BHUMI: Jurnal Agraria dan Pertanahan
Volume 10, Number 1, May 2024

ISSN: 2442-6954
e-ISSN: 2580-2151
Doi: https://doi.org/10.31292/bhumi.v10i1.706

Evaluation of Land Suitability for Organic Horticulture Farming in Support of Sustainable Agrarian Governance

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Received: October 17, 2023; Reviewed: October 11, 2024; Accepted: October 27, 2024

Abstract: Land compatibility can contribute to the optimization of agricultural land use, because this evaluation is used to determine the most appropriate spatial plan for current and future land use. Identifying the suitability of agricultural land is necessary to adapt to increasing food needs caused by expanding population, environmental pollution and climate change. Therefore, this research was conducted to assess the suitability of snake fruit plants. Various factors were considered in this research, such as rainfall, temperature, nutrient availability (wa), rainfall density (rc), organic carbon (nr), slope, flood hazard (fh) and erosion hazard (eh). The results of the classification of land suitability classes in the Sleman Regency area, in this case, are that snake fruit plants in most areas fall into the criteria for land suitability class S2 or quite suitable. The results are with an area of42,150 Ha or with a percentage of 73.4% of the land suitability class S2 or Sufficiently Suitable. (Medium Suitable) is land that has quite heavy barriers to maintain the level of management that must be carried out. In the land suitability class S1 or very suitable in the research area with an area of 10625 Ha or with a percentage of 18.5, the land suitability class Very Suitable (Very Suitable) is land that has no boundaries. The results of the land suitability assessment, both actual and potential, can be carried out by improving efforts such as improving drainage, adding organic material, planting according to contours, fertilizing.

Keywords: Horticulture, Land uniformity, Land suitability, Organic farming, Snake Fruit

INTRODUCTION

As the world's population grows, more efforts and innovation are needed to increase agricultural production, improve global supply chains, and achieve sustainability (Li et al., 2017). The Sustainable Development Goals (SDGs) lead in this direction through support for sustainable agriculture, empowerment of small farmers, and tackling climate change. The increasing scarcity of land resources in many parts of the world makes sustainable use and management of these resources extremely important(Paul et al., 2020). Given the current level of land degradation and limited land resources, the need to optimize land use while preserving ecosystems is very important(Bozdağ et al., 2016). The development of land resource use in the last two decades has shown significant changes in many regions, including Sleman District (Devi et al., 2021). One of the main issues is the increase in urbanization and land conversion for non-agricultural uses. Increased consumer awareness of healthy and environmentally friendly products is increasing the demand for organic agricultural products (Andrea et al., 2021). Consumers explore the health benefits and low risk of organic agricultural products, which also drives demand. Relatedly, the conversion of land to organic forms of production is also attracting interest as organic is believed to show a more positive environmental record and support soil sustainability in the long run (Seth & Jain, 2019). Therefore, it is important to evaluate the feasibility of land for organic production; to be in line with the consumer society, converter market needs meet consumer needs but also support the development of existing resources (Hariyati et al., 2023).

Site-specific research can lead to more accurate recommendations for optimally utilizing the land's potential, and identifying limiting factors that may be overcome through appropriate agricultural practices, such as crop rotation, use of organic fertilizers, and soil conservation techniques. In addition, this study also provides in-depth insights into efforts to minimize limiting factors, such as addressing soil erosion, improving water retention, and improving soil quality through the addition of compost and organic matter. These efforts are important as many previous studies suggest that good soil management can sustainably improve land quality and productivity, even on land with certain limitations (Maleki et al., 2022). Thus, research that considers site-specific aspects and limiting factors allows the development of sustainable land optimization strategies that are appropriate to local conditions, and support the long-term sustainability of organic farming (Nurda et al., 2020).

Evaluation of land suitability for horticultural crops is basically to obtain data on land characteristics which are limiting factors in the growth and development of the plants themselves (Mujiyo et al., 2021). These limiting factors can influence optimal production. Rice is one of the main food crops and commercial crops (Mulyani et al., 2023). One of GIS' capabilities is to carry out land suitability analysis. Identification of land use is important to find out whether land use carried out by human activities is in accordance with its potential or carrying capacity and can also be used to find out how much land use has changed.(Kahsay et al., 2018). Integration of remote sensing technology is a potential form of seeing land use fairly accurately without having to carry out surveys at every existing point, but can only use samples from remote sensing results. So it can produce information about the distribution of land use (Karimi et al., 2018).

Land suitability evaluation can answer the suitability of land for the development of a commodity and economically it will answer the feasibility of farming(Kadam et al., 2021). The purpose of land suitability evaluation is to provide an assessment of land suitability for the purposes that have been considered (Abdelrahman et al., 2016). The benefit of land suitability evaluation is to provide an understanding of the relationships between land conditions and its use, as well as providing planners with various comparisons and alternative use options that are expected to be successful.(Yalew et al., 2016). Land suitability or land capability classification is the grouping of land based on its suitability or ability for certain use purposes(El Baroudy, 2016). This grouping is usually carried out by soil scientists using soil map units (SPT), or often also called land map units (SPL) from the results of soil surveys as an evaluation unit and as a basis for determining distribution boundaries (Sumani et al., 2018).

The diversity of the nature of land and environmental resources means that the potential and limiting factors for agricultural commodities differ from one region to another. Indonesia, as an archipelagic country surrounded by oceans, influences the climate and weather in various regions (Sappe et al., 2022). Where, climate and weather are important factors in the formation of soil, water, growth and plant production(Bozdağ et al., 2016). Therefore, Indonesia has unique biophysical conditions between its regions. This is what encourages the existence of superior agricultural commodities in each region, one of which is Sleman Regency. Land Suitability Analysis (*Land Suitability Analysis / LSA*) is a Geographic Information System (GIS) based process used to determine the suitability of land for a particular use (Rayes et al., 2023). The basic premise of LSA is that land has various values, both internal and external, where each value can be categorized as supporting or hindering the use of the land, both existing and planned (Romadhona & Mutmainnah, 2024). Based on the above, it is necessary to carry out research, namely evaluating the level of suitability of land for snake fruit plants, as a parameter to see the suitability of land for cultivation, as well as improvement efforts that need to be made to improve and develop rice and snake fruit plants (Arowolo & Deng, 2018).

Geographic Information System (GIS)-based spatial analysis has emerged as an important tool in evaluating agricultural land suitability by providing precise and comprehensive analysis of spatial data. Previous studies, such as those conducted by (Hartati et al., 2018), have highlighted the effectiveness of GIS in identifying suitable areas for various crops in Yogyakarta. However, there are still significant gaps in integrating GIS-based analysis with actual and potential limiting factors that affect land suitability, such as soil quality, water availability and climatic conditions (Mishra et al., 2015). Current research often ignores these dynamic environmental variables, which are critical for accurate land suitability assessment. By addressing this gap, our research aims to advance the current state of affairs by incorporating actual and potential limiting factors into a GIS-based spatial analysis framework, thus providing a more robust and nuanced understanding of agricultural land suitability in Yogyakarta. This comprehensive approach will not only improve accuracy in land use planning but also support sustainable agricultural development in the region (El Behairy et al., 2022).

The assessment of land suitability for snake fruit in Sleman Regency involves a comprehensive analysis of the physical and chemical characteristics of soil and climate that affect crop productivity. The land suitability evaluation includes measuring parameters such as soil texture, pH, organic matter content, drainage, slope, and rainfall. The actual land analysis shows the current condition of the land in use, while the potential land analysis identifies the optimal potential that could be achieved with certain interventions, such as improved drainage or addition of organic matter. The main limiting factors in land suitability in Sleman include steep slopes, lack of organic matter, and poor drainage issues. This in-depth understanding of land analysis is important in agrarian and land planning, as it can guide sustainable land management policies and actions and support food security and agriculture-based local economic development. With this approach, land management recommendations can be tailored to improve land suitability and productivity of snake fruit crops in Sleman Regency.

METHODS

The potential of an area for agricultural development is basically determined by the nature of the physical environment which includes climate, soil, topography/form of the hydrological area and use requirements or commodities that are evaluated to provide an idea or information that the land has the potential to be developed for certain purposes. This means that if land is used for a certain use, taking into account the required inputs, it will be able to produce results as expected. Land use that is not in accordance with its potential will result in decreased productivity, degradation of land quality and will be unsustainable(Yalew et al., 2016). In order to avoid this, land evaluation is needed to support sustainable agricultural development planning. The data used in the research is secondary data related to previous research, temperature data, rainfall, slope maps, land use maps, soil type maps, administrative maps, rainfall data, climate data and temperature data from various agencies. Sleman Regency has high agricultural development potential, with various superior agricultural commodities, such as rice, corn, horticulture and plantations. This makes Sleman Regency an appropriate location for agricultural research. Based on these advantages, Sleman Regency is an ideal location for agricultural research. Research in Sleman Regency can provide valuable information and input for agricultural development in Indonesia.

The land suitability research method for snake fruit implication includes several stages of work integrated into a comprehensive model, which consists of in-situ measurements of various environmental factors including soil texture, pH range, nutrient levels, topography, and microclimate in the study area. Primary data were obtained from direct field surveys in the form of soil surveys and sampling at various potential land points. Secondary data such as geospatial maps, rainfall and temperature were used to complete the spatial analysis framework. These are further processed using a land suitability analysis model, an example of which comes from the FAO Framework which divides land into Inherent Suitability Classification classes S1, S2, S3, and N. To ensure the accuracy of the output, this method is complemented by laboratory test validation of the soil samples taken and field validation through interviews with local farmers and direct observation of the growth of snake fruit plants in locations that have been used. This data triangulation technique is necessary so that the analysis results can reflect the conditions in the field. GIS is also used as a tool to map and analyze land suitability spatially. This validation step is very important because it takes into account the different characteristics of the leftover land that may have an impact on snake fruit land productivity.

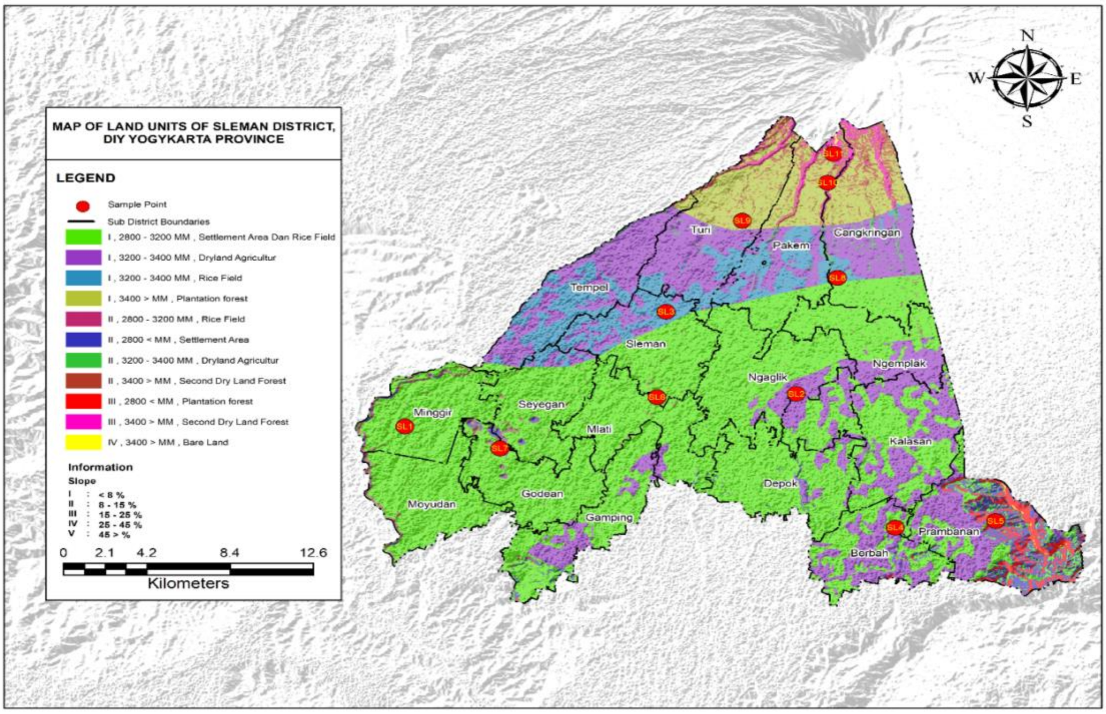

Figure 1. Map of Research Locations and Data Sampling
Source: Data Processing, 2023

At this stage, the selection of land units aims to represent variations in rainfall and land use patterns from each in Sleman Regency. This approach is based on previous studies that prove that variations in microclimate and climatic land types affect the evaluation of land suitability results and overall agricultural conditions (Anshar et al., 2022). As already mentioned, in this study each land unit was selected to represent a variety of climatic characteristics, particularly rainfall, as well as different types of land use in Sleman Regency. Thus, the division of the area into eleven subdistrict locations, these locations are Minggir and Moyudan (SL 1), Ngaglik and Depok (SL 2), Sleman and Tempel (SL 3), Berbah (SL 4), Prambanan and Kalasan (SL 5), Mlati and Sayegan (SL 6), Godean and Gamping (SL 7), Ngemplak (SL 8), Turi (SL 9), Pakem (SL 10), and Cangkringan (SL 11). It is designed to cover the entire spectrum of agro-ecological conditions. In particular, locations characterized by low rainfall, such as Minggir and Moyudan, as well as Prambanan and Kalasan which have higher rainfall, are important in analyzing variations in environmental conditions and their impact on agricultural suitability. One important aspect of the design of these areas is the different types of land use between them, with some sub-districts having a predominance of paddy fields, while others have a predominance of plantation and horticultural land, allowing this study to capture the interaction between climate and land type in an agricultural context.

The selection of sub-district land units as the basis for this research is synergistic with the need to enrich the data in order to evaluate the suitability of Sleman's agricultural land. The condition of each sub-district as a representation of certain environmental conditions offers an image that maps patterns of suitability, whether in the form of suitability or unsuitability, and identifies the potential or limitations of land obtained from the findings of valid and relevant empirical data (Sangkala et al., 2024). The variation in the location of subdistrict land units to account for different rainfall, as well as varying land use, allows for data that can illustrate the extent of land adaptation needs, as well as opening up the potential for increased production or development of sustainable agricultural practices that require specific locations in various regions of Sleman. The results of a more in-depth analysis provide a strong basis for formulating various land use strategies that are responsive to local conditions, such as addressing the challenge of optimal land provision according to the needs of each sub-district.

This research was carried out using a survey method, by conducting direct surveys in the field. The sampling point was determined using purposive sampling. Purposive sampling means samples are selected based on certain considerations in accordance with the research objectives so as to facilitate the location and location of soil samples in the field. This research activity was carried out in four activity stages, namely the preparation stage, field activity stage, laboratory analysis, and data processing and map making stage. In the process of evaluating the suitability of temperature, rainfall and soil texture, matching is carried out between the conditions of temperature, rainfall and soil texture in the field (in this case Sleman Regency) with the classification of land suitability classes for Slebong snake fruit plants as a result of modifications from the initial suitability table which is based on the condition of rainfall, temperature and soil texture at the location of the snake fruit plant production center, the data inputs in the suitability evaluation process are temperature distribution maps, rain distribution maps and soil texture maps and the output is a suitability map for each parameter with additional attributes in the form of respective suitability ratings. each parameter.

A field survey was carried out to determine the location and condition of rice and snake fruit production centers. Researchers came to the location of the center for developing organic snake fruit and rice plants and then took soil samples to validate the soil texture in the research area. Researchers also took samples and saved the location coordinates in GPS (Global Positioning Systems) (Romadhona et al., 2020). This research aims to analyze the suitability of land in Sleman Regency so that government policy directions can be implemented in sub-district areas based on superior agricultural commodities, both crop and horticultural crops. In this research, specifically rice and snake fruit plants which are widely developed in the research area in accordance with the characteristics of the land. There is. Apart from that, this research is also aimed at evaluating land suitability which is carried out by comparing the physical characteristics of the land with existing land suitability criteria using software.

RESULTS AND DISCUSSION

In the pre-survey stage, consultation was carried out with the local government, followed by a field survey stage by making direct observations on agricultural land for the process of taking soil samples. Soil analysis in the laboratory is carried out to produce data on land characteristics that are used to prepare land characteristics. The matching process is carried out using an application that produces the suitability of the selected land for direction. In this way, recommended land use directions can be obtained in the research area. Land suitability is the suitability of a piece of land for a particular type of use. Evaluation of land suitability can be carried out if data on land characteristics is obtained. Land characteristics are land properties that can be measured or estimated. Land suitability evaluation can contribute to the optimization of agricultural land use, because this evaluation is used to determine the most appropriate spatial plan for current and future land use.

Suitability of Soil Type and Temperature

In Figure 2. Soil types in Sleman Regency are divided into litosol, regosol, grumosol and cambisol. Most of the Sleman area is dominated by the regosol soil type with an area of 39,124 Ha or 68.12%. Regosol is a type of soil that is still developing, formed in piles of newly deposited parent material, which was transported from other places and buried in that place. Regosol soil with a coarse texture or high sand content will have good porosity because it is dominated by macro pores, but has a low fertility level where nutrients are easily leached, then the grumusol soil type with an area of 7037 Ha or with a percentage of 12.35% grumusol soil is formed From the weathering of limestone rocks and volcanic tuffa, which have a low organic material content, grumusol anah also has a low nutrient content, especially the nutrient nitrogen (N) (Sari et al., 2021).

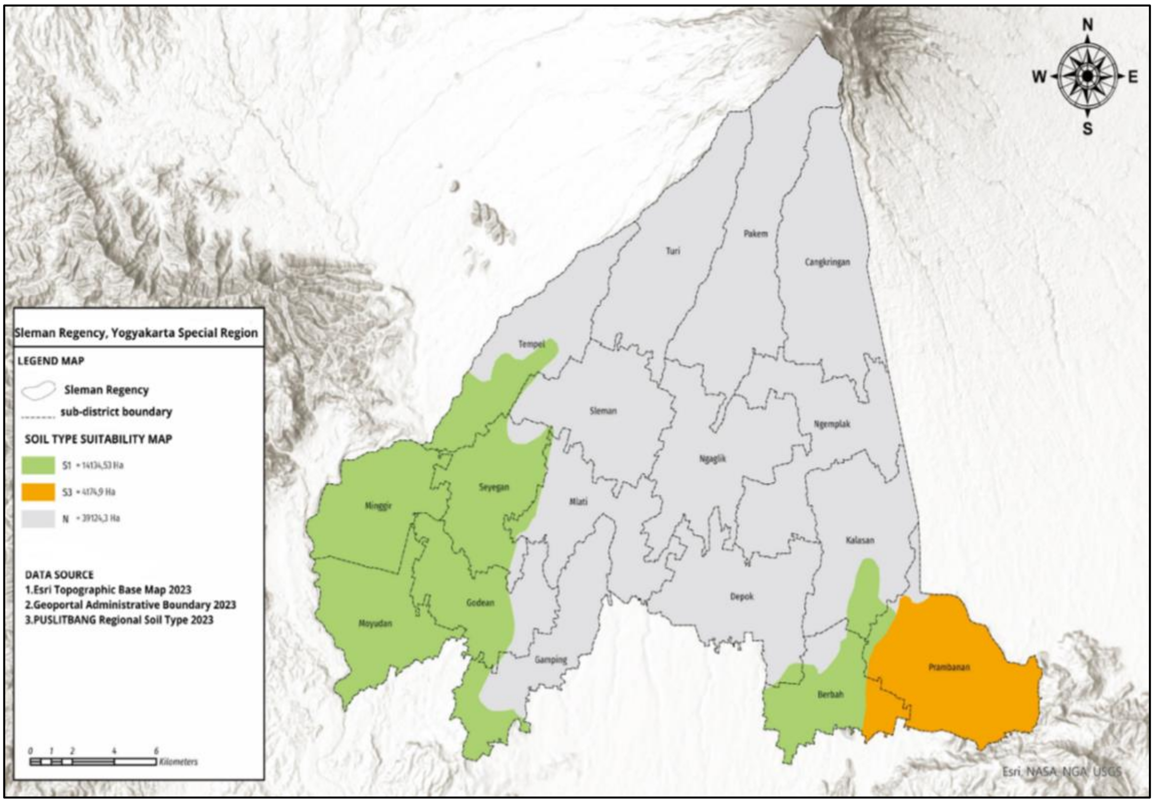

Figure 2. Land Suitability Map Based on Soil Type
Source: Data Processing, 2023

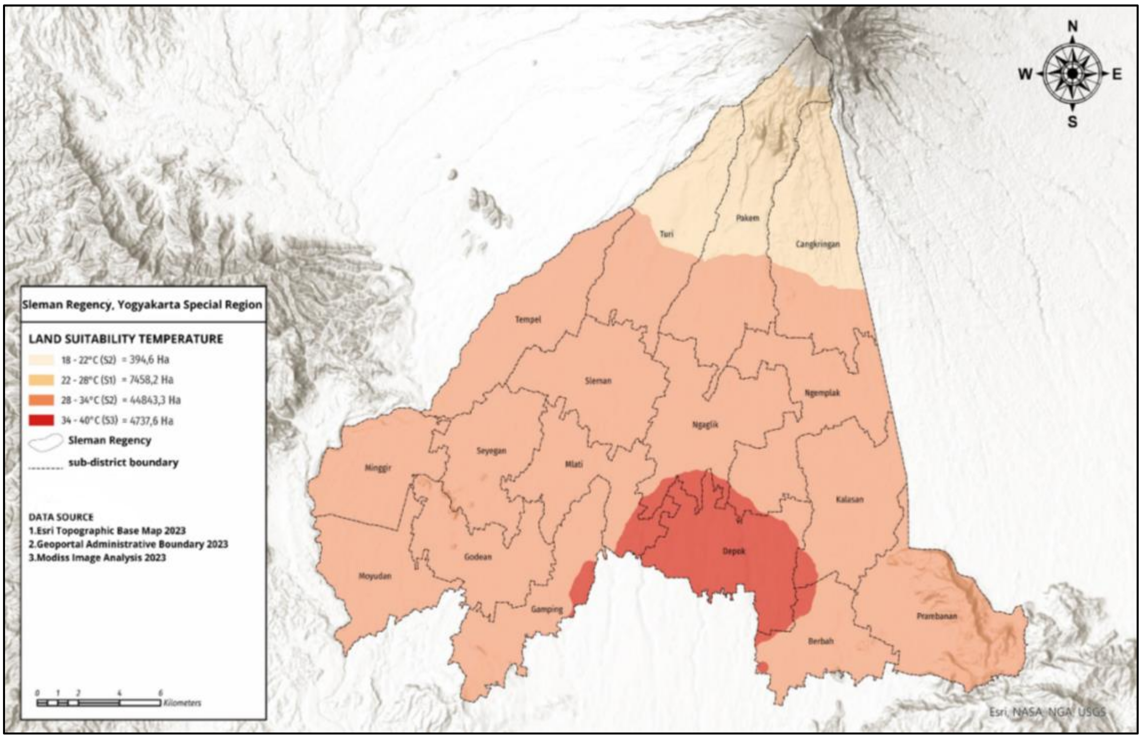

Figure 3. Land Suitability Map Based on Temperature
Source: Data Processing, 2023

Based on the data in Table 1, the cambisol soil type in Sleman Regency covers an area of 7,097 hectares, which is about 12.35% of the total area. Cambisol soils, which generally have fertile physical and chemical properties, are very suitable for agricultural development, especially on lands with limited irrigation needs.

Table 1. Distribution of soil types in Sleman Regency

Type of soil	Area (Ha)	Percentage (%)
Grumusol	7037,187	12.25
Cambisole	7097,342	12.35
Latosol	4174,935	7.26
Regosol	39124,377	68.12

Source: Data Processing, 2023

High organic matter content plays an important role in fertilizing the soil because it functions as a source of nutrition for plants, improves soil structure, and increases the carrying capacity of the soil, even though it has disadvantages, namely high lime content and high base saturation, the next type of soil is the least abundant in the region. Sleman Regency is a type of latosol soil. This type of soil has an area of 4174 Ha or with a percentage of 7.62%. Latosol soil comes from volcanic ash parent material which covers the parent rock. Latosol soil is spread in areas with wet climates with elevations between 300 - 1000 meters (Romadhona & Arifandi, 2020).

For the suitability of the soil type, the suitability class is S1 (very suitable), which means it has no significant limiting factors or minor limiting factors and will not significantly reduce land productivity. The area that is very suitable based on the condition of the soil type in the research area is 14,134 Ha. or with a percentage of 24.6%. Furthermore, S3 (marginal according to) Land in class S2 has limiting factors and these limiting factors will influence its productivity. Requires additional inputs that are not too large so that the limiting factors can usually be overcome by farmers themselves. The area included in the marginal class based on the condition of the soil type in the research area is 4174 ha or with a percentage of 7.26%. Furthermore, the criteria for class N (not suitable) in this class are not suitable for the use of snake fruit plants because they have very severe limiting factors and/or are very difficult to overcome. The area that falls into the class is not suitable for snake fruit plants based on the condition of the soil type in the research area, namely 39124 Ha or with a percentage of 68.12%.

Temperature Suitability

Temperature is one of the environmental factors that influences land suitability. Each plant has different temperature requirements to grow and develop well. Air temperature conditions in the Sleman Regency area are mostly at 28^0C – 34^0C with an area of 44834 Ha or with a percentage of 78.07% in the temperature range of 28^0C – 340C in the suitability class for snake fruit in the S2 category (quite suitable) this shows that the land has limiting factors, and these limiting factors will have an influence on productivity. Furthermore, at an air temperature range of 22^{0}C - 28^{0}C, this temperature range has an area of 7458 Ha or with a percentage of 12.98% in the temperature range of 22^{0}C - 28^{0}C. In the suitability class, Snake fruit land is in the S1 category (very suitable). The land does not have any limiting factors. significant or real to sustainable use, or the limiting factor is minor and will not have a real effect on land productivity because it is at the optimum value.

Table 2. Suitability of Temperature in Sleman Regency

Temperature	An area	Percentage (%)	Conformity class
18 – 22	394.66	0.68	S2
22 - 28	7458.20	12.98	S1
28 - 34	44843.30	78.07	S2
34 - 40	4737.67	8.24	S3

Source: Data Processing, 2023

In the results of the analysis shown in Table 2, it can be seen that the temperature range of 18°C - 22°C with a land area of 394 hectares or 0.68% is included in the suitability class S2 or moderately suitable for snake fruit plants. This means that there is a limiting factor that affects the productivity of this land. The factor is that unsuitable temperatures can hinder the optimal growth of snake fruit plants. The temperature range that is classified as higher, namely 34°C - 40°C with a total land area of 4,737 hectares or 8.24% is included in the S3 or marginal suitability class. This means that this land still has limiting factors despite efforts to reduce them. This shows that land with high temperatures has more significant limitations in terms of optimal snake fruit cultivation, so its management must be more effort to be able to produce optimal productivity for cultivated plants. In this class of criteria the land has severe limiting factors, and these limiting factors will greatly influence its productivity, requiring additional input which is more than land classified as S2.

Land Suitability Based on Rainfall and Flood Hazard

Rainfall is the amount of water that falls on a flat ground surface during a certain period which is measured in units of height (mm) above the horizontal surface if there is no evaporation, runoff and infiltration. In assessing the land suitability class for snake fruit plants, most of the Semarang Regency area is in the value range of 500 – 1000 mm/yr with an area coverage of 41,400 Ha or with a percentage of 72.08 in the land suitability class for snake fruit in the S1 category (very suitable). a significant or real limiting factor to sustainable use, or a limiting factor that is minor and will not have a real effect on land productivity because it is at the optimum value.

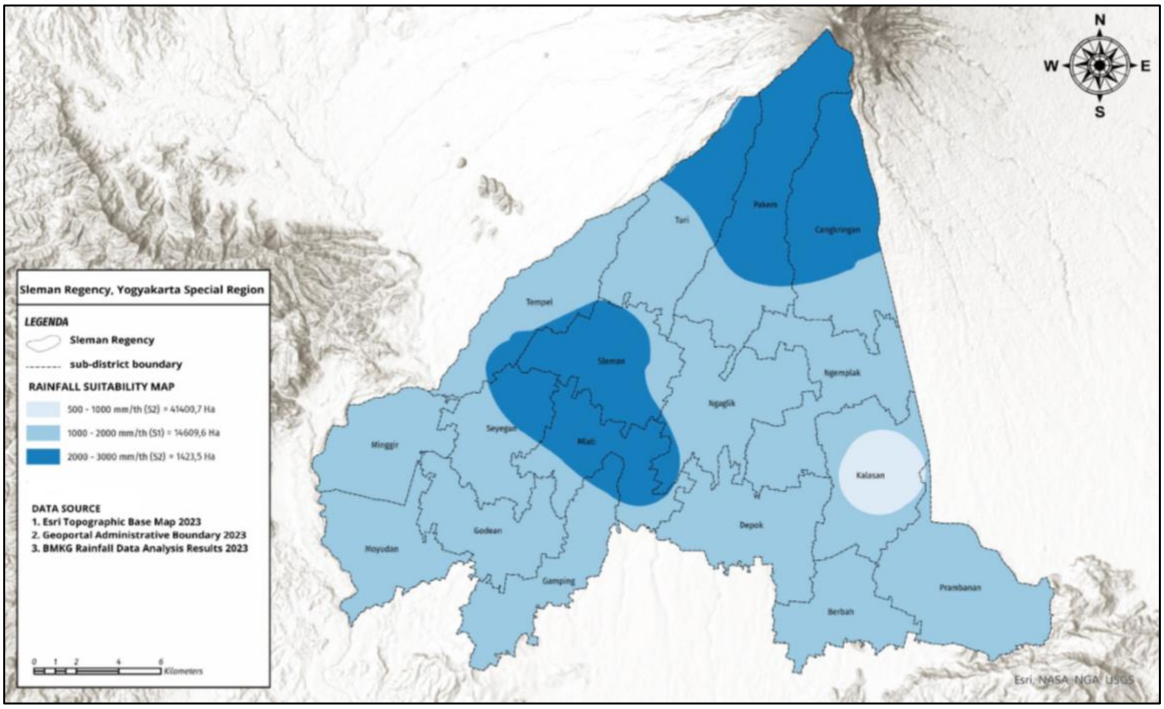

Figure 4. Land Suitability Map Based on Rainfall
Source: Data Processing, 2023

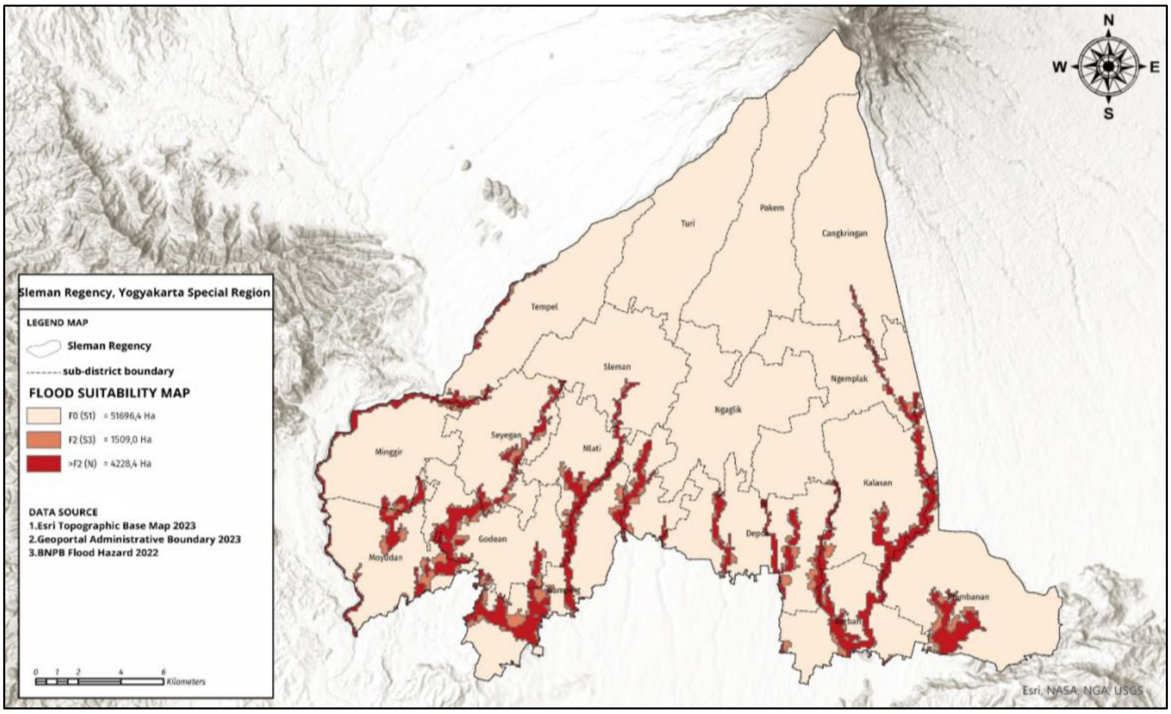

Figure 5. Land Suitability Map Based on Flood Hazard
Source: Data Processing 2023

In the data presented in Table 3, snake fruit is in the S2 suitability class moderately suitable in the range of rainfall 1000-2000 mm/year with an area of 14,609 Ha, or a percentage of 25.43% of the total area. The suitability indicates that rainfall in this range is sufficient to show snake fruit, although it is still in the category of not very suitable.

Table 3. Suitability Criteria for Rainfall in Sleman Regency

Rainfall	Wide	Percentage %	Suitability
500 - 1000 mm/yr	41400.70	72.08	S1
1000 - 2000 mm/yr	14609.60	25.43	S2
2000 - 3000 mm/yr	1423.57	2.47	S2

Source: Data Processing, 2023

This S2 class indicates that there are limiting factors; however, these factors are still not significant enough to reduce the total suitability of the area as a snake fruit plant. This explains that this limiting factor will affect its productivity, requiring additional input (input). In the last range, namely 2000 – 3000 mm/yr with a coverage area of 1423 Ha or with a percentage of 2.47% in this temperature range, it is included in the criteria for snake fruit plants, namely S2 (quite suitable), indicating that the land has limiting factors, and these limiting factors will affect productivity. Rainfall is a climate element that is closely related to erosion. Rainwater that falls to the earth will cause erosion of the soil in its path, causing erosion on certain slopes of land. Soil erosion during rain is a complex phenomenon resulting from the release and transport of soil due to rain splash, storage (*storage*), surface flow and infiltration. The importance of this process is related to a number of factors, namely rainfall intensity, infiltration rate and surface runoff, soil properties and land surface conditions such as soil moisture, soil roughness and slope length and land steepness.(Dharumarajan et al., 2022).

Table 4. Suitability Criteria for Flood Hazard in Sleman Regency

Flood Danger	Wide	Percentage %	Suitability
F0	51696,400	90.01	S1
F2	1509,070	2.62	S3
>F2	4228,374	7.36	N

Source: Data Processing, 2023

According to Table 4, based on the data processing conducted, it can be seen that flooding is one of the negative aspects of land suitability. Flooding can damage soil structure, resulting in erosion, sedimentation and soil degradation, all of which contribute to land degradation. If the land has been degraded by flooding, the productivity of the land will decrease, and the risk of crop failure will increase. Soil erosion results in the loss of nutrients that plants need, while sedimentation can cause piles of material that can inhibit plant rooting. The degradation of soil quality due to flooding also means that there is limited soil as an optimal growing medium, which will reduce the potential yield of production. Apart from that, flooding can also cause changes in land use. Land previously used for agriculture or plantations can be turned into open land or idle land. This change in land use can reduce land productivity.

The suitability criteria for flood hazards in the research area are mostly included in the FO criteria or without flood hazard, namely with an area coverage of 51696.4 Ha or with a percentage of 90%. In this condition, it is included in the land suitability class S1 (very suitable), meaning that it will not reduce productivity. land, in reality this can be a priority for plants, one of which is snake fruit, then in the condition of F2 or medium value with an area coverage of 1509.07 Ha with a percentage of 2.62% in this condition the land suitability criteria is S3 (marginal suitability) this indicates the land These factors have severe limiting factors, and these limiting factors will affect productivity. To overcome the limiting factors in S3 requires high capital, so there is a need for help or intervention from the government or the private sector. Next, a value of >F2 in this value range is included in moderate to severe flood hazard conditions with an area coverage of 4228 Ha or with a percentage of 7.36% in this condition it is included in the land suitability criteria N (not suitable) this indicates land that is not suitable (N) because it has limiting factors very severe and/or difficult to overcome.

Erosion

Soil erosion is also directly related to the assessment of land suitability for snake fruit in Sleman, especially with regard to soil quality and long-term sustainability of production (Sari et al., 2021). Erosion practices result in a decrease in soil fertility by removing topsoil rich in organic matter and vital nutrients for plants. High soil erosion rates will also reduce the soil's ability to retain water and help reduce the risk of crop drought and low land productivity. In the series of land suitability studies in Sleman, identification of eroded areas is an important first step for conservation efforts.

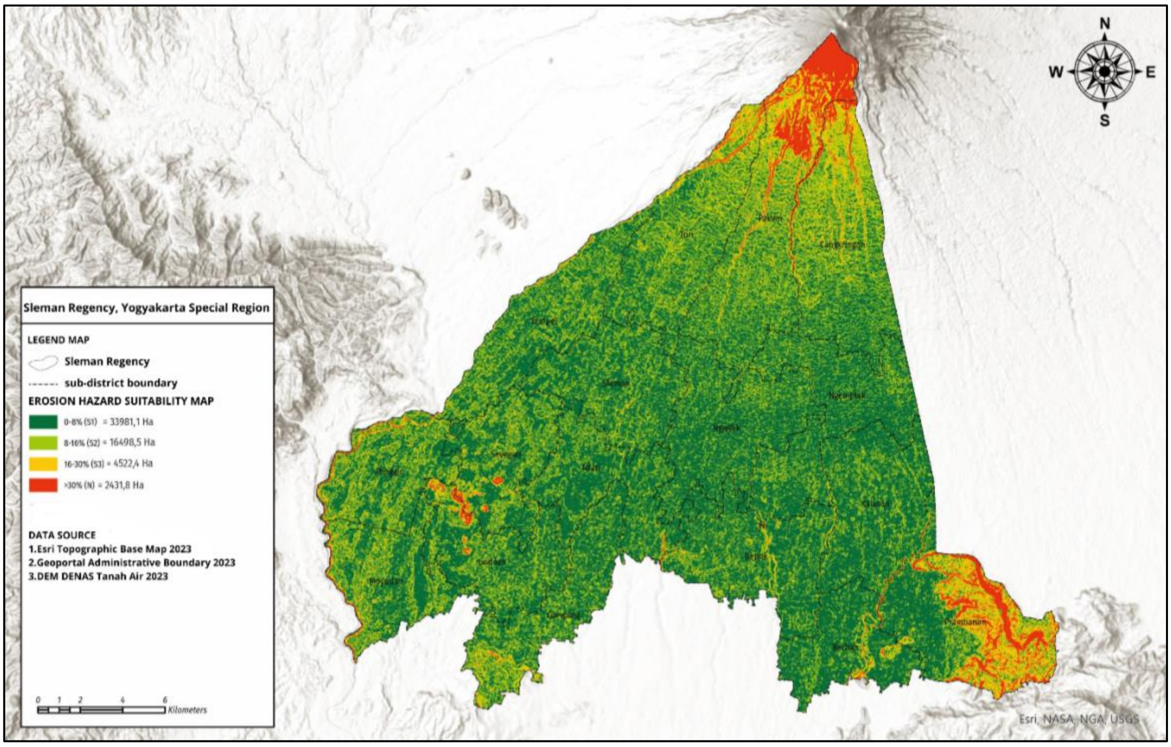

Figure 6. Land Suitability Based on Erosion Hazard
Source: Data Processing, 2023

The data displayed in Table 5 shows that land suitability related to potential erosion hazards in the study area is in the very light category, with a range of values of 0 – 8% and a coverage area of 33,981 hectares or about 59.16% of the total area. This has No. limiting factors, then in the value range of 8-16% with mild conditions and an area coverage of 16498 Ha or with a percentage of 28.72% this value falls into class S2 land suitability (quite suitable) this limiting factor will affect productivity – it requires additional input (input), in the next value range, namely 16 – 30%, which is in the medium condition.

Table 5. Suitability Criteria for Erosion Hazards in Sleman Regency

Landslide Danger	Wide	Percentage %	Suitability
0-8%	33981.10	59.16	S1
8-16%	16498.50	28.72	S2
16-30%	4522.44	7.87	S3
>30%	2431.80	4.23	N

Source: Data Processing, 2023

In this value range the area coverage is 4522 Ha or with a percentage of 7.87% with this condition being included in the land suitability class category S3 (according to marginal) this is of course a concern because to overcome the limiting factors in S3 requires high capital, the last with a value range of >30% is in severe to very severe conditions, the area coverage in this value range is 2431 Ha or with a percentage of 4.23% This indicates that this land is not suitable (N) because it has very severe limiting factors or is difficult to overcome.

Table 6. Suitability characteristics of snake fruit land

Land use requirements/characteristics	**Land suitability class**			
	S1	**S2**	**S3**	**N**
Temperature (tc)				
Average temperature (°C)	18 – 25	25 – 30 – 15 – 18	30 – 35 – 10 – 15	> 35 - < 10
Water availability (wa)				
Rainfall (mm)	1,000 – 2,000	500 – 1,000 – 2,000 – 3,000	250 – 500 – 3,000 – 4,000	< 250 > 4,000
Humidity (%)	> 42 is good	36 – 42	30 – 36	< 30
Oxygen availability (oa)				
Drainage	currently	A bit hampered	hampered, rather quickly	very slow, fast
Rooting medium (rc)				
Texture	fine, somewhat fine, medium		rather rough	rough
Coarse material (%)	< 15	15 – 35	35 – 55	> 55
Soil depth (cm)	> 100	75 – 100	50 – 75	< 50
Nutrient retention (nr)				
Clay CEC (cmol)	> 16	≤ 16		
Base saturation (%)	> 35	20 – 35	< 20	
pH H2O	5.5 – 7.8	5.0 – 5.5 – 7.8 – 8.0	< 5.0 - > 8.0	
C-organic (%)	> 1.2	0.8 – 1.2	< 0.8	
Toxicity (xc)				
Salinity (dS/m)	< 4	4 – 6	6 – 8	> 8
Sodicity (xn)				
Alkalinity/ESP (%)	< 15	15 – 20	20 – 25	> 25
Sulfic hazard (xs)				
Sulfide depth (cm)	> 125	100 – 125	60 – 100	< 60
Erosion danger (eh)				
Slope (%)	< 8	8 – 16	16 – 30	> 30
Danger of erosion	very low	low – medium	heavy	Very heavy
Flood danger (fh)				
Puddle	F0			> F0

Table 7. Suitability Characteristics of Snake Fruit Plants

Land Units	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Temperature (tc)								
Average annual temperature	22.8	20	23.8	22.3	19	21.8	21	20.8
Water availability (wa)								
Rainfall (mm year-1)	2141	2141	2141	2141	2141	2141	2141	2141
Humidity (%)	75	75	75	75	75	75	75	75
Rooting Media (rc)								
Drainage	Good	hampered	Good	A bit hampered	A bit hampered	hampered	hampered	Rather fast
Texture	currently	It's a bit subtle	It's a bit subtle	currently	Rather rough	currently	Rather rough	Rather rough
Soil depth	113	123	118	116	121	120	132	115
Nutrient retention (nr)								
Land CEC	26.11	12.78	23.88	11.92	16.4	27.16	19.78	24.88
pH	7.48	5.63	6.28	6.20	5.71	6.48	6.63	6.68
C-organic	1.02	1.55	0.91	1.58	0.62	1.02	1.55	0.91
Base Saturation	23.17	24.01	29.53	28.17	24.47	27.42	29.65	15.67
Toxicity (xc)								
Salinity (Ds/m)	2	2	1	2	1	2	3	2
Sulphidic Hazard (cm)								
Sulfide Depth (cm)	110	114	120	125	121	128	140	135
Sodicity (xn)								
Alkalinity/esp (%)	25	30	28	35	22	20	24	32
Nutrient availability (na)								
N-total	0.07	0.08	0.10	0.8	0.06	0.14	0.07	0.08
K_2O available	0.66	0.77	0.90	0.32	0.94	0.90	0.65	0.90
P_2O_5 available	2.30	2.55	2.16	3.65	2.62	1.82	1.54	2.40
Erosion danger (eh)	Light	Currently	Very light	Currently	Light	Light	currently	currently
Slope (%)	2	3	2	6	7	9	8	3

Land Suitability Based on Parameters

The results of the land suitability class assessment provide information about the use and utilization of land in accordance with plant criteria. Land suitability class assessment is an important approach in directing further research or evaluation for subsequent development efforts. Determining the land suitability class for the plant being researched or the research land characteristics required in land evaluation are matched with the land suitability criteria for snake fruit plants to obtain land suitability classes, limiting factors and improvement efforts that can be made.

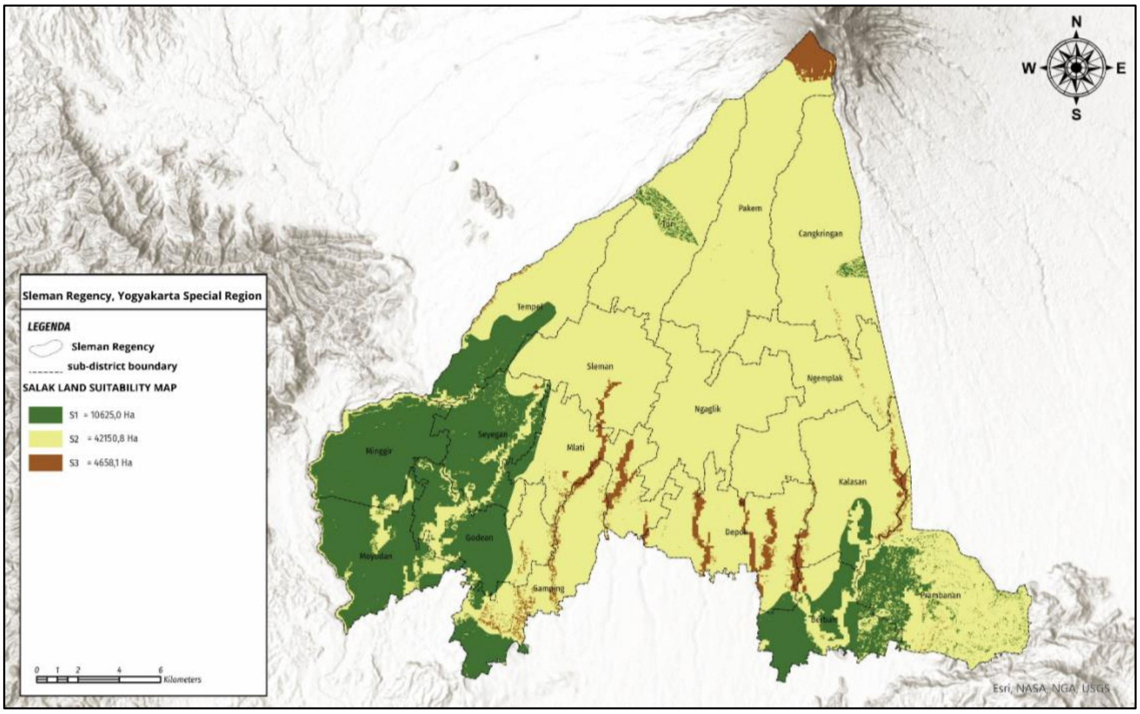

Figure 7. Land suitability based on parameters
Source: Data Processing 2023

Table 8 conveys how overlays of land suitability maps were made for each of the following parameters: soil type, rainfall, erosion hazard, flood hazard, and temperature. In the initial stage, each of these parameters was analyzed separately to determine the extent to which snake fruit requires a proportion of the land. Minimum law principle was used to generate the final land suitability classification, with the largest unweighted governing factor determining the final land suitability classification value.

Table 8. Land Suitability Based on Parameters

Suitability	Land area	Percentage
S1	10625.0	18.5
S2	42150.8	73.4
S3	4658.1	8.1

Source: Data Processing, 2023

The map was then overlaid with a land use map to obtain a suitable location for extensification of snake fruit cultivation in the research area in Sleman Regency. The results of the classification of land suitability classes in the Sleman Regency area, in this case, are that snake fruit plants in most areas fall into the criteria for land suitability class S2 or quite suitable. The results are with an area of 42,150 Ha or with a percentage of 73.4% of the land suitability class S2 or Sufficiently Suitable. (Moderately Suitable) is land that has quite heavy boundaries to maintain the level of management that must be carried out.

Barriers will reduce productivity and profits, and increase required inputs. In land suitability class S1 or very suitable in the research area with an area of 10625 Ha or with a percentage of 18.5, Very Suitable land suitability class (*Highly Suitable*) is land that does not have serious restrictions for sustainable use or only has insignificant restrictions and has No. real effect on production and does not cause an increase in inputs provided in general. In the S3 or marginal suitability class, the research area has an area of 4658 Ha or with a percentage of 8.1%, the S3 or Marginal Suitable class is land that has very heavy restrictions to maintain the level of management that must be carried out. Barriers will reduce productivity and profits need to be increased input required.

Table 9. Land Suitability and Limiting Factors

Land Unit	Land Suitability		
	Actual	**Potential**	**Limiting Factors**
SL 1	S2wanrxneh	S1	Rainfall, C-Organics, Alkalinity, Erosion Hazards
SL 2	S2waoanrxneh	S1	Rainfall, Drainage, C-Organics, Alkalinity, Erosion Hazards
SL 3	S3oaexneh	S2oa	Drainage, Alkalinity, Erosion Hazards
SL 4	S3oaxn		Drainage, Alkalinity
SL 5	S3rcxn	S2rc	Soil Depth, Alkalinity
SL 6	S3rcxneh	S2rc	Soil Depth, Alkalinity, Erosion Danger
SL 7	S3nr	S2nr	C-Organic
SL 8	S3nrxn	S2nr	C-Organic, Alkalinity
SL 9	S3nrxneh	S2nr	C-Organic, Alkalinity, Erosion Hazard
SL 10	S3nreh	S1	C-Organic, Erosion Hazard
SL 11	S3xn	S1	Alkalinity
SL 12	S3xneh	S2	Alkalinity, Erosion Hazard
SL 13	S3eh	S1	Erosion Danger

Information: *temperature (tc), water availability (wa), oxygen availability (oa), rooting media (rc), nutrient availability (nr), alkalinity (xn), erosion hazard (eh)*

Source: Data Processing 2023

Based on the results of the study referring to Table 9, there are several major limiting factors in agricultural development that can be categorized into two types: 1 permanent limiting factors or factors that are not economical to improve. Such as temperature, rainfall, dry season length, and humidity, the factors referred to are natural and beyond human control, difficult to change without high costs, or significant technological effort. Therefore, these constraints need to be taken into account in land use planning in order to remain sustainable, and in harmony with natural conditions. The above factors are key in considering the potential for land production and agricultural resilience in the study area.

This finding is in line with the opinion of previous researchers who stated that in land evaluation, elevation factors related to temperature and moisture regimes cannot be improved with current technology (Afsholnissa et al., 2019). These factors are part of the natural conditions that are fixed and cannot be changed even with the intervention of modern technology, making it a challenge to manage agricultural land. Evaluation of land suitability produces land suitability classes along with limiting factors that cause a decrease in soil fertility. Some limiting factors include temperature (tc), water availability (wa), oxygen availability (oa), rooting media (rc), nutrient availability (nr), danger of erosion (eh). There are several limiting factors which can be divided into two types, namely (1) limiting factors which are permanent or uneconomical to repair, such as temperature, rainfall, length of dry period and humidity. This is in accordance with opinion (Rayes et al., 2023) which states that in land evaluation the altitude factor which is the temperature regime, humidity cannot be improved with existing technology (2) limiting factors that can be improved and are still economically profitable by incorporating appropriate technology such as: drainage, rooting media, nutrient retention , nutrient availability, flood danger, toxicity, erosion danger. In the research area, several limiting factors on the characteristics of snake fruit plantations are rainfall, organic C, drainage, alkalinity, erosion hazard and soil depth.

In addition, this study also identified limiting factors that can be improved and still be economically profitable with the application of appropriate technologies, such as drainage, rooting medium, nutrient retention, nutrient availability, flood hazard, toxicity, and erosion hazard. This supports previous research findings which state that with appropriate technology, some land limitations can be overcome to increase agricultural productivity (Harini et al., 2015). Implementation of good drainage systems can reduce the risk of flooding, while the use of appropriate fertilizers can increase the availability and retention of nutrients in the soil, allowing for more optimal land utilization. This research confirms the importance of selecting the right technology in addressing the limiting factors that can be improved to enhance farmland sustainability and productivity.

Table 10. Land Suitability and Improvement Efforts

Land Unit	Actual	Potential	Repair Efforts
SL 1	S2wanrxneh	S1	Increased drainage, addition of organic material, planting according to contour
SL 2	S2waoanrxneh	S1	Increased drainage, addition of organic material, planting according to contour
SL 3	S3oaexneh	S2oa	Increased drainage, addition of organic material, planting according to contour
SL 4	S3oaxn	-	-
SL 5	S3rcxn	S2rc	Addition of organic materials
SL 6	S3rcxneh	S2rc	Addition of organic material, planting according to contour
SL 7	S3nr	S2nr	Addition of soil organic matter
SL 8	S3nrxn	S2nr	Addition of soil organic matter
SL 9	S3nrxneh	S2nr	Adding organic soil material, increasing drainage and planting according to contour
SL 10	S3nreh	S1	Addition of organic material, planting according to contour
SL 11	S3xn	S1	Addition of organic materials

Information: temperature (tc), water availability (wa), oxygen availability (oa), rooting media (rc), nutrient availability (nr), alkalinity (xn), erosion hazard (eh)

Based on the data in Table 10, the analysis suggests that in SL1 S2wanrxneh, the actual conditions have potential for improvement, especially the S1 land suitability class. Breakthroughs that can be made include improving drainage systems, applying organic materials, and planting patterns according to contours to make optimal land use. The C-Organic limiting factor can be improved by applying the right organic fertilizer, so that soil fertility and agricultural productivity can increase in the area. These measures are expected to provide an optimal balance in land use and sustainability of agricultural practices. And inorganic in balance. Meanwhile, slope limiting factors can be improved by means of conservation techniques, namely making terraces. At SL2 S2waoanrxneh with actual conditions, in this condition improvements can be made to 55ea t S1 in the potential condition of improvement efforts by improving drainage, adding organic material and planting snake fruit plants according to the soil contour conditions in the area. In SL3 with the actual condition of S3oaexneh, this condition can be improved by improving drainage, adding organic material and planting according to the contour.

At SL 4 S3oaxn in this condition it can be included in repair efforts by increasing drainage and adding organic material. SL 5 is in the marginal s3rcxn class category with improvements that can be made by adding organic materials. On SL6 land, efforts can be made by adding organic material and planting according to the contour. Efforts to improve the limiting factors for erosion hazards are carried out by applying conservation techniques on sloping land. As is known, the majority of farmers in the local area carry out agricultural cultivation by not cultivating sloping land so that the agricultural land is located on a high slope and has threats.

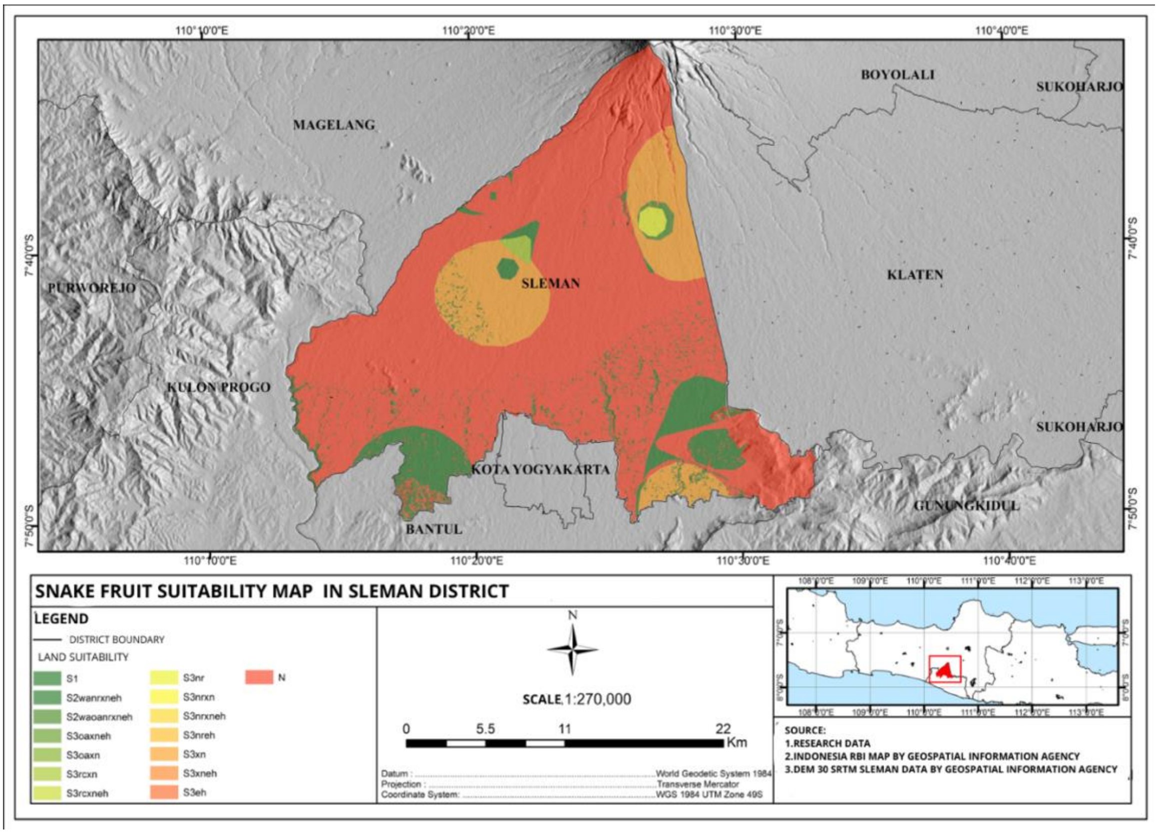

Figure 8. Map of land suitability and limiting factors
Source: Data Processing, 2023

SL7 with the actual condition of S3nr, there are improvement efforts that need to be made to reach marginally appropriate conditions, namely by improving efforts by adding organic materials. SL8 S3nrxn on this land is in the unsuitable category but needs improvement efforts to change it to marginally suitable conditions, namely by adding soil organic matter so that C-Organic is suitable. On SL8 land with actual conditions s3nrxn this condition can be changed to marginal (S20) with improvements in the addition of organic material. In SL9 with the S3nrxneh active condition, this condition can change to be in accordance with efforts to improve the addition of organic materials. Planting according to contour and increasing drainage. According to (Widiatmaka et al., 2016)The limiting factor in the form of water availability, if there is excess water, can be improved by improving the drainage system and if there is a shortage of water, it can be improved by carrying out irrigation. Excess water is channeled through drainage channels made at the edges of agricultural land.

At SL10 with the actual conditions of s3nreh this condition becomes marginally suitable if efforts are made to improve it by planting according to the contour and adding organic material to make it very suitable land (S1), SL 10 with the actual conditions of s3xn can be made to improve it by adding organic material to become land which is very suitable. The efforts made to increase organic C in the soil are by providing organic material in the form of compost and also manure by spreading it. Compost fertilizer comes from the processing of plant remains which contain many microorganisms.

CONCLUSIONS

In the results of the assessment of land suitability classes for snake fruit plants in the research area, it was found that the majority of land suitability classes for snake fruit plants fell into the S2 criteria of Moderately Suitable with a land area of 42,150.8 Ha or with an overall percentage of 73.4%. , next is the suitability of the S1 class Very Suitable (Highly Suitable) with a land area of 10625 Ha or with a percentage of 18.5%, then for the S3 class criteria Marginally Suitable with a land area of 4658.1 Ha or with a percentage of 8.1 %. In assessing the actual conditions, several limiting factors mean that the land in the research area needs improvement efforts. Several limiting factors were found such as rainfall (wa) in several areas, C-Organic conditions (nr), drainage conditions (rc), alkalinity (xn), erosion hazard (eh), flood hazard (fn) and soil depth (rc) there are factors that can be improved to meet the maximum land suitability criteria, but there are also limiting factors that cannot be improved even with high inputs such as rainfall (wa) and soil depth (rc). In the actual land conditions, the values obtained for each land unit are SL1-S2wanrxneh, SL2 S2 waoanrxneh, SL3-S3oaexneh, SL4-S3oaxn, SL5-S3rcxn, SL6-S3rcxneh, SL7-S3nr, SL8-S3nrxn, SL9-S3nrxneh, SL10- S3nreh, SL11-S3xn, SL12-S3xneh, SL13-S3eh, with conditions like that, improvement efforts can be made by improving drainage, adding organic material, planting according to the contour, and fertilizing to make potential land.

ACKNOWLEDGEMENTS

Researcher would like to express his gratitude because this research was fully funded by the Indonesian Education Scholarship (BPI), Higher Education Financing Centre (BPPT), through the Educational Financing Service Center (Puslapdik), the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, and the Management Institution Education Fund, with the following statement letter (LPDP) 1189/J5.2.3./BPI.06/10/2021.

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