

Analysis of the Agricultural Sector's Potential and Spatial Planning Issues in Sianjur Mula-Mula Subdistrict, Samosir Regency

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Abstrak

Sektor pertanian menjadi tulang punggung perekonomian lokal di Kecamatan Sianjur Mula-Mula, berkat kondisi lahan yang relatif subur dan cocok untuk pertanian. Keberadaan tanah vulkanik, iklim sejuk, dan lahan yang luas menjadikan wilayah ini sangat menjanjikan untuk pengembangan komoditas pertanian. Penelitian ini bertujuan untuk menganalisis potensi sektor pertanian dan isu perencanaan tata ruang di Kecamatan Sianjur Mula-Mula, Kabupaten Samosir. Metode penelitian yang digunakan adalah pendekatan deskriptif-komparatif dengan memanfaatkan data sekunder, termasuk peta RTRW, data penggunaan lahan, kondisi fisik wilayah, dan statistik pertanian. Pengumpulan data dilakukan melalui analisis dokumen dan tinjauan pustaka dari berbagai sumber ilmiah yang relevan. Analisis deskriptif digunakan untuk menggambarkan kondisi wilayah dan potensi pertanian, sedangkan analisis komparatif diterapkan untuk membandingkan kondisi penggunaan lahan aktual dengan pedoman perencanaan tata ruang. Hasil penelitian menunjukkan bahwa wilayah ini memiliki komoditas unggulan seperti beras, jagung, cabai, kopi, kemiri, dan produk hortikultura yang berkembang sesuai dengan karakteristik masing-masing desa. Analisis spasial juga mengungkapkan inkonsistensi dalam penggunaan lahan di dalam kawasan permukiman, perkebunan, pariwisata, dan daerah aliran air. Keselarasan antara perencanaan spasial dan kondisi fisik wilayah sangat diperlukan untuk mendukung pembangunan pertanian berkelanjutan.

Kata kunci: Potensi Pertanian, Perencanaan Tata Guna Lahan, Penggunaan Lahan, Sianjur Mula-Mula

Abstract

The agricultural sector serves as the mainstay of the local economy in Sianjur Mula-Mula Subdistrict, thanks to the area's relatively fertile terrain and conditions suitable for farming. The presence of volcanic soil, a cool climate, and ample land make this region highly promising for the development of agricultural commodities. This study aims to analyze the potential of the agricultural sector and spatial planning issues in Sianjur Mula-Mula Subdistrict, Samosir Regency. The research method employed is a descriptive-comparative approach utilizing secondary data, including RTRW maps, land use data, physical conditions of the region, and agricultural statistics. Data collection was conducted through document analysis and a literature review of various relevant scientific sources. Descriptive analysis was used to describe the regional conditions and agricultural potential, while comparative analysis was applied to compare actual land use conditions with spatial planning guidelines. The results of the study indicate that this region has leading commodities such as rice, corn, chili, coffee, candlenut, and horticultural products that develop in accordance with the characteristics of each village. Spatial analysis also reveals inconsistencies in land use within residential, plantation, tourism, and water catchment areas. Alignment between spatial planning and the physical conditions of the region is necessary to support sustainable agricultural development.

Keywords: Agricultural Potential, Land Use Planning, Land Use, Sianjur Mula-Mula

INTRODUCTION

The agricultural sector plays a strategic role in regional development due to its significant contribution to food security, employment, and economic growth in rural communities (Dede et al., 2024). In various regions of Indonesia, particularly in rural areas reliant on agriculture, agricultural activities remain the primary source of income for communities (Maulana et al., 2026). Effective spatial planning is crucial for ensuring the sustainability of the agricultural sector, especially in areas rich in natural resources but vulnerable to land-use changes (Olivia et al., 2025). In the context of regional development, spatial planning serves not only as a tool for regulating land use but also as a foundation for determining the direction of development for sectors with high growth potential, including agriculture (Munibah et al., 2026).

The Sianjur Mula-Mula subdistrict is one of the areas in Samosir Regency characterized by physical features and natural resource potential that support agriculture. This region is known for its relatively fertile volcanic soil, as it is located within the geological zone of Lake Toba (Gultom et al., 2024). Additionally, the cool climate, available agricultural land, and access to water sources make this area highly promising for the development of food products, horticulture, plantations, and livestock farming (Gloria et al., 2022). Some of the agricultural commodities found in this region include rice, corn, chili peppers, coffee, andaliman, and various other types of horticultural crops (Mangiring et al., 2024). This indicates that the agricultural sector plays a vital role in the local economy.

Developments in regional development and the growing demand for space often lead to land-use issues (Jie et al., 2025). The mismatch between spatial planning and actual land-use conditions is one of the main challenges in managing agricultural areas (Westi Utami, 2024). Based on the results of spatial analysis and land-use evaluation, several locations were identified that, in the spatial plan, were designated for plantations or specific developments, even though physically these areas function as water catchment zones or steep-sloped areas that should be designated as protected zones (Choiriyyah et al., 2024). This situation can lead to conflicts over land use and increase the risk of environmental damage, such as erosion, reduced soil fertility, and disruption of the water balance in the area.

Issues related to inappropriate land-use planning in agricultural areas can have a direct impact on the sustainability of agricultural yields and environmental stability in those

regions (Choiriyyah et al., 2024). Using steeply sloped land for agriculture or plantations without considering soil capacity can lead to soil degradation and reduced crop yields in the long term (Rahmadani et al., 2025). Additionally, converting water catchment areas into agricultural land can reduce the region's ability to store water and increase the risk of natural disasters (Alfandhani et al., 2021).

In the study of agricultural geography and regional planning, it is important to analyze spatial suitability because it can reveal the relationship between the physical characteristics of a region and existing land-use patterns (Firmansyah et al., 2026). To describe the current situation in the agricultural sector and to compare the alignment between spatial plans and existing land use, a descriptive-comparative approach was applied. A comparative descriptive approach can identify various types of spatial mismatches and their impacts on the development of the agricultural sector in the studied area. Spatial analysis involving RTRW maps and land-use interpretation is also a key element in identifying the distribution patterns of agricultural land, conservation areas, and water catchment zones.

This research is important because the Sianjur Mula-Mula subdistrict has great potential in the field of agriculture but faces various challenges in spatial management that need to be adapted to the physical conditions of the environment. An assessment of spatial planning suitability is expected to provide insights into sustainable agricultural development and serve as a basis for decision-making regarding regional development. Additionally, the results of this study are expected to contribute to the advancement of agricultural geography studies, particularly those concerning the relationship between agricultural sector potential, the physical conditions of the area, and spatial planning.

RESEARCH METHODS

This study was conducted in the Sianjur Mula-Mula subdistrict, which is administratively located in Samosir Regency, North Sumatra Province. The selection of this study site was based on the area's characteristics, which include significant agricultural potential and indications of a mismatch between spatial planning and actual land use conditions (Permana et al., 2023). This area also features a variety of physical conditions, ranging from lowlands to hilly areas with relatively steep slopes, making it of interest for analysis from the perspectives of agricultural development and spatial planning.

This study employs a descriptive-comparative method. The descriptive method serves to explain the physical conditions of the area, the capacity of the agricultural sector,

and land-use patterns at the study site (Chandra et al., 2020). On the other hand, the comparative method is used to compare actual land use conditions with the spatial utilization guidelines contained in the Regional Spatial Plan (RTRW). This approach is applied to assess the degree of conformity or non-conformity of spatial utilization in agricultural areas at the study site.

This study relies entirely on secondary data obtained from various relevant sources and institutions (Sari et al., 2025). The information obtained includes the Samosir Regency Spatial Plan (RTRW) map, data on land use, the physical conditions of the area, topography, and a number of other documents related to agriculture and spatial planning (Siliwangi et al., 2025). In addition, this study also refers to various academic references such as journal articles, books, and previous research related to spatial planning, agricultural geography, and regional management. Statistical data on agriculture was also utilized to strengthen the analysis regarding the potential of the agricultural sector in Sianjur Mula-Mula Subdistrict (Awellya Novia et al., 2025).

Data collection was conducted through document analysis and a literature review. Document analysis involved gathering various types of documents relevant to the study, such as information on the Regional Spatial Plan (RTRW), land use, the physical conditions of the area, and agricultural statistics (Nandita & Prayoga, 2025). On the other hand, the literature review was conducted by studying various relevant scientific sources to strengthen the theoretical foundation and support the research discussion. The use of secondary data was chosen because it provides a comprehensive understanding of regional conditions and aligns with the research needs focused on the analysis of land use and the potential of the agricultural sector (Duan et al., 2025).

The techniques used to analyze the data in this study include descriptive analysis and comparative analysis. Descriptive analysis serves to provide an explanation of the general conditions of the study area, including the physical conditions of the area, land use, and the potential of the agricultural sector in Sianjur Mula-Mula Subdistrict (Niswardi, 2020). This method also aims to describe various types of agricultural commodities, topographical conditions, and regional characteristics that influence community agricultural activities.

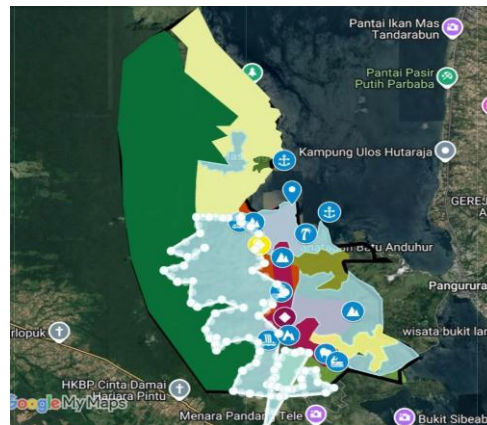
A comparative analysis was conducted to assess the actual state of land use against the spatial planning guidelines outlined in the Samosir Regency Spatial Plan (RTRW). This assessment was carried out to determine the degree of compliance with spatial use

regulations in agricultural areas, plantations, conservation areas, and water catchment zones (Siti Hanyfah, 2022). Through this study, various types of spatial planning inconsistencies that could lead to land-use conflicts or environmental issues were identified. The results of this analysis then served as the basis for formulating agricultural spatial management guidelines that are better suited to local conditions and the principles of sustainable development (Maulana Fauzi, 2024).

RESULTS AND DISCUSSION

RESULTS

The Sianjur Mula-Mula subdistrict is one of the areas in Samosir Regency whose physical characteristics support the development of the agricultural sector. This area is located within the Lake Toba geological zone, which means the soil there is dominated by volcanic material with a relatively high level of fertility. The cool climate and availability of agricultural land have led to the agricultural sector becoming the community's primary economic activity.



Picture 1. Location Map of Sianjur Mula-mula Subdistrict (Source: Pemkab Samosir, 2018)

The distribution of agricultural potential in Sianjur Mula-Mula Subdistrict reveals variations in leading commodities across each village, influenced by the area's physical conditions, soil characteristics, and the community's ability to utilize natural resources. Agricultural activities are the dominant sector supporting the economic livelihoods of rural communities in this area. The evolving agricultural structure includes food crops, horticulture, and smallholder plantations, with varying levels of productivity across different regions. This diversity of agricultural products reflects the community's ability to adapt to local environmental conditions. The potential possessed by each village presents

significant opportunities for the development of a sustainable, agriculture-based local economy.

Table 1. Distribution of agricultural potential in several villages in Sianjur Mula Mula Subdistrict based on commodities widely cultivated by the community (Source: BPS Samosir 2023)

Village/Region	Major Agricultural Crops
Village Sianjur Mula-Mula	Corn, rice, coffee, cassava, sweet potatoes, peanuts, candlenuts
Village Simbolon Purba	Pady rice, corn, chili peppers, shallots
Village Hutaginjang	Coffee, candlenuts, corn, cassava
Village Siboro	Rice, sweet potatoes, cassava, peanuts
Village Ginolat	Corn, chili peppers, tomatoes
Village Aek Sipitu Dai	Paddy rice, vegetables, onions, chili peppers
Village Sarimarrihit	Corn, coffee, cassava, candlenuts
Village Bonandolok	Upland rice, corn, sweet potatoes
Village Huta Tinggi	Vegetables, chili peppers, tomatoes, coffee.

The village of Sianjur Mula-Mula has a fairly diverse range of agricultural commodities, including corn, rice, coffee, cassava, sweet potatoes, peanuts, and candlenuts. This diversity of crops indicates a mixed farming system that has developed over a considerable period of time. Farmland in this village is optimally utilized to meet consumption needs while also generating additional income for farming households. Coffee and candlenut are relatively high-value commodities due to their strong market demand both locally and in other regions. The farming systems adopted by the community also reflect efforts to maintain economic stability through agricultural diversification.

The village of Simbolon Purba is known as an area with strong potential in the food crops and horticulture sectors. Paddy rice, corn, chili peppers, and shallots are the main commodities widely cultivated by the local community. The fertile soil and reliable water supply have a significant impact on the success of agricultural activities in this region. The relatively intensive horticultural production reflects the community's economic focus on high-value commodities. Agricultural activities in the village help increase community income while strengthening local food security.

The village of Hutaginjang is characterized by agriculture dominated by smallholder plantation crops such as coffee and candlenuts. The highland topography and relatively cool temperatures support optimal growth of perennial crops. Corn and cassava

are also cultivated as important food sources for the village community. Land use patterns in this area reflect a combination of plantation and food crops within a single traditional agricultural system. These cultivation activities make a significant contribution to meeting the economic needs of farming households.

Siboro Village has agricultural potential that is more focused on the development of food crops such as rice, sweet potatoes, cassava, and peanuts. These types of commodities reflect a farming pattern among the community that remains oriented toward daily consumption needs. Land use is intensive, adapted to the physical conditions of the area, which largely support root crops and legumes. Agricultural production in this village also serves as a source of additional income for the rural community. The growing agricultural activities indicate the community's dependence on the primary sector as the mainstay of their economic livelihood.

Ginolat Village has emerged as an area with significant potential in the horticulture subsector. Corn, chili peppers, and tomatoes are the primary crops that dominate the community's agricultural activities. Favorable environmental conditions offer great opportunities for the development of cash crops with high economic value. The horticultural produce from this village has good marketing prospects because market demand for chili peppers and tomatoes tends to be stable. Productive land use also demonstrates the community's ability to develop a more commercially viable agricultural sector.

Aek Sipitu Dai Village has a fairly productive agricultural profile, with primary commodities including paddy rice, vegetables, onions, and chili peppers. Adequate water availability provides crucial support for the sustainability of the paddy farming system in the area. Horticultural cultivation activities are developing quite well because environmental conditions are highly conducive to the growth of various types of vegetable crops. High agricultural production makes this village one of the key areas in meeting the food needs of the sub-district's population. Intensive land management further highlights the community's high dependence on the agricultural sector as their primary source of livelihood.

The village of Sarimarrihit has an agricultural system dominated by corn, coffee, cassava, and candlenuts. These crops reflect a blend of food crops and smallholder plantations within the community's agricultural system. The village's highland location has a positive impact on the growth of coffee and candlenuts. Agricultural activities in this

village not only serve to meet household consumption needs but also serve as a source of income for the community. Diverse land use reflects the community's ability to adapt cultivation practices to local environmental conditions.

Bonandolok Village is known as an area characterized by a dominant dryland farming system. Upland rice, corn, and sweet potatoes are the primary crops extensively cultivated by the community. The selection of these crop types is a form of adaptation to the topographic conditions and limitations of the irrigation system. Agricultural activities are still carried out traditionally by utilizing the natural resources available around the village. The agricultural produce plays a vital role in meeting the food needs of the local community.

Huta Tinggi Village has great potential in the horticulture and smallholder farming sectors. Vegetables, chili peppers, tomatoes, and coffee are the leading crops that thrive in this region. The relatively cool temperatures support optimal productivity for highland horticultural crops. Agricultural activities in the village offer promising economic opportunities for the community, as several of these crops command high market prices. The development of the agricultural sector also demonstrates the appropriate utilization of land resources in accordance with the environmental characteristics of the mountainous region.

Table 2. Production of Seasonal Vegetables and Fruits by Crop Type in Sianjur Mula-mula Subdistrict (quintals), 2020–2023 (BPS Samosir 2023)

Kind of Plants	2020	2021	2022	2023
Shallots	3.910	3.810	10.210	5.702
Big Chili	216	9201	1.938	1.374
Curly Chili	NA	2.170	413	1.239
Cayenne Pepper	-	-	10	-
Potato	-	-	-	-
Cabbage	-	-	-	-
Tomato	-	-	310	120
Garlic	160	-	-	-

The overall distribution of agricultural potential in Sianjur Mula-Mula Subdistrict reveals a diversity of key crops that thrive according to the specific characteristics of each village. Corn and rice are the dominant crops cultivated throughout nearly the entire region, serving as the primary sources of food for the community. Coffee, candlenuts, chili peppers, shallots, and various types of vegetables grow more optimally in areas with specific agroecological conditions. This variety of commodities reflects the high potential

of the agricultural resources possessed by this sub-district. The sustainable development of the agricultural sector has the potential to improve community welfare while strengthening the region's agriculture-based economic structure.

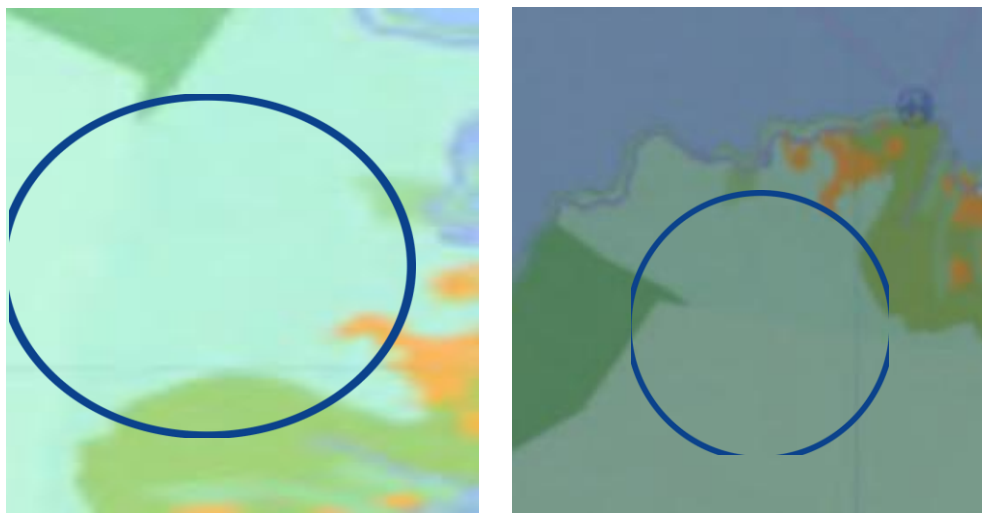
Agricultural activities in Sianjur Mula-Mula Subdistrict include food crop farming, horticulture, plantation farming, fisheries, and livestock farming. The main crops cultivated by the community include rice, corn, sweet potatoes, chili peppers, tomatoes, and various types of horticultural vegetables. According to data from the BPS (Central Statistics Agency), the production of seasonal vegetables and fruits in Sianjur Mula-Mula Subdistrict during the 2020–2023 period showed fairly fluctuating trends for several crop types. Red onions were the crop with the highest production compared to other types of crops. In 2020, red onion production reached 3,910 quintals and decreased slightly to 3,810 quintals in 2021. However, in 2022, there was a very significant increase to 10,210 quintals before declining again to 5,702 quintals in 2023. This indicates that shallots are one of the leading commodities with significant potential in the region, although production has not yet stabilized on an annual basis. Chili pepper production has also experienced a sharp fluctuation. In 2020, production was only 216 quintals, then increased drastically in 2021 to around 9,201 quintals. After that, production dropped to 1,938 quintals in 2022 and fell again to 1,374 quintals in 2023. Meanwhile, production of curly chili peppers was first recorded in 2021 at 2,170 quintals, dropped to 413 quintals in 2022, and then increased again to 1,239 quintals in 2023. Bird's eye chili production was very low, with only 10 quintals recorded in 2022, while there was no production in other years. Several other commodities, such as potatoes and cabbage, showed no production during the 2020–2023 period. Tomato production was first recorded in 2022 at 310 quintals and decreased to 120 quintals in 2023. As for garlic, it was only produced in 2020 at 160 quintals and was not recorded in subsequent years.

The analysis results indicate a discrepancy between the actual land use conditions and the regional spatial plan. One such discrepancy is evident in rural residential areas, which appear smaller on the RTRW map than they actually are on the ground. This discrepancy suggests that the expansion of residential areas has not been fully accounted for in the spatial planning documents.



Picture 2. Inconsistencies between residential areas in the RTRW and land use interpretations (Source Pemkab Samosir, 2018 & Author 2026)

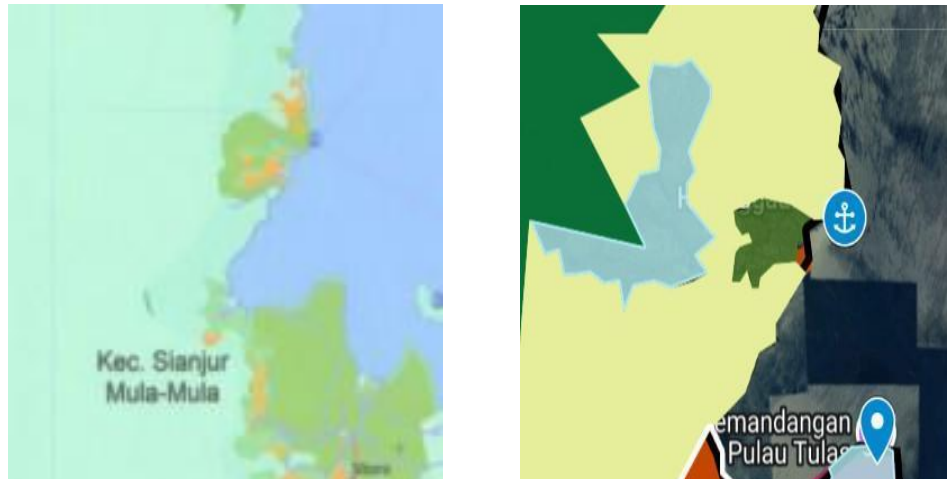
Spatial analysis reveals differing interpretations of land use in the Tulas Island area. Based on the results of the MyMaps analysis, the area was identified as a tourist destination, whereas the physical conditions of the area indicate characteristics more suited to a water catchment area. This discrepancy has the potential to lead to land-use conflicts if the development of the tourist area proceeds without taking the area's ecological functions into account.



Picture 3. Mismatch in land use in the Tulas Island area (Source: Pemkab Samosir, 2018 & Author 2026)

The northern part of Sianjur Mula-Mula Subdistrict is designated as an agricultural area in the Regional Spatial Plan (RTRW). Spatial analysis indicates that the area features

a topography of hills and steep slopes, making it more suitable for use as a water catchment area. This situation highlights a discrepancy between the land-use guidelines and the physical conditions of the area.



Picture 4. Mismatch between plantation areas and water catchment areas
(Source: Pemkab Samosir, 2018 & Author 2026)

The results of the subsequent analysis indicate that the water catchment areas in the northern and western parts of the study area should be designated as protected forest areas. These areas play a crucial ecological role in maintaining the water balance and reducing the risk of environmental degradation. Inconsistencies in land-use designations can disrupt the area's hydrological system if land use is not aligned with the land's carrying capacity.



Picture 5. A water catchment area that should be designated as a protected forest area (Source:: Pemkab Samosir, 2018 & Author 2026)

DISCUSSION

The Sianjur Mula-Mula subdistrict has significant potential in the agricultural sector, as it is supported by physical conditions that are relatively suitable for farming activities. The volcanic soil originating from the Lake Toba geological region has a high level of fertility, making it capable of supporting the growth of various types of food crops, horticultural crops, and plantation crops. The cool climate also contributes to the agricultural productivity of the community, particularly for highland commodities such as chili peppers, coffee, and horticultural vegetables. These conditions indicate that the agricultural sector remains a key sector within the region's economic structure.

The predominance of agricultural activities indicates that the majority of the population relies on the primary sector for their economic livelihood. Growing agricultural production not only serves to meet the food needs of the local community but also generates economic value that supports household income. The plantation subsector, through commodities such as coffee, candlenuts, cocoa, and andaliman, demonstrates the potential for economic development based on the region's flagship commodities. Fisheries and livestock activities are also growing, supported by the presence of Lake Toba, the availability of water sources, and natural feed sources derived from agricultural byproducts. This situation highlights the interconnections among agricultural subsectors that form an integrated agrarian economic system.

The results of the comparative analysis indicate that there are still several discrepancies between actual land use conditions and the spatial utilization guidelines in the Samosir Regency Spatial Plan (RTRW). These discrepancies suggest that the implementation of spatial planning has not fully taken into account the physical conditions of the region and the development of land use on the ground. The difference in the size of residential areas in the RTRW compared to actual conditions indicates that residential development is occurring gradually without being accompanied by optimal updates to spatial data. This situation could lead to spatial conflicts if residential expansion continues in areas that do not align with their designated land use.

Spatial planning inconsistencies are also evident in the Tulas Island area, which, based on spatial analysis, is more suitable for use as a water catchment area rather than a tourist destination. The function of a water catchment area plays a crucial role in maintaining the region's hydrological balance, particularly in areas directly linked to the Lake Toba ecosystem. Developing a tourist destination without considering the environment's carrying capacity can reduce the soil's ability to absorb water and increase the risk of ecological damage in the future. These conditions highlight the importance of aligning spatial interpretations with land-use policies to ensure that regional development continues to prioritize environmental sustainability.

Another issue was identified in the northern part of Sianjur Mula-Mula Subdistrict, which is designated as an agricultural zone in the RTRW, even though the area's topography features steep slopes and serves as a water catchment area. Land use in areas with high slopes for agricultural activities can increase the risk of erosion and land degradation. Mismatched land use relative to the land's capacity can lead to a decline in environmental quality and disrupt the long-term sustainability of the agricultural sector. Areas with steep topographic characteristics should be designated as protected zones or water catchment areas to maintain slope stability and the region's water management.

Water catchment areas and protected forests play a vital ecological role in supporting sustainable agriculture in Sianjur Mula-Mula Subdistrict. These areas help maintain groundwater availability, control surface runoff, and preserve environmental balance. The conversion of protected areas into agricultural zones has the potential to reduce environmental carrying capacity and increase the risk of disasters such as landslides and erosion. Spatial planning tailored to the physical characteristics of the region is a

crucial step in supporting sustainable agricultural development while preserving the ecological balance of the area.

Based on the research findings, aligning the region's physical conditions with spatial planning policies is a key aspect in the development of Sianjur Mula-Mula Subdistrict. Land use that considers land capacity and the ecological functions of the area can support the sustainability of the agricultural sector while minimizing land-use conflicts. Adjusting spatial planning policies to the actual conditions of the region is also necessary to ensure that agricultural development proceeds optimally without causing environmental degradation in the future.

CONCLUSION

Sianjur Mula-Mula District has a huge potential in the agricultural sector, supported by the physical conditions of the area, such as fertile volcanic soil, a cool climate, and the availability of water resources that support the development of various flagship commodities like rice, corn, chili, coffee, candlenut, and horticultural crops. This potential shows that agriculture is still the mainstay of the community's economy and plays a strategic role in supporting regional development based on local resources. The study also shows a mismatch between actual land use and the directions of the Samosir Regency Spatial Planning (RTRW) in residential areas, tourist areas, agricultural areas, and water absorption areas that physically have important ecological functions. These mismatches could lead to conflicts over land use, reduce the environment's carrying capacity, and threaten the sustainability of agrarian systems and regional hydrological balance. This situation shows that agricultural sector development needs to be aligned with the region's biophysical characteristics so that land productivity and ecological functions can progress sustainably. Based on research findings, there is a need to update spatial planning policies to be more adaptive to actual field conditions by strengthening the protection of water absorption areas and regions with steep slopes, controlling land conversion that doesn't match the environment's capacity, and developing leading commodities based on land suitability to improve community welfare. Strengthening synergy between local governments, communities, and other stakeholders is also needed to achieve sustainable agricultural development that can balance economic and ecological functions in the region. Further research is recommended to use more detailed spatial analysis with the support of remote sensing data and geographic information systems so that land-use changes and land

suitability levels can be analyzed more deeply as a basis for formulating sustainable regional development policies.

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