

Study of Contour and Slope of Mohupomba Island Region Using QGIS Application for Sustainable Agricultural Development

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Abstract

Understanding the important characteristics of the topography of Mohupomba Island through contour and slope analysis using the QGIS application is the focus of this study. This study aims to identify variations in elevation and slope to support sustainable land use planning, particularly for agricultural development and disaster mitigation. The method used was qualitative descriptive with stages of collecting DEMNAS Geospatial Data from the Geospatial Information Agency (BIG) to obtain accurate elevation information, data processing using QGIS version 3.40, and visual analysis of contour and slope maps. The results showed that Mohupomba Island has an elevation range of 0–17 meters above sea level (masl), with a dense contour pattern in the eastern region indicating steep slopes, while the western part tends to be gentle. Most of the area is dominated by flat (0–8%) and gentle (8–15%) slopes, which are suitable for agricultural activities using soil conservation techniques. Meanwhile, areas with slopes >45% are classified as very steep and have a high potential for erosion and landslides, so they are not recommended for agricultural land development.

Keywords: Mohupomba Island, Contour, Slope, QGIS, Sustainable Agricultural Development.

INTRODUCTION

Understanding the shape and characteristics of the earth's surface is essential because these characteristics influence the distribution of natural resources such as mineral-, water, fertile soil, and forests. The study of the shape and characteristics of the earth's surface (geomorphology) is very important because it is related to security, economy, environment, and technology. Without this understanding, humans will find it difficult to manage resources,

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reduce disaster risks, and plan for sustainable development. Analysis of the contours and slope of a region allows for further study of water flow, erosion potential, and land stability.

Mohupomba Island is located in Bajo Kec Village, Tilamuta District, Boalemo, with coordinates of 0.472432° latitude and 122.362544° longitude. Mohupomba Island is physically elongated with a flat and sloping surface on the eastern side, which is dominated by shrub vegetation, while the western side of the island is a habitat for mangroves that grow well. The middle of the island is covered with dozens of coconut trees, some of which are cultivated and some of which grow naturally. The composition and vegetation of mangrove ecosystems in areas growing on small islands are generally not the same and depend on the ecology of the island's ecosystem. The existence of forest vegetation on small islands is something that needs to be preserved, because most of the forests on small islands are remnants of natural mainland ecosystems with high biodiversity. Over time, the process of geographical isolation has led to the formation of distinctive vegetation patterns and the existence of endemic species on most small islands. In addition, the function and potential of forest vegetation on small islands play an important role, both ecologically and economically, for the communities that inhabit them (Mirmanto, 2009) . Therefore, it is necessary to identify the characteristics and classification of this island and conduct further research to maintain the stability of land use on Mohupomba Island, Boalemo Regency.

Identifying changes in land use and planning sustainable agricultural development in an area requires multi-temporal spatial data that can show the specific direction of land use changes. Such spatial data can be sourced from satellite image interpretation or thematic data owned by government agencies, which can then be used for analysis using a Geographic Information System (GIS). The use of GIS and CS is an effective technology for processing multi-temporal spatial data to detect the characteristics of land use changes in an area, which is useful for sustainable natural resource management and can be used as information for future spatial planning. The existence of GIS facilitates the processing of research data, because GIS can handle geographically referenced data through the processes of input, management, manipulation, analysis, and output (Womsiwor et al., 2019)

This island has a fairly complex topography, consisting of lowlands and hills. To understand the diverse contour characteristics of this region, Geographic Information System (GIS) technology can be utilized. One of the widely used GIS software is QGIS. The results of the study (Soegijaparanata et al., 2023) show that the use of QGIS can improve the effectiveness of urban planning with more accurate and interactive visualizations, as well as provide solutions to transportation and land use problems in Surakarta. This study concludes that the integration of

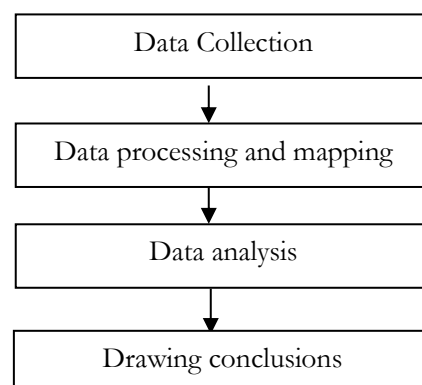


QGIS in smart city development can accelerate the implementation of evidence-based policies at the local government level. Contour and slope mapping through GIS applications such as QGIS can be useful in spatial planning and disaster mitigation efforts. In addition, the mapping results can also make a significant contribution to geophysical and environmental physics studies, particularly in understanding landscape dynamics, geomorphological processes, and the interaction between physical conditions in the region and natural disaster risks (Fitrianingrum & Sibiu, 2025) .

With its topographic analysis and digital contour mapping features, QGIS can help users obtain information on elevation, slope, and other landforms. The application of QGIS in contour studies can integrate spatial data with an environmental physics approach, particularly in understanding the distribution of gravitational potential energy and mass flow on the Earth's surface. This study aims to describe how QGIS can be used to understand contours on Mohupomba Island for the development of sustainable agricultural resources. The results of this study are expected to provide knowledge on the use of digital mapping technology for data sources in the development of island-based agriculture.

METHOD

This research was conducted on Mohupomba Island, Boalemo Regency, Gorontalo Province, with coordinates of 0.472432° latitude and 122.362544° longitude. The method used was a qualitative descriptive approach with a focus on the application of QGIS technology in understanding the contours of Mohupomba Island. The steps taken in this study are shown in Figure 1 below.



Based on the research steps in Figure 1, each step can be explained as follows:

1. The data collected in this study used DEMNAS geospatial data from the Geospatial Information Agency (BIG) to obtain accurate elevation information. This data was then combined with regional administrative data covering district/city and sub-district boundaries to ensure the accuracy of the research location. The integration of these two data sources enabled spatial analysis to be carried out with positional accuracy and regional context in accordance with the official administrative divisions.
2. The second stage was data processing and contour mapping. The application used at this stage was QGIS version 3.40. At this stage, in addition to creating contour maps, mapping of the region's slopes was also carried out to support the analysis. The criteria indicating slope classes can be seen in Table 1 (Banjarnahor et al., 2018) .

Table 1. Slope Class

Slope %	Classification
0-8	Flat
>8-15	Gentle
>15-25	Slightly Steep
>25 -45	Steep
>45	Very steep

Source: Banjarnahor et al., 2018).

3. The technical data analysis used visual interpretation of contour maps and slope maps. The interpretation was carried out by observing the distance between contour lines and the color gradation on the slope map, so that areas that were relatively flat, hilly, or steep could be identified.
4. The final stage involved drawing conclusions based on the interpretation results to answer the research objectives and assess the effectiveness of utilizing QGIS-assisted geospatial technology in understanding the characteristics of the Mohupomba Island region.

RESULTS AND DISCUSSION

This study examines the terrain characteristics of Mohupomba Island with QGIS-assisted analysis. Mohupomba Island, or Idaman Boalemo Island, is an island located opposite the village of Bajo, Tilamuta District, Boalemo Regency, Gorontalo Province. This island is a bat colony, most of which is sloped and uninhabited by humans. There are two islands adjacent to Mohupomba Island, namely Mohupomba Da'a Island and Mohupomba Kiki Island. These two

islands were originally one entity, but due to geological processes, they became two separate islands. This area has a land morphology dominated by sand and topsoil (humus) layers, as well as cliffs and hills. The island has natural vegetation such as coconut trees, mangroves, and other shrubs, which can be seen in (Figures 2a and 2b). The Bajo tribe's village settlements in this area tend to be scattered, with a distance of 15-20 minutes by boat to reach the island. The coastal area of Mohupomba Island has a natural coastline and its land cover is dominated by relatively extensive and well-preserved forests.



Figure 2a. Cliffs of Mohupomba Island
(Source: Google Earth Pro)



Figure 2b. Morphology of the Mohupomba Island Area
(Source: Google Earth Pro)

The contour mapping results using QGIS show that Mohupomba Island has a significant elevation variation of 0-17 meters above sea level, with hills in the central part of to the edge of the cliffs and flat coastline in the eastern part. The contour map of Mohupomba Island is shown in Figure 3a.

Contour lines indicate relative height above sea level; closely spaced contour lines indicate steep slopes, while widely spaced contour lines indicate gentle slopes. The contour pattern on the map shows the presence of hills, valleys, and coastlines. The contours shown in (Figure 3a) indicate a lowest elevation of 0 meters above sea level and a highest elevation of 17 meters above sea level, with a concentration of dense lines in the hilly areas in most of the eastern region. The density of contour lines per 1 meter reflects the steepness of the slopes and a significant increase in elevation from north, south, and west (coast) to east (highlands). The curved and dense contour lines on the eastern side indicate steep slope morphology, while the flatter contours in the west describe areas with gentle slopes and different potential for agricultural land use. Areas with dense contours and high elevation tend to have higher erosion rates and limitations in land use for intensive agriculture (Mahfuzh et al., 2024). In addition, dense contours also indicate the need for special attention in spatial planning, especially in the context of disaster mitigation such as landslides.



's research suggests that effective tools for understanding the contours and slopes of the North Loloda District, based on contour mapping results, show that the eastern part of the North Loloda District is dominated by steep to very steep slopes with high contour line density, while the western part tends to be flatter and closer to the coast. This area has an elevation range of 0 to 17 meters above sea level. Sloping land covers around 67% of the area and is fairly evenly distributed throughout the region. On sloping and rocky land, land management must be carried out using a conservation concept. Technically, agricultural area development must be carried out through an evaluation of land suitability for commodities that are compatible with its biophysical and environmental characteristics, and the application of appropriate technology in dealing with problems in the field (Hikmat et al., 2023) .

Soil characteristics vary with altitude. Differences in altitude in a region will affect how nutrients are transformed and the abundance of microorganisms in the soil. In higher altitude areas, rainfall is generally higher, air temperatures are lower, and soil nutrient content tends to be higher because organic matter decomposition occurs more slowly . If the soil is prone to erosion, nutrients and fertile soil layers can be eroded, reducing the quality of the soil where taro grows. These conditions can inhibit the optimal growth of taro plants. Research findings (Maulana et al., 2024) reveal that altitude affects the increase in organic matter, which is a parameter of soil erodibility, where land at lower altitudes has a higher potential for erosion than land at higher altitudes.

Determining the base elevation of agricultural land is a major factor in all agricultural land planning. Various problems often arise as obstacles to agricultural cultivation in tidal fields, including acidity, salinity, and insufficient water levels to reach agricultural land, often caused by inappropriate water management systems. All of the above problems arise as a result of inaccuracies in determining the base elevation of agricultural land. In determining the base elevation of agricultural land in tidal areas, it is greatly influenced by the range of tidal fluctuations in seawater. The results of the study " show that the elevation of agricultural land at the study site to be developed as agricultural land is higher than the water level, which facilitates the management of the water management system. The determination of the elevation of agricultural land in swampy areas is greatly influenced by the movement of tidal water.

Based on elevation data, the Mohupomba Island region has an elevation range of 0-17 meters above sea level (masl), indicating topographical variations from lowlands to steep hills. The distribution of slopes resulting from these variations can be seen on the Mohupomba Island Slope Map in Figure 3b.





Figure 3a. Contour Map of Mohupomba Island



Figure 3b. Slope Map of Mohupomba Island

The slope map in (Figure 3b) provides a more specific visual representation of the slope gradient on Mohupomba Island. This map reinforces the interpretation of the previous contour pattern, which shows that most of the eastern region is dominated by flat to very steep slopes. The flat coastal slopes are thought to be related to the conditions of the coastal area with a wide intertidal zone, as a result of abrasion along the coastline and the supply of sediment entering the sea through the Waitasoi River, which affects the presence of mangrove vegetation along the area, causing sediment to be trapped. Meanwhile, gentle slopes are thought to have been formed as a result of abrasion on the coast and the influence of input from the mainland, but on a small scale (Kalay et al., 2018) . Slope is a measure of the relative inclination of land to a flat plane in general. According to Laura & Ratna,(2025)slope is formed due to differences in elevation between one area and another.

Based on the slope map of Mohupomba Island, which is dominated by flat land, it is suitable for agricultural resource utilization by considering limiting factors. Furthermore, slopes that are predominantly gentle can still be utilized for agricultural land resource development using soil conservation techniques. Slopes < 45% (very steep) are generally not recommended for agricultural resource development activities. The lower the slope, the higher the infiltration value obtained. This is in accordance with the research " , which states that slopes of 0-8% have the same classification and infiltration value as slopes of 8% - 23%. From this comparison, it is known that under US regulations. Soil Conservation standards for slopes with a gradient of 0-8% have higher classification and infiltration values compared to slopes with a gradient of 8%-23%. These values are 1.208,474 (Very fast) > 213,789 (Fast). Similarly, according to Dulbahri's provisions, slopes with a gradient of 0-8% have a high infiltration rate compared to slopes with



a gradient of 8% - 23%, which have a moderate infiltration rate.

Based on the contour map and slope of Mohupomba Island, which is predominantly flat with natural vegetation (shrub forest), agricultural resources were developed by considering land use types. This is in accordance with the statement (Reza Septianugraha and Abraham Suriadikusumah, 2016) Land use Forest land use with a slope of 16-25% has the best effect on organic C content (4.21%) compared to other treatments, and forest land use with a slope of 8-15% has the best effect on soil permeability (12.87 cm/hour) compared to other treatments. For example, in areas with high slopes, special attention is needed in land use planning and infrastructure development to avoid the risk of landslides. Thus, slope maps not only provide a topographical overview but also serve as an important basis for area-based decision-making. High slope gradients can cause surface erosion, as indicated by the study " , which found that slope gradients of 26-40% in the middle and upper slopes had the highest erodibility values compared to other slope gradients and positions. If the soil erodibility value in a studied area is classified as high.

Slope gradient is closely related to the level of erosion hazard. In line with (Harianti & Emalinda, 2021) , steep slopes on the northern foot of Mount Talang cause erosion to be more prone to occur. On land with steep slopes, the tendency for erosion and sedimentation to occur is generally quite high. Cultivating crops on slopes and along contours will increase soil erosion. Erosion will carry nutrients and organic matter needed by plants to lower areas. If this continues, it will cause further land degradation, which will impact crop productivity.

Parameters used to assess land physical conditions include parent material type, slope gradient, conservation measures, soil texture, and land use analysis. Research by(Laura & Ratna, 2025) shows that the slope gradient in the Marapi Slopes of Tanah Datar Regency, specifically in the sample area, has three variations, namely gentle with a height of 8-15%, steep with a height of 25-45%, and very steep with a height of >45%. The parent material found on the slopes of Marapi in Tanah Datar Regency is susceptible to erosion. Good quality or susceptible parent material has the potential to produce more fertile and productive soil.

The slope factor is always involved, in addition to other factors such as accessibility, land value, and so on, to determine the level of suitability of land use planning. Therefore, it can be said that the slope factor plays a dominant role because it has derivative effects, such as sensitivity to erosion, susceptibility to landslides, and difficulty in accessing and cultivating the land. The results of the study " show that the aspect of slope has a significant influence on development in Serang Regency, where ideal development is carried out in areas with flat morphology. Areas with flat morphology are relatively safer than hilly and mountainous areas



with steep slopes that have the potential for landslides.

It is hoped that the use of appropriate conservation techniques, soil management, and crops will further enhance soil resistance to erosion. The relationship between slope and soil properties and crop appearance observed can be expressed in a linear equation explaining that soil properties and crop yield decrease as the slope increases (Banjarnahor et al., 2018) .

CONCLUSION

The conclusion of this study from the contour map of Mohopomba Island shows an elevation of 0-17 m above sea level and a slope dominated by flat and gentle slopes influenced by the topography of the land mass and the width of the plain. The slope on Mohupomba Island is dominated by slopes of 0-8 (flat) and >8-15 (gentle). This study emphasizes the importance of integrating GIS technology such as QGIS in topography-based spatial planning. The results of contour and slope mapping can be used as a reference in land management, especially for determining sustainable agricultural zones and protected areas. The research recommendations include the application of soil conservation techniques in sloping areas and the protection of natural vegetation to maintain the stability of the island's ecosystem.

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