the accuracy of the information. Field visits are undertaken to verify the consistency of data from satellite imagery, maps, and secondary sources with real-world conditions. Additionally, field data collection aims to gather supplementary information not covered by secondary sources, such as detailed soil characteristics and accessibility conditions in remote areas. Interviews with local communities and authorities are also conducted to gain deeper insights into the opportunities and challenges of land management in Nabire Regency (Fathy et al., 2019).

Once data is collected, it undergoes processing and formatting for spatial analysis using Geographic Information System (GIS) software. The datasets are converted into raster and vector formats as required for the analysis. This meticulous and comprehensive data collection process forms a robust foundation for land suitability analysis, ultimately resulting in maps that depict land development potential based on various physical and socio-economic factors. Therefore, accurate and complete data collection is a crucial step that ensures the success and validity of this study in providing policy recommendations for land use management in Nabire Regency (Wahyuddin et al., 2021).

## 2.4 Data Processing

The data collected in various formats (raster, vector, and tabular) must first be standardized and converted into compatible formats to enable further analysis. This process begins with map projection alignment, ensuring that all data shares a consistent geographic reference. This step is essential to prevent

spatial analysis errors caused by discrepancies in coordinate systems. Once alignment is complete, the converted data is processed using overlay techniques, which combine multiple geospatial data layers, such as land cover, soil quality, slope, elevation, and water availability, to produce a comprehensive land suitability map.

During the overlay stage, each prepared data layer is integrated to analyze the compatibility of factors influencing land use potential. For example, by combining land cover and slope data, areas suitable for agriculture or settlements can be identified (Lanya et al., 2019). This process not only provides a clear visualization of suitability patterns but also establishes a foundation for the subsequent weighting analysis. Weighting is applied to determine the relative importance of each variable in influencing land suitability. These variables include both physical and social factors, such as soil conditions, accessibility, and environmental carrying capacity.

The weighting of variables is determined through a combination of literature reviews, local expertise, consultations with subject matter experts, and findings from field surveys (Sia et al., 2021). After assigning weights, the results of the overlay and weighting analyses are used to generate a Land Suitability Unit (LSU) map. This map depicts the potential land use for various purposes, including agriculture, settlements, or conservation areas, based on the analyzed factors.

The outcome of this process is an LSU map categorized into several classes, such as highly suitable, suitable, moderately suitable, and unsuitable, based on the final analysis scores. These categories provide a clear depiction of land feasibility for various uses. Classification details and the weighting of variables used in this analysis are presented in Table 1, Table 2, and Table 3, facilitating interpretation and offering a robust foundation for land use policy recommendations in Nabire Regency.

Table 1. Land suitability units based on morphological capability

| Morphology | Slope (%) | Morphological Capability | Score |
|---|---|---|---|
| Steep Hills | > 45 | High morphological capability | 1 |
| Moderate Hills | 25 – 45 | Moderate morphological capability | 2 |
| Gentle Hills | 15 – 25 | Medium morphological capability | 3 |
| Rolling Plains | 2 – 5 | Low morphological capability | 4 |
| Flat Plains | 0 – 2 | Very Low morphological capability | 5 |

Table 2. Land suitability units for slope stability

| Morphology | Slope (%) | Elevation (m) | Soil Type | Rainfall (mm/year) | Soil Movement Vulnerability Zone | Slope Stability | Score |
|---|---|---|---|---|---|---|---|
| Steep Hills | > 45 | 2500–3672 | - | > 3000 | Zone 1 (Highly Vulnerable) | Low Stability | 1 |
| Moderate Hills | 25 – 45 | 1500–2500 | Alluvial | 2000–3000 | Zone 2 (Vulnerable) | Moderate Stability | 2 |
| Gentle Hills | 15 – 25 | 500–1500 | Grumasol | 1000–2000 | Zone 3 (Slightly Vulnerable) | Moderate Stability | 3 |
| Rolling Plains | 2 – 5 | 100–500 | - | < 1000 | Zone 3 (Safe) | High Stability | 4 |
| Flat Plains | 0 – 2 | 0–100 | - | - | Zone 3 (Safe) | High Stability | 5 |

Table 3. Land suitability units for foundation stability

| Morphology | Foundation Stability and Capacity | Score |
|---|---|---|
| Steep Hills | Low foundation stability and capacity | 1 |
| Moderate Hills | Moderate foundation stability and capacity | 2 |
| Gentle Hills | Medium foundation stability and capacity | 3 |
| Rolling Plains | Moderate foundation stability and capacity | 4 |
| Flat Plains | High foundation stability and capacity | 5 |

### 2.5 Result Analysis and Validation

The spatial analysis of land suitability identifies areas most appropriate for specific activities, such as improving the quality of life for the community. This analysis focuses on evaluating lands with potential for development into settlements, agriculture, or other activities that enhance community welfare (Mazahreh et al., 2019). The result analysis integrates spatial and statistical data to describe land potential for supporting various sectors, including agriculture, settlements, and infrastructure. The analysis outputs include a land suitability map categorized into several classes, ranging from very suitable to unsuitable (Özkan et al., 2020). These maps provide a visual representation of areas with high development potential and regions that should be avoided due to constraints such as poor soil conditions, steep slopes, or disaster risks. Additionally, quantitative data on the area distribution of each suitability class and key influencing factors are generated, offering comprehensive insights for land management.

The validation stage compares the data obtained from various sources, such as satellite imagery, geospatial datasets, and information provided by stakeholders involved in regional development planning (Li et al., 2022). This comparison enhances the validity of the results and provides a holistic understanding of land suitability conditions in Nabire Regency. The validation process also incorporates environmental, social, and economic factors that influence land development outcomes. For example, spatial analysis not only determines land suitable for agriculture but also evaluates the sustainability of land use and its broader impact on community welfare.

Validation findings underscore that socioeconomic factors, such as education levels and the ability of communities to manage natural resources, are critical for successful policy implementation (Herzberg et al., 2019). These factors highlight the necessity of involving both local communities and decision-makers in land development planning. Such involvement ensures that analytical results translate into inclusive and sustainable policies that align with regional development goals. By integrating diverse data sources and considering a range of factors, this study provides robust recommendations for sustainable land use and community-focused development.

## 3. RESULTS AND DISCUSSION

### 3.1 Settlement and Land Use Analysis

Figure 1 illustrates the physical and socioeconomic landscape of Nabire Regency, providing a detailed map of settlement and land use patterns. Different colors on the map represent various types of land use: red indicates settlements, purple signifies mangrove forests, green represents forests, and other colors denote additional land uses. This map serves as a critical tool for understanding how land in Nabire Regency is utilized, offering insights into the distribution of residential areas, productive agricultural zones, and natural forest regions. Such information is indispensable for sustainable development planning, ensuring environmental balance is preserved while meeting community needs.

The analysis reveals that land use in Nabire Regency is predominantly forested, covering approximately 90% of the total area or about 9,495 $km^2$. The remaining 10% consists of fields, plantations, settlements, and other uses. This underscores the significance of forests as an essential natural resource supporting the local ecosystem. However, it also highlights the pressing challenge of managing land sustainably to address community needs without compromising environmental integrity.

Sustainable development strategies must prioritize optimal land use while safeguarding forest sustainability. The insights derived from this map can guide better planning efforts, such as designing infrastructure compatible with regional conditions, promoting a sustainable agricultural sector, and preserving untouched forest areas. By leveraging this data, policymakers can ensure that development initiatives align with the region's ecological and socioeconomic needs, fostering long-term resilience and growth.

### 3.2 Analysis of Land Development Capability

The land development capability analysis, conducted through the Land Ability Unit framework, provides a detailed map illustrating the potential and constraints of land use in Nabire Regency. Different

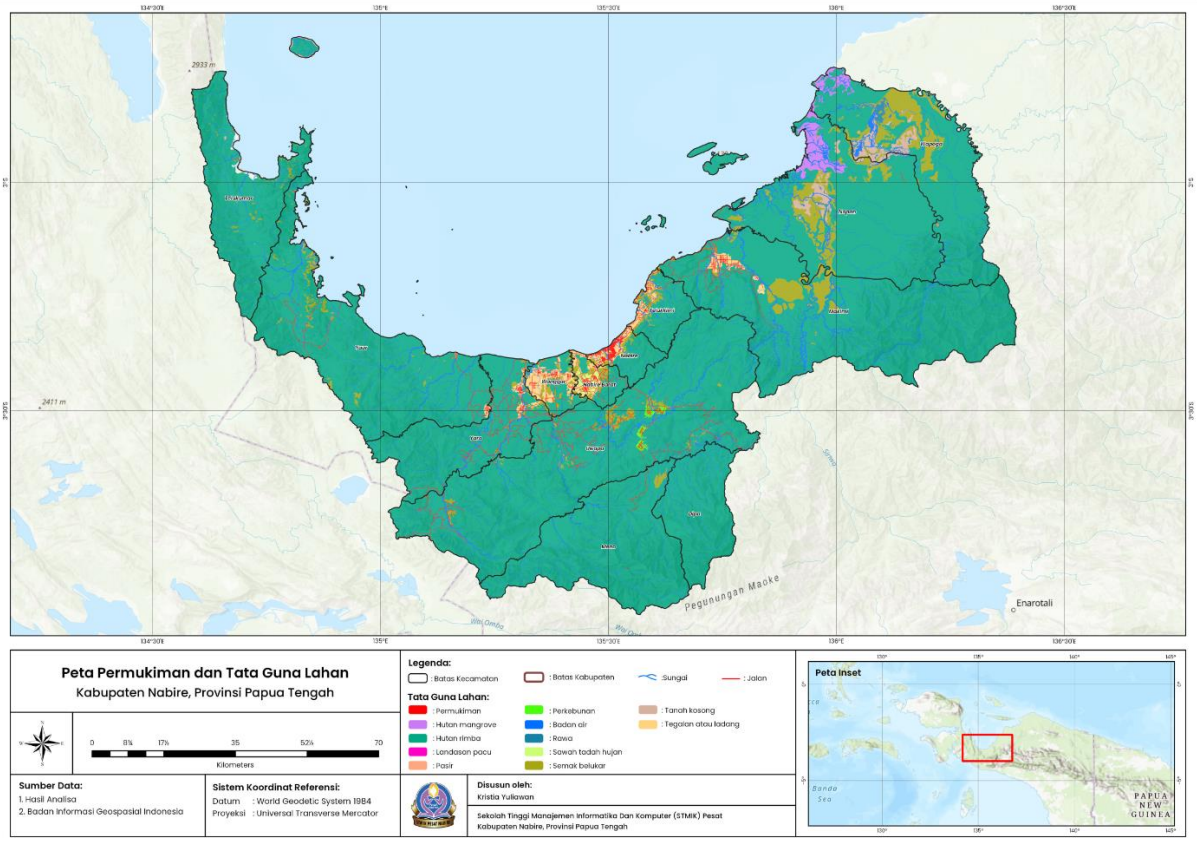


Figure 1. Map of settlement and land use of nabire regency

colors on the map represent varying levels of land development capability. Green areas indicate dominant vegetation, such as forests, gardens, or grasslands, which are often associated with high land development potential. These areas typically have fertile soil rich in nutrients, making them ideal for agricultural activities. Furthermore, natural vegetation often signifies adequate water availability, a critical factor for supporting settlements and industrial activities. Additionally, green zones often feature stable, gently sloping topography, reducing the risk of natural disasters such as landslides or floods.

Conversely, areas trending toward red on the map signify lower land development capacity. These areas often face challenges such as steep slopes, which increase the risk of erosion and hinder cultivation. Poor soil fertility further limits land productivity, making it less suitable for agriculture and development. Moreover, red areas are frequently prone to natural disasters, including floods, landslides, and earthquakes, posing significant risks to infrastructure and limiting the potential for sustainable development.

The analysis reveals that approximately 2,885 km$^2$ (27%) of Nabire Regency's land area falls into the very low capability category, while 6,011 km$^2$ (57%) is categorized as having medium development capability. High-capability areas constitute 1,689 km$^2$ (16%) of the total land area. These findings, as depicted in Figure 2, provide critical insights into the region's land development potential and offer a valuable basis for formulating strategies to optimize land use while mitigating risks and constraints.

### 3.3 Analysis of Land Development Directions

Figure 3 presents a map illustrating the potential and constraints of land development in Nabire Regency, highlighting areas suitable for various land uses. Different colors on the map represent land development directions, ranging from areas highly suitable for agriculture to those unsuitable for development. Dark green areas indicate regions with high agricultural potential, characterized by fertile soil ideal for diverse crops. Yellow or light green areas are generally suitable for residential or industrial development, offering moderate potential for settlement expansion. Conversely, red or orange areas signify

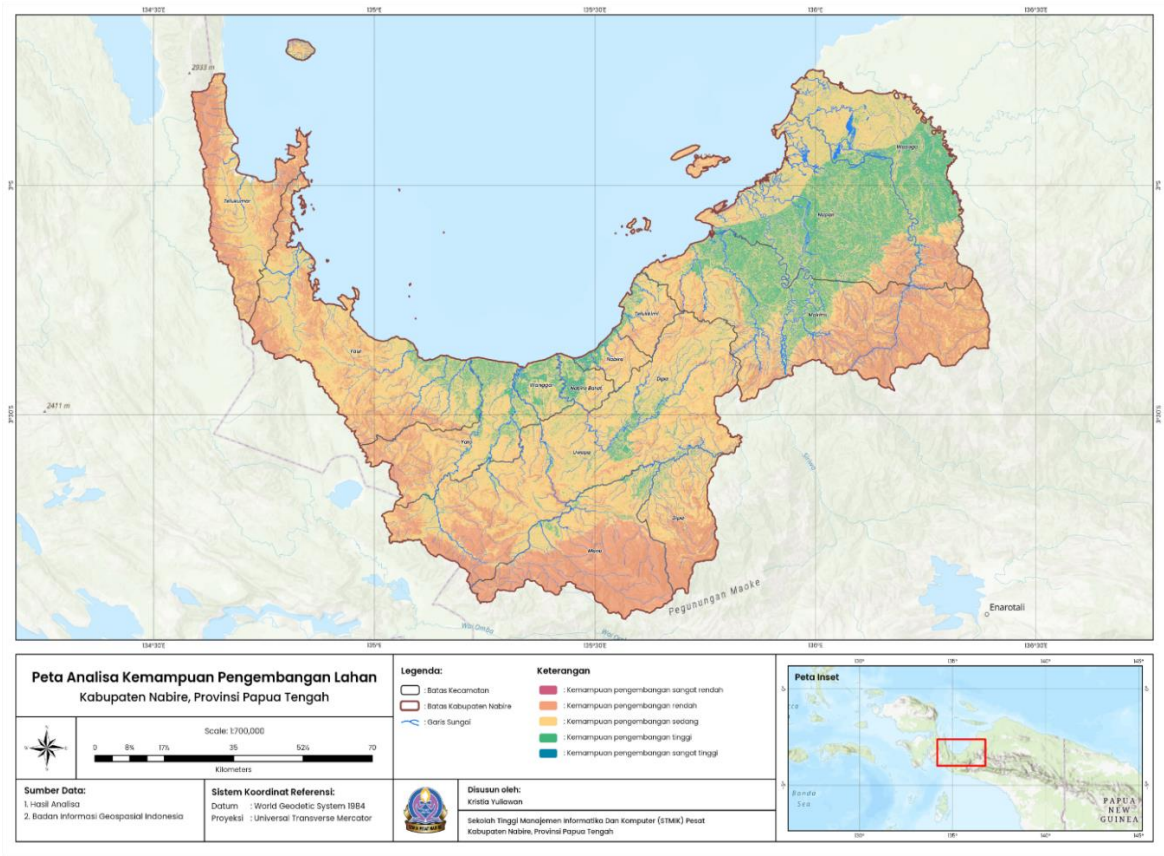


Figure 2. Map of land development capability analysis map of nabire regency

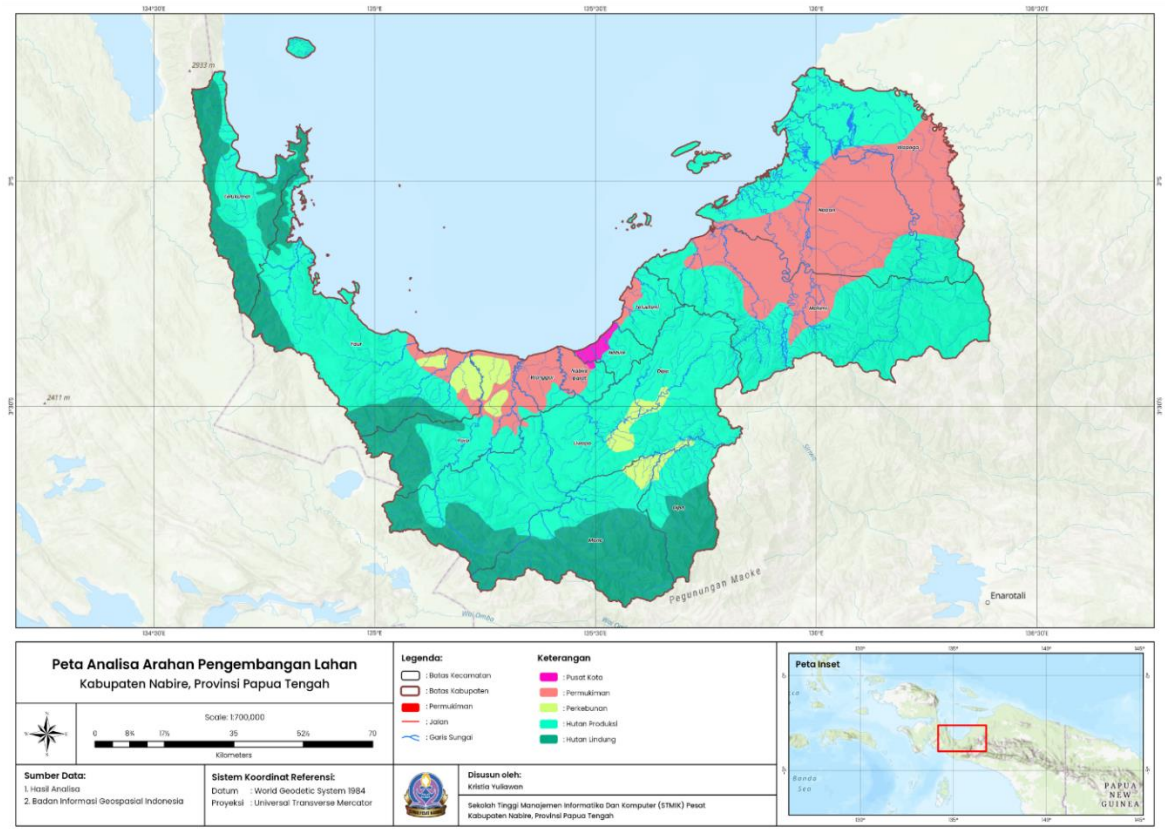


Figure 3. Map of land development direction analysis map of nabire regency

significant obstacles to land development, such as steep slopes, infertile soils, or a high risk of natural disasters.

The analysis reveals that Nabire Regency holds substantial potential for sustainable natural resource management. Approximately 19% of the land area, or 2,048 $km^2$, is designated as protected forest to conserve biodiversity and mitigate environmental degradation. Production forests, covering 57% (6,077 $km^2$), offer opportunities for sustainable management to support the region's economic needs. Additionally, plantations occupy 309 $km^2$ (3%), and settlements account for 2,150 $km^2$ (21%), emphasizing the need for strategic planning to balance development with ecological preservation.

This data underscores the importance of informed land use planning to maximize resource potential while maintaining environmental sustainability. Areas with high agricultural potential should be developed for agricultural activities, while regions suitable for settlements can support residential and industrial growth. By identifying land potential and constraints, development in disaster-prone areas can be avoided, reducing environmental damage. This approach not only increases agricultural productivity but also generates employment opportunities and improves community welfare. The insights provided by this analysis equip the government and local communities with a framework for implementing effective and sustainable land use strategies.

### 3.4 Discussion

Previous studies, such as the one by Ramlan et al. (2018), utilized the FAO (Food and Agriculture Organization) method to evaluate land suitability. The FAO approach prioritizes agricultural suitability based on physical and agronomic soil factors. In contrast, the present study employs a weighting method that incorporates additional factors affecting community quality of life, such as access to education, healthcare, and infrastructure. Although both methods generate land suitability maps, their contextual applications differ significantly. The weighting analysis adopted in this study provides a more comprehensive and contextual perspective, emphasizing holistic regional development that prioritizes community well-being.

In terms of qualitative comparisons, earlier research often focused on assessing the quality of life in rural and suburban areas as a key issue in sustainable development. For example, Antoh et al. (2018) examined behavioral and environmental factors influencing community sustainability. However, this study did not incorporate spatial analysis to evaluate land suitability. Instead, it relied on subjective, qualitative variables, such as individuals' perceptions of living conditions, satisfaction with public services, and general well-being. Data collection methods included questionnaire surveys and interviews, emphasizing respondents' personal assessments without deeply integrating spatial factors.

By comparison, this study on land suitability and community quality of life in Nabire Regency adopts a spatial approach that integrates geospatial data. This method evaluates land suitability by combining physical, geographical, and accessibility variables with conventional welfare metrics. The spatial analysis enables the development of more detailed and applicable insights for spatial-based development planning. This integrated approach aims to support equitable improvements in community quality of life across the Nabire Regency region, offering a robust framework for sustainable and inclusive development.

## 4. CONCLUSION

The analysis of land suitability in Nabire Regency plays a critical role in understanding the region's developmental potential and identifying obstacles to sustainable growth. The study reveals that approximately 90% of the land is dominated by forests, while the remaining 10% consists of fields, plantations, settlements, and other land uses. Specifically, 57% (6,077 $km^2$) of the land is designated as production forest, 19% (2,048 $km^2$) is proposed as protected forest, 3% (309 $km^2$) is allocated for plantations, and 21% (2,150 $km^2$) is designated for settlements.

The findings indicate that a significant portion of the land has moderate development capacity, making it suitable for agriculture and settlement. However, challenges such as the conversion of agricultural land and rapid urbanization must be addressed to mitigate environmental degradation. These pressures

underscore the need for strategic interventions to balance development demands with environmental preservation.

The analysis further highlights disparities in access to services and quality of life across different regions, emphasizing the developmental inequalities that require urgent attention. Spatial planning recommendations based on land suitability analysis are crucial for improving the quality of life for the Nabire community. By fostering a balance between development and environmental sustainability, these recommendations aim to support equitable and inclusive growth. With an appropriate approach to natural resource management, the region can achieve optimal land use, which in turn will enhance community welfare and ensure long-term environmental sustainability. This integrated strategy serves as a foundation for sustainable development in Nabire Regency, addressing both current challenges and future opportunities.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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