Study of Settlement Patterns in the Coastal Area of Sendang Biru Hamlet, Malang Regency, Based on Geographic Information Systems (GIS)

Irawan Setyabudi[1*], Andy Argay[2], Debora Budiyono[3]

Landscape Architecture Study Program, Faculty of Agriculture,

Universitas Tribhuwana Tunggadewi Malang

*Corresponding Author, Email : isetyabudi.st@gmail.com

Abstract

Settlements are human living environments that form part of the natural ecosystem. Coastal areas are among Indonesia's most dynamic and potential settlement zones, providing both economic and cultural functions. This study analyzes the settlement pattern of Sendang Biru Hamlet, located in Tambakrejo Village, Sumbermanjing Wetan District, Malang Regency—one of East Java's designated fishing settlements with emerging tourism potential. Despite its promising location, the settlement faces challenges related to road corridors, inadequate public facilities, and the disorganized spatial pattern of residential yards. The research aims to identify and analyze settlement patterns in Sendang Biru Hamlet using a Geographic Information System (GIS) integrated with the Focus Group Discussion (FGD) approach. The GIS method was employed to map land use, topography, hydrology, and vegetation characteristics, while the FGD provided participatory input from local stakeholders to validate spatial findings. Results indicate that the settlement pattern in Sendang Biru Hamlet is predominantly linear, following the main road network, with residential and supporting facilities developing continuously along this corridor. Spatial analysis further shows that most of the land is moderately suitable for settlement expansion, characterized by gentle slopes, adequate water resources, and productive vegetation. The study concludes with recommendations to optimize settlement design through landscape-based planning, the use of environmentally friendly materials, and community-oriented development to support sustainable coastal tourism in Sendang Biru.

Keywords: Settlement Pattern; Coastal Area; Geographic Information System (GIS); Focus Group Discussion (FGD); Spatial Planning

1 Introduction

A settlement conveys the concept of a home or a cluster of houses along with their surrounding infrastructure and environmental facilities. Housing and settlements are two inseparable entities that are closely related and essentially complementary (Wijaya et al., 2017). A settlement can also be interpreted as a place where people live, reflecting specific social, economic, and cultural purposes. Ideally, a settlement should provide comfort not only to its residents but also to visitors (sastra M, 2006). According to (Broughton, 1969), settlement patterns are shaped by the dynamic relationship between people, nature, society, and technology — a concept known as Ekistics. In coastal contexts, settlement morphology is often influenced by physical features such as topography, hydrology, and vegetation, as well as by economic activities like fishing and tourism. (Li et al., 2022)

Settlements represent human living environments that form part of the natural ecosystem. A settlement area can be defined as a portion of the environment—whether urban or rural—that functions as a residential and living space supporting daily activities (Ade Wulandari et al., 2020). Rural settlements are commonly referred to as villages, which often consist of several hamlets. A village is a social unit characterized by close interpersonal relationships and informal interactions among its inhabitants. (Kornilova et al., 2021)

According to (Yao et al., 2023) a settlement pattern is the functional spatial organization based on human activities and influenced by both physical and non-physical settings that directly affect spatial patterns and their formation processes. To examine settlement patterns—especially in coastal regions—a specialized, geography-based analytical system employing modern technology is required.

Recent advancements in information technology have made it possible to manage and analyze spatial information more accurately and efficiently. The use of information technology aims to enhance efficiency in various aspects of data management, ensuring timely processing, precision, and reliability. One of the most widely adopted approaches that integrates information systems and geographical science is the Geographic Information System (GIS). (Ali, 2023)

GIS mapping has become an essential tool in decision-making, planning, and spatial analysis. It serves as an interactive, engaging, and effective medium for enhancing understanding, education, and research on spatial concepts such as location, space, population distribution, and geographical elements on the Earth's surface (Makkulawu et al., 2023).

Sendang Biru Hamlet, located in Tambakrejo Village, Sumbermanjing Wetan District, Malang Regency, is one of the coastal settlements designated as a fishing area in East Java. However, the settlement faces several challenges related to road corridors, public facilities, and the spatial organization of residential yards. Road corridors remain underdeveloped due to limited infrastructure, including insufficient hard and soft surface materials. Public facilities such as street lighting, places of worship, and other communal amenities are still inadequate. Meanwhile, many residential yards are used productively—for gardening or other activities—but lack aesthetic consideration in their arrangement.

Despite these challenges, Sendang Biru Hamlet has significant potential. From an ecological perspective, it retains extensive natural land cover, non-dominant housing structures, and a community that continues to preserve the natural environment, maintaining a healthy local ecosystem. This ecological potential provides a strong foundation for sustainable development.

Given these opportunities, analyzing and identifying the settlement pattern in Sendang Biru Hamlet is crucial to generate informed recommendations for future planning and development. This research aims to identify and analyze the characteristics of coastal settlement patterns in Sendang Biru Hamlet, Tambakrejo Village, Sumbermanjing Wetan District, Malang Regency, as part of a broader study on the development of fishing village settlement concepts.

This study utilizes the Geographic Information System (GIS) as its primary analytical tool to visualize and interpret settlement patterns in the area. The use of GIS is expected

to produce informative outputs such as maps of existing land cover, vegetation types, and settlement pattern characteristics in Sendang Biru Hamlet. GIS-based presentation and settlement pattern recommendations are intended to enhance public accessibility to spatial information. Moreover, the resulting recommendations will help evaluate the settlement layout in relation to topography, land cover, and land use, providing actionable guidance for the local community to implement in future development initiatives.

2 Methodology

2.1 Research Location and Duration

This research was conducted in Sendang Biru Hamlet, located in Tambakrejo Village, Sumbermanjing Wetan District, Malang Regency, East Java Province, Indonesia. The selection of this study site was based on the necessity to manage the settlement pattern of Sendang Biru Hamlet, a coastal area characterized by diverse activities such as fishing, fish trading, and tourism. The coexistence of these activities creates spatial and functional complexity, which requires an effective settlement management approach to improve accessibility, circulation, and overall spatial order.

Sendang Biru Hamlet is a coastal settlement facing Sempu Island, a well-known natural conservation area and tourist attraction. However, the hamlet itself is located along a different route from the main beach tourism area, creating a spatial distinction between residential and recreational zones.

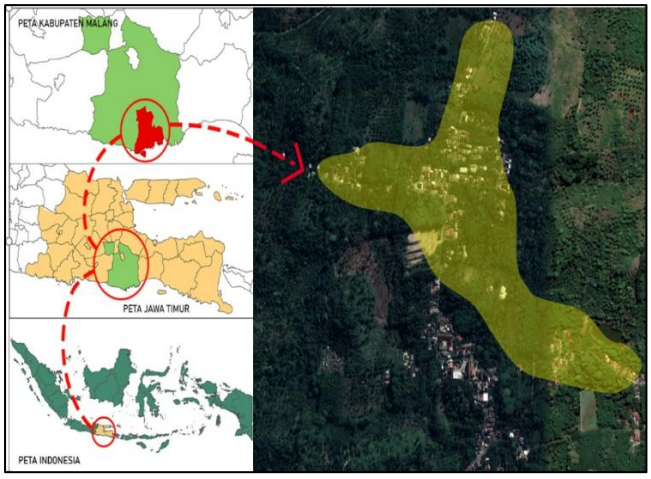

Figure 1. Research Location Map

The total coastline length of Malang Regency is approximately 85.92 kilometers, with a marine area extending 4 nautical miles covering about 565.45 km², and up to 12 nautical miles covering approximately 1,696.35 km². Specifically, Sumbermanjing Wetan District has a coastline of about 27.02 kilometers, with a 4-nautical-mile marine area of 176.76 km² and a 12-nautical-mile marine area of 536.29 km².

2.2 Type of Research

This study employs a descriptive quantitative research method using two main approaches:

a) Survey approach, aimed at observing the study area and collecting secondary data, including both spatial and non-spatial information; and
b) Spatial analysis approach, which focuses on evaluating land suitability parameters and criteria based on abiotic, biotic, socio-economic, socio-cultural, and land-use factors.

Data processing and analysis techniques utilize the Geographic Information System (GIS), applying scoring and overlay methods based on vector data (Jia et al., 2017). The descriptive research design is employed to provide a comprehensive depiction of settlement patterns in the coastal area of Sendang Biru Hamlet.

The data collected in this study consist of primary and secondary data:

1. Primary data were obtained through field photography and interviews;
2. Secondary data were grouped into three major aspects:

a) Ecological aspects, including land use, ecosystem composition (flora and fauna), and natural hazards;
b) Socio-economic aspects, including population density, community activities, livelihood, education level, and income; and
c) Physical aspects, including building conditions, settlement patterns, road networks, drainage systems, housing facilities, and building orientation.

In addition, this study employs the Focus Group Discussion (FGD) method as a participatory qualitative complement. The FGD is a well-established data collection technique in social research, conducted by gathering a group of participants to discuss a specific issue in depth. It is widely regarded as both practical and effective in obtaining insights from local stakeholders.

In this research, the FGD involved seven participants, consisting of the neighborhood (RW) head, community unit (RT) head, village office staff, and several community representatives. The discussions focused on community perceptions, spatial usage patterns, and challenges related to settlement management in Sendang Biru Hamlet.

Table 1. Analytical Parameters for Land Use Assessment

No	Parameter	Category	Description	Score
1	Topography	0–15%	Suitable	3
		>15–45%	Moderately Suitable	2
		>45%	Not Suitable	1
2	Hydrology (km)	<0.5	Suitable	3
		0.5–2	Moderately Suitable	2
		>2	Not Suitable	1
3	Vegetation	Non-natural	Suitable	3
		Semi-natural	Moderately Suitable	2
		Natural	Not Suitable	1

Source: Modified from (Kadriansari et al., 2017)

The output of this research is a conceptual recommendation for settlement patterns that maximize the potential of the Sendang Biru area to enhance both tourism attractiveness and environmental conservation. The proposed concept is developed based on the evaluation results derived from the analytical findings of the study. To ensure that the recommended concept is

accepted by the local community of Sendang Biru Hamlet, it is essential to validate the analytical results with relevant stakeholders through a Focus Group Discussion (FGD).

3 RESULTS AND DISCUSSION

3.1 General Overview

Sendang Biru Hamlet is located in Tambakrejo Village, Sumbermanjing Wetan District, Malang Regency. The village consists of two hamlets: Tambakrejo and Sendang Biru. Sendang Biru Hamlet is a coastal settlement whose shoreline faces directly toward Sempu Island. The total coastline length of Malang Regency is approximately 85.92 km, with marine waters extending 4 nautical miles covering about 565.45 km², and up to 12 nautical miles covering approximately 1,696.35 km². The coastline of Sumbermanjing Wetan District itself stretches about 27.02 km, with marine areas of 176.76 km² (4 nautical miles) and 536.29 km² (12 nautical miles).

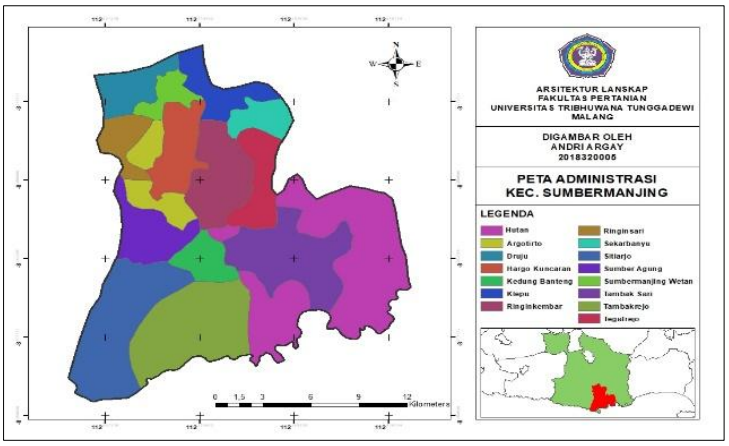

Figure 2. Administrative Map of Sumbermanjing Wetan District

The total land area of Sendang Biru Hamlet is approximately 2,735,850 m² (≈2.74 km²). Most of this area is utilized for ecosystems and dry fields (tegalan), while the rest is occupied by residential yards, gardens, rice fields, housing areas, cemeteries, and public infrastructure. In general, the landform of Sendang Biru is hilly, with moderately to steep slopes ranging from 50 to 250 meters above sea level. The slope gradients in the study area vary considerably, including flat (<3%), gently sloping (3–8%), moderately steep (25–40%), and very steep (>40%) terrains.

The coastal section of Sendang Biru is partly composed of limestone and coral formations with steep cliffs, while other parts consist of slightly sloping sandy beaches of relatively short length (50–100 meters) found on the eastern and western sides.

Analysis

The land-use analysis of Sendang Biru Hamlet was conducted by considering the natural resources present within the study area. The classification of land-use suitability in Sendang Biru Hamlet is divided into three categories: S (Suitable) with a score of 3, CS (Moderately Suitable) with a score of 2, and NS (Not Suitable) with a score of 1.

These classifications were used to assess the relationship between land-use patterns and environmental characteristics within the coastal settlement area.

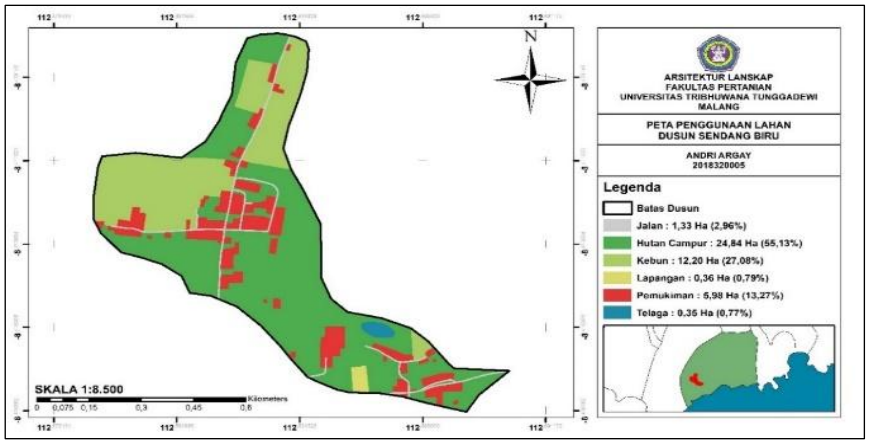

Figure 3. Land-Use Map of Sendang Biru Hamlet

Table 2. Types of Land Use

No	Type of Land Cover	Area (Ha)	Percentage (%)
1	Road	1.33	2.96
2	Mixed Forest	24.84	55.13
3	Plantation/Garden	12.20	27.08
4	Open Field	0.36	0.79
5	Settlement	5.98	13.27
6	Pond/Lake	0.36	0.77
Total		45.06	100.00

The following section presents the results derived from the three analytical parameters based on land use in Sendang Biru Hamlet, as previously explained in the research methodology.

1. Topography

Based on field observations and data processing, the topographical conditions of Sendang Biru Hamlet, according to the land suitability assessment criteria, fall into two categories:

a) Suitable (S) — with a slope range of 0–15%, covering an area of 15.75 ha (34.95%)
b) Moderately Suitable (MS) — with a slope range of >15–45%, covering an area of 29.31 ha (65.05%)

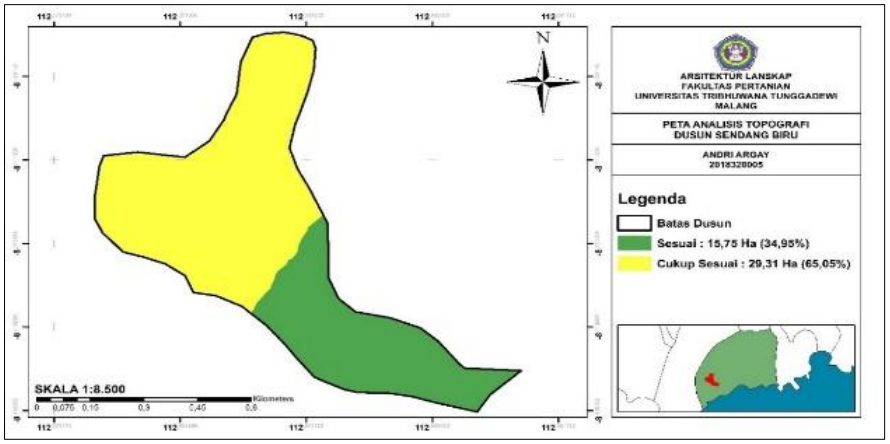

Figure 4. Topographic Map of Sendang Biru Hamlet

Table 3. Topographic Analysis

No	Type of Land Cover	S (ha)	MS (ha)	NS (ha)
1	Road	0.43	0.90	-
2	Mixed Forest	12.31	12.53	-
3	Plantation	0.35	11.84	-
4	Open Field	0.36	-	-
5	Settlement	1.94	4.04	-
6	Pond/Lake	0.36	-	-
Total (ha)	**15.75**	**29.31**	**-**	**45.06**
Total (%)	**34.95**	**65.05**	**-**	**100.00**

Note: S = Suitable, MS = Moderately Suitable, NS = Not Suitable.

The topographic analysis indicates that the majority of the area (65.05% or 29.31 ha) falls within the moderately suitable category, suggesting that the land's slope conditions are acceptable for settlement development but may require adaptation measures. Only about 34.95% (15.75 ha) of the land area is classified as highly suitable with gentler slopes.

2. Hydrology

Based on field observations and data processing using ArcGIS Map software, the hydrological conditions of Sendang Biru Hamlet were assessed according to land suitability criteria. The results show that the entire area (100%) falls into the Moderately Suitable (MS) category, indicating that the water quality and hydrological characteristics are generally acceptable for settlement use.

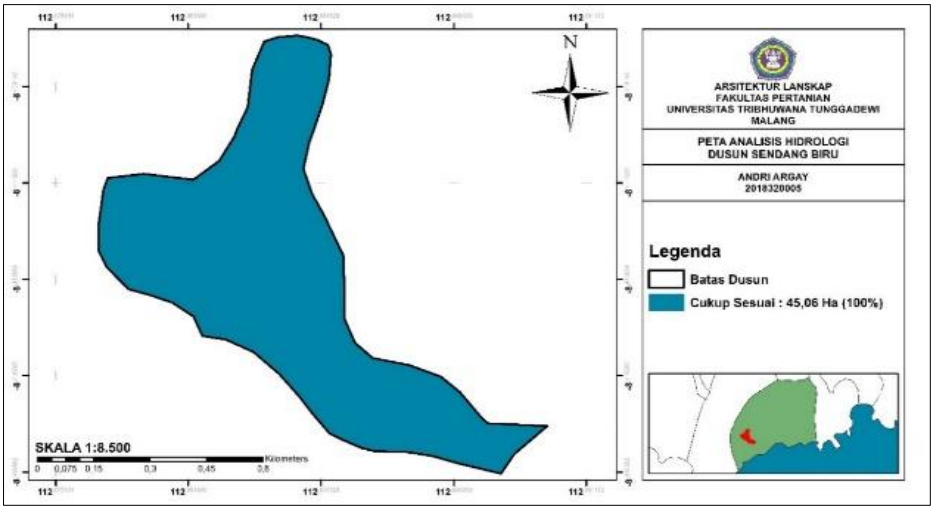

Figure 5. Hydrological Map of Sendang Biru Hamlet

Table 4. Hydrological Analysis

No	Type of Land Cover	S (ha)	MS (ha)	NS (ha)
1	Road	-	1.33	-
2	Mixed Forest	-	24.84	-
3	Plantation	-	12.20	-

4	Open Field	-	0.36	-
5	Settlement	-	5.98	-
6	Pond/Lake	-	0.36	-
Total (ha)	-	**45.06**	-	**45.06**
Total (%)	-	**100.00**	-	**100.00**

Note: S = Suitable, MS = Moderately Suitable, NS = Not Suitable.

The hydrological analysis shows that all areas (45.06 ha or 100%) are classified as moderately suitable due to the generally good water quality and availability throughout the hamlet. However, the hydrological network may need optimization to support sustainable land use and settlement planning.

3. Vegetation

Based on field observations and spatial data processing using ArcGIS Map software, the vegetation conditions in Sendang Biru Hamlet were assessed according to land suitability parameters. The results show that:

a) Suitable (S) areas cover 10.03 ha (22.25%)
b) Moderately Suitable (MS) areas cover 23.19 ha (51.47%)
c) Not Suitable (NS) areas cover 11.84 ha (26.28%)

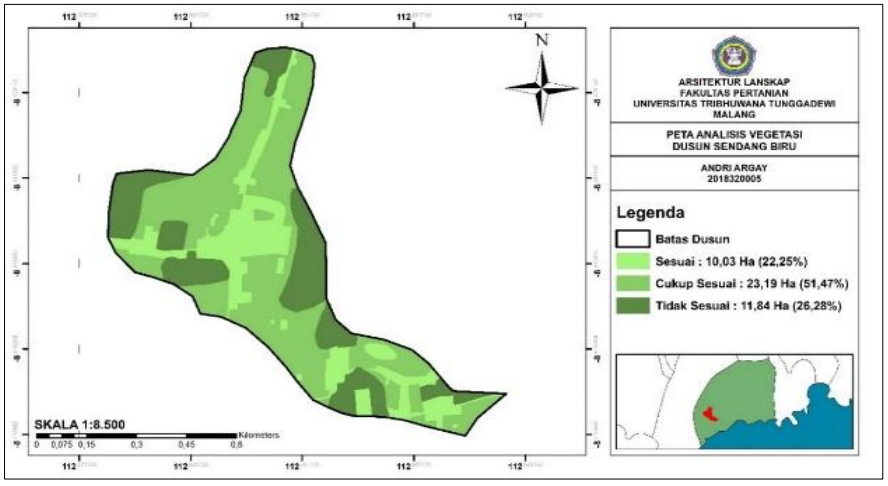

Figure 6. Vegetation Map of Sendang Biru Hamlet

Table 5. Vegetation Analysis

No	Type of Land Cover	S (ha)	MS (ha)	NS (ha)
1	Road	1.33	-	-
2	Mixed Forest	1.65	14.45	8.74
3	Plantation	0.35	8.74	3.11
4	Open Field	0.36	-	-
5	Settlement	5.98	-	-
6	Pond/Lake	0.36	-	-
Total (ha)	**10.03**	**23.19**	**11.84**	**45.06**
Total (%)	**22.25**	**51.47**	**26.28**	**100.00**

Note: S = Suitable, MS = Moderately Suitable, NS = Not Suitable.

The vegetation analysis indicates that more than half of the total land area (51.47%) is classified as moderately suitable. This reflects the presence of semi-natural vegetation types that still support ecological balance but may require conservation and enrichment. Meanwhile, 22.25% of the area is classified as highly suitable with dense and natural vegetation cover, while 26.28% is considered not suitable due to limited or degraded vegetation.

The results of the hydrological analysis of the Sendang Biru Hamlet area, based on land coverage, indicate that land suitability in terms of vegetation falls into the moderately suitable category, covering an area of 23.19 hectares, which accounts for 51.47% of the total area. The existing vegetation consists mainly of banana trees, coconut trees, bamboo, and sugarcane.

Characteristics

In general, the settlement pattern of Sendang Biru Hamlet is similar to that of other coastal settlements, where the layout follows a linear pattern. This finding is consistent with the GIS (Geographic Information System) mapping data. The residents' houses are arranged in rows facing the main road. This pattern is influenced by several factors beyond economic conditions—particularly the parameters analyzed in this study, including topography, hydrology, and vegetation, which affect land use in Sendang Biru Hamlet.

Based on field observations and data analysis, the topographical condition of Sendang Biru Hamlet falls into two land suitability categories:

a) Suitable, with a slope of 0–15%, covering 15.75 hectares (34.95%); and
b) Moderately suitable, with a slope of >15–45%, covering 29.31 hectares (65.05%).

These topographical characteristics directly influence the linear settlement form found in Sendang Biru Hamlet.

The community primarily obtains clean water from rainwater harvesting. Since the hamlet is not located directly along the coastline, freshwater sources remain accessible for daily activities. This availability of clean water is one of the main reasons why residents chose this location for their settlement.

Vegetation in Sendang Biru Hamlet predominantly consists of productive plant species, such as banana, coconut, and sugarcane, which can be utilized as food and economic resources. This factor also supports the community's preference to reside in this area—not only because it is relatively safe from coastal hazards but also because the land is fertile and suitable for cultivating productive crops.

Figure 7. illustration the existing condition of Sendang Biru Hamlet

Settlement Pattern and Spatial Characteristics

The most prominent feature of the settlement pattern in Sendang Biru Hamlet is the spatial relationship between residential units, the main road, and local access roads, which together form the public space network of the area. The grouping of houses occurs along both the main road and local roads.

Building orientation generally faces the road for accessibility, and house clusters are either fenced or unfenced, indicating boundaries of private ownership.

a. Central Area

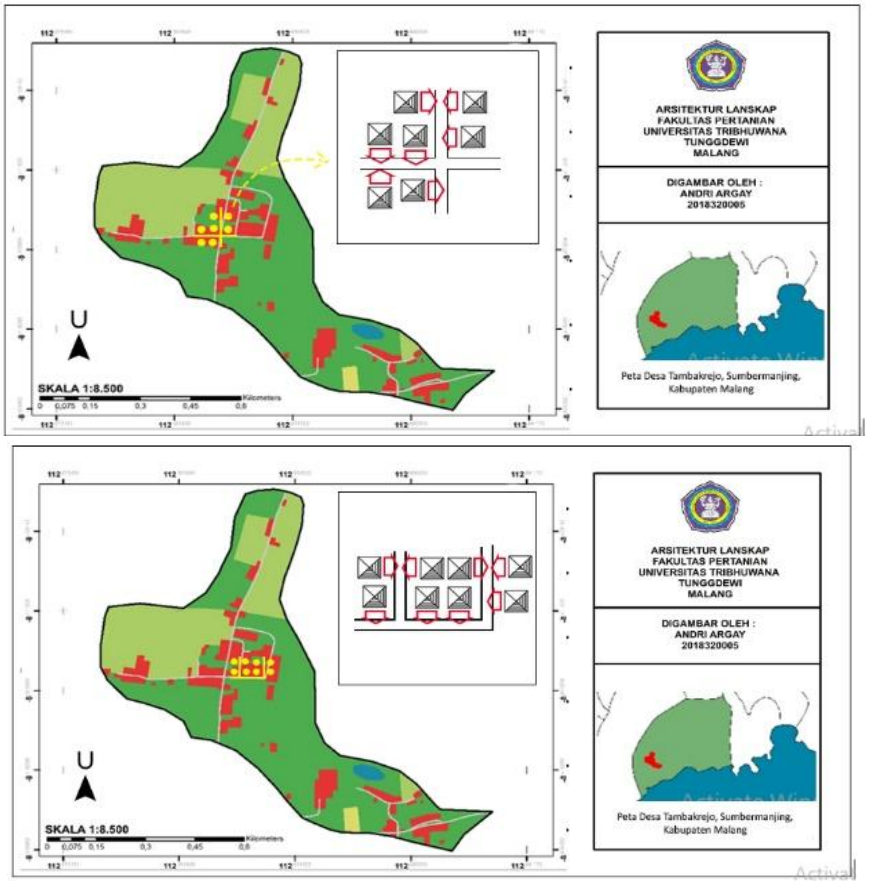

Figure 8. Street Pattern and Building Orientation in Central Sendang Biru

The main road runs north–south, while the houses are oriented east–west. The road width is approximately 2 meters, forming a linear pattern.

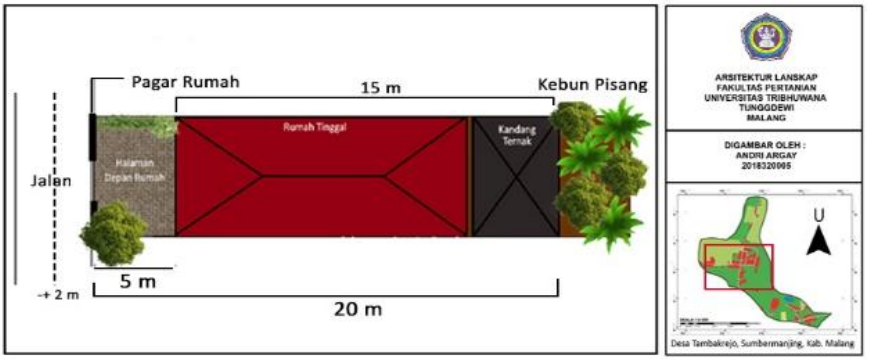

Figure 9. Site Plan of Residential Units in the Central Area of Sendang Biru Hamlet

The central area of Sendang Biru Hamlet exhibits a denser settlement pattern compared to the northern and southern areas. In this section, residential buildings are constructed in close proximity to one another, reflecting a more compact spatial arrangement.

b. Northern Area

Figure 10. Street Pattern and Building Orientation in Northern Sendang Biru

The schematic of the street pattern and building orientation shown in Figure 10 illustrates the northern part of Sendang Biru Hamlet. The main road also runs north–south, maintaining a linear configuration. Houses are located predominantly along the western edge, and the road width is approximately 2 meters.

Figure 11. Site Plan of Residential Area in the Northern Part of Sendang Biru Hamlet

Based on the site plan above, it can be observed that residential units in the northern area of Sendang Biru Hamlet generally have front and side yards, with gardens or small plantations located behind the houses. These backyards are often planted with banana trees, coconut trees, and other productive crops.

The side yards are typically used for drying clothes or cultivating vegetables, while the front yards serve as open spaces or small courtyards. In some cases, they are also utilized for drying clothes or as small retail areas for residents who operate home-based shops.

c. Southern Area

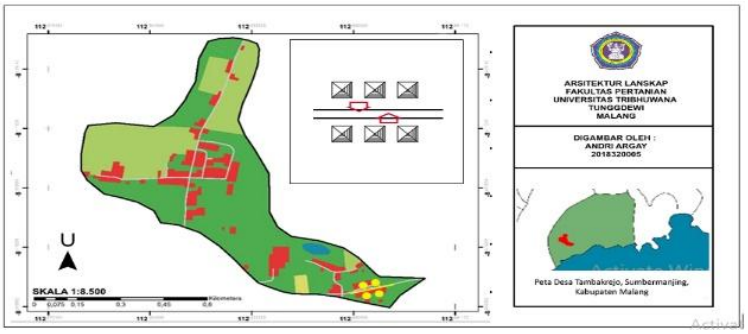

Figure 12. Street Pattern and Building Orientation in the Southern Part of Sendang Biru

The sketch of the street pattern and building orientation in Figure 11 represents the southern part of Sendang Biru Hamlet, which extends in an east–west direction and follows a linear layout. Residential buildings are arranged facing each other, with their orientations directed north–south. The main road in this area is approximately 2 meters wide, running east to west.

Figure 13. Site Plan of Residential Area in the Southern Part of Sendang Biru Hamlet

Based on the site plan above, the southern area of Sendang Biru Hamlet also features front and side yards, with gardens or plantations located behind the houses, typically planted with banana and coconut trees. Side yards are mainly used for drying clothes or cultivating vegetables, while front yards function as courtyards or small commercial spaces for residents who operate shops.

4 Recommendations

Several recommendations have been proposed for Sendang Biru Hamlet, including improvements to road corridors, residential yards, and evacuation routes. These recommendations are divided into three zones: Northern Area, Central Area, and Southern Area.

a. Northern Area

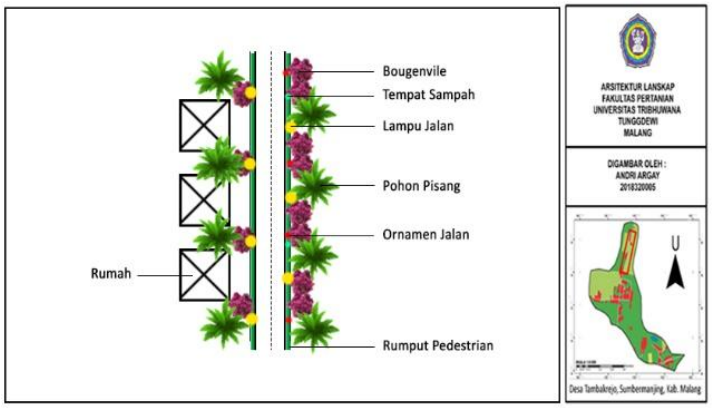

Figure 14. Road Site Plan of the Northern Part of Sendang Biru Hamlet

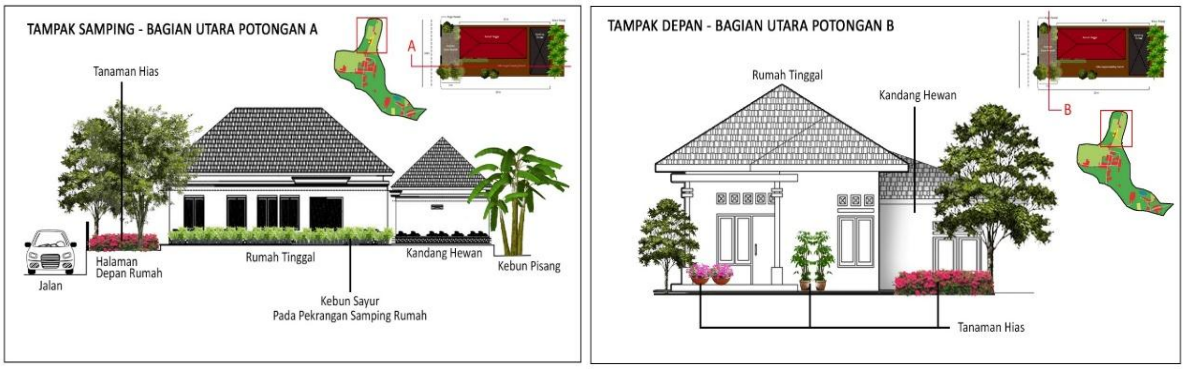

Figure 15. Settlement Pattern Model for the Northern Area of Sendang Biru:(a) Side Section View; (b) Front Section View

For the northern area, the recommended roadside ornamental plant is Bougainvillea *(Bougainvillea spp.)*, which provides both aesthetic and shading benefits. The recommended shade tree is Banana *(Musa paradisiaca)*. Recommended productive plants for residential yards include: Lettuce *(Lactuca sativa)*, Cassava *(Manihot esculenta)*, Chili *(Capsicum frutescens)*, Sunkist Orange *(Citrus sinensis)*, Spinach *(Amaranthus spp.)*. Recommended ornamental plants for home gardens include: Red Spinach *(Amaranthus tricolor)*, Bougainvillea *(Bougainvillea spp.)*, Yellow Palm *(Dypsis lutescens)*, Snake Plant *(Sansevieria trifasciata)*, Norfolk Pine *(Araucaria heterophylla)*.

b. Central Area

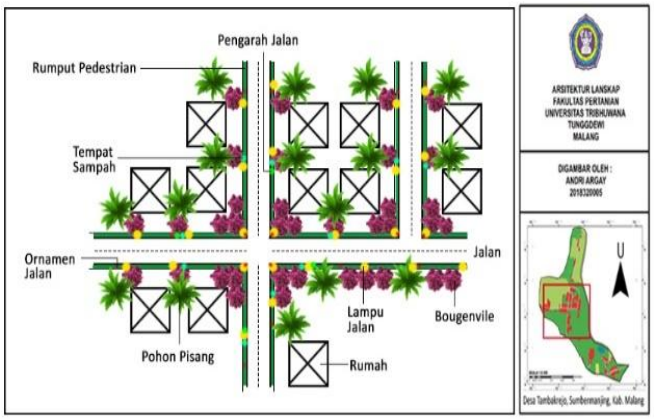

Figure 16. Road Site Plan of the Central Part of Sendang Biru Hamlet

Figure 17. Settlement Pattern Model for the Central Area of Sendang Biru: (left) Side Section View; (right) Front Section View

The recommendations for the central area are similar to those for the northern zone. The recommended ornamental plant along roadsides is Bougainvillea *(Bougainvillea spp.)*, while the shade tree remains Banana *(Musa paradisiaca)*. Productive plants for residential yards: Lettuce *(Lactuca sativa)*, Cassava *(Manihot esculenta)*, Chili *(Capsicum frutescens)*, Sunkist Orange *(Citrus sinensis)*, Spinach *(Amaranthus spp.)*. Ornamental plants for residential gardens: Red Spinach *(Amaranthus tricolor)*, Bougainvillea *(Bougainvillea spp.)*, Yellow Palm *(Dypsis lutescens)*, Snake Plant *(Sansevieria trifasciata)*, Norfolk Pine *(Araucaria heterophylla)*.

c. Southern Area

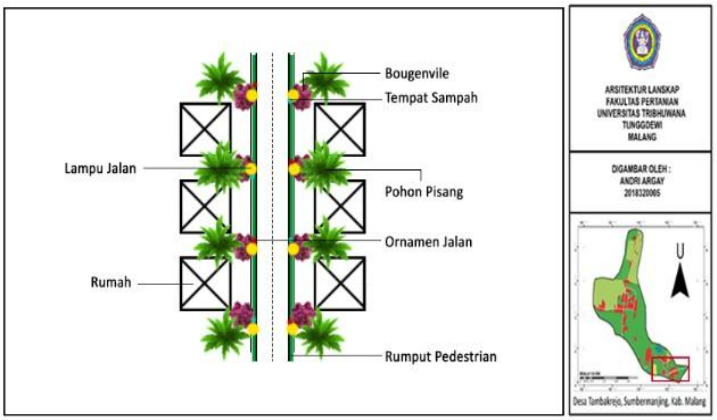

Figure 18. Road Site Plan of the Southern Part of Sendang Biru Hamlet

Figure 19. Settlement Pattern Model for the Southern Area of Sendang Biru:(a) Side Section View; (b) Front Section View

The southern area also follows a similar recommendation pattern. The recommended roadside ornamental plant is Bougainvillea *(Bougainvillea spp.)*, and the recommended shade tree is Banana *(Musa paradisiaca)*. Productive yard plants: Lettuce *(Lactuca sativa)*, Cassava *(Manihot esculenta)*, Chili *(Capsicum frutescens)*, Sunkist Orange *(Citrus sinensis)*, Spinach *(Amaranthus spp.)*. Ornamental garden plants: Red Spinach *(Amaranthus tricolor)*, Bougainvillea *(Bougainvillea spp.)*, Yellow Palm *(Dypsis lutescens)*, Snake Plant *(Sansevieria trifasciata)*, Norfolk Pine *(Araucaria heterophylla)*.

Recommendations for New Buildings, Public Facilities and Evacuation Route

Based on the existing conditions, new buildings constructed in Sendang Biru Hamlet are recommended to use environmentally friendly materials. The interior and exterior design should be adapted to residents' preferences and financial capabilities.

However, residents are encouraged to maximize the use of their yards as productive spaces, which can provide both household and ecological benefits.

For residents keeping livestock, it is recommended that animal shelters be built at least 10 meters away from the main house to prevent contamination of nearby water sources such as drains or irrigation channels. If sufficient distance cannot be maintained, a solid barrier wall should be constructed to minimize pollution. Additionally, daily sanitation must be maintained to prevent the spread of diseases. In addition to vegetation and landscaping, several public facility recommendations are proposed for Sendang Biru Hamlet, including the provision of mosques, parks, public toilets, and a landmark.

Since the coastline is located on the southern side, the recommended evacuation route directs residents toward the northern highlands, which are at a higher elevation and safer distance from the coastline. The recommendation also includes the installation of warning sirens as part of the early warning system. Sirens and loudspeakers are essential for issuing evacuation commands and public announcements during emergencies.

Based on the evacuation route map, the southern direction leads to the beach, while the northern direction leads to higher terrain. Therefore, the northern route is recommended as the primary evacuation path, offering greater safety and distance from potential coastal hazards.

5 Conclusion

Based on the findings obtained from surveys and interviews using the Focus Group Discussion (FGD) analysis method, the settlement pattern in Sendang Biru Hamlet is characterized as linear. The settlement layout is relatively simple, with residential units, public facilities, and social infrastructure arranged continuously along the main roads. The recommended settlement pattern is divided into three zones: the northern, central, and southern parts of Sendang Biru Hamlet. The northern and southern areas share similar characteristics, as both regions remain relatively natural and less densely populated compared to the central area, where residential development is more concentrated. In addition, several recommendations were proposed regarding road corridors and supporting facilities. The recommended plant species for roadside corridors include Bougainvillea (Bougainvillea spp.) as ornamental vegetation and Banana trees (Musa paradisiaca) as productive and shading vegetation. Further studies are recommended to deepen the understanding of settlement patterns in Sendang Biru Hamlet. Future research may focus on detailed settlement design and planning, employing a variety of analytical and spatial methods. Such efforts would contribute to the development of a more sustainable, well-organized, and community-oriented settlement pattern, in line with the aspirations and needs of the local residents.

References

Ade Wulandari, S., Karmilah, M., & Yuliani, E. (2020). Perubahan Fungsi Rumah Menjadi Ruang Ekonomi pada Penggal Jalan Kawasan Wisata Pantai Kartini. *Sultan Agung Fundamental Research Journal*, *`1*(1).

Ali, E. (2023). Geographic Information System (GIS): Definition, Development, Applications & Components. *Department of Geography,*.

Broughton, P. S. (1969). EKISTICS: AN INTRODUCTION TO THE SCIENCE OF HUMAN SETTLEMENTS. *American Journal of Public Health and the Nations Health*, *59*(3). https://doi.org/10.2105/ajph.59.3.569

Jia, P., Cheng, X., Xue, H., & Wang, Y. (2017). Applications of geographic information systems

(GIS) data and methods in obesity-related research. In *Obesity Reviews* (Vol. 18, Issue 4). https://doi.org/10.1111/obr.12495

Kadriansari, R., Subiyanto, S., & Sudarsono, B. (2017). Analisis Kesesuaian Lahan Permukiman Dengan Data Citra Resolusi Menengah Menggunakan Sistem Informasi Geografis (Studi Kasus : Semarang Bagian Barat Dan Semarang Bagian Timur). *Jurnal Geodesi Undip*, *6*(4).

Kornilova, A. A., Khorovetskaya, Y. M., Abdrashitova, T. A., Smagulova, A. B., & Lapteva, I. V. (2021). Modern model of a rural settlement: Development of planning structure and reconstruction of villages. *Civil Engineering and Architecture*, *9*(1). https://doi.org/10.13189/cea.2021.090118

Li, H., Yuan, Y., Zhang, X., Li, Z., Wang, Y., & Hu, X. (2022). Evolution and transformation mechanism of the spatial structure of rural settlements from the perspective of long-term economic and social change: A case study of the Sunan region, China. *Journal of Rural Studies*, *93*. https://doi.org/10.1016/j.jrurstud.2019.03.005

Makkulawu, A. R., Soemarno, Santoso, I., & Mustaniroh, S. A. (2023). Exploring the Potential and Benefits of AHP and GIS Integration for Informed Decision-Making: A Literature Review. *Ingenierie Des Systemes d'Information*, *28*(6). https://doi.org/10.18280/isi.280629

sastra M, suparno. (2006). Perencanaan dan pengembangan perumahan. *2006*.

Wijaya, K., Permana, A. Y., & Swanto, N. (2017). KAWASAN BANTARAN SUNGAI CIKAPUNDUNG SEBAGAI PERMUKIMAN MASYARAKAT BERPENGHASILAN RENDAH (MBR) DI KOTA BANDUNG. *Jurnal Arsitektur ARCADE*, *1*(2). https://doi.org/10.31848/arcade.v1i2.7

Yao, Q., An, N., Gu, G., Yang, E., Yang, H., Li, C., & Yan, K. (2023). Research Progress on Features and Characteristics of Rural Settlements: Literature Distribution, Key Issues, and Development Trends. In *Buildings* (Vol. 13, Issue 10). https://doi.org/10.3390/buildings13102457