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RESEARCH ARTICLE

# Rice Fields Suitability Zonation in North Penajam Paser Regency Using Multicriteria-Based Simple Additive Weighting (SAW) and GIS

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**Abstract**. The East Kalimantan Provincial Government has designated North Penajam Paser Regency as one of rice food supports for the National Capital City (IKN) of the Archipelago. This decision is based the domestic production which met and even exceeded demand in 2020. One step to support rice production is to identify land with the greatest potential for cultivation. Therefore, this study aimed to analyze land suitability zonation for rice production using the criteria of climate, topography, and soil properties, as well as infrastructure. Land suitability was evaluated using simple additive weighting (SAW), multicriteria, and GIS methods taking into account the factors of drainage, soil depth, texture, type, rainfall, temperature, slope, distance from road, distance from river, and land use land cover. Suitability zonation (classes) were arranged based on land suitability classification outlined by the Food and Agriculture Organization (FAO, 1976) in Minister of Agriculture Regulation No. 79 of 2013, namely Very Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), Not Suitable (N1). The results showed that the areas classified as highly, moderately, marginally, and not suitable were 4,960 ha (3.1%), 103,738 ha (65.5%), 44,889 ha (28.4%), and 4,708 ha (3.0 %) respectively.



## 1. Introduction

The Indonesian government is planning to relocate the national capital from Jakarta to the East Kalimantan Province. Furthermore, President Joko Widodo affirmed that the forthcoming capital city will be situated across two regencies, specifically Kutai Kertanegara and North Penajam Paser. To achieve this, several factors need to be considered, particularly regarding the readiness of the area to ensure a consistent and adequate food supply to support IKN (Nusantara Capital City) food security. Legislation number 3 of 2022 pertaining to the Indonesian Capital City (IKN) IKN stipulates that 75% of land should be used for green open spaces, with only 10% allocated for food production areas (Fahmi et al., 2023). Penajam Paser Utara District has a relatively large area of land and tropical climatic conditions that support the cultivation of paddy rice. Therefore, this district has great potential to contribute as a major food buffer area for IKN.

Rice is a national food commodity and has a strategic role in ensuring food security. Identifying suitable land for wet-rice cultivation in PPU is an important step in supporting food security in IKN. Paddy rice plants have requirements to grow optimally, including an average annual rainfall of more than 2,000 mm per year, with an even distribution during the growing season, adequate irrigation systems on flat land, and good farming infrastructure and sloping with slopes of less than 3% (Harini R et al., 2015, Fitriana et al, 2024). Various problems often faced in rice cultivation include fluctuations in rainfall, climate change, varying soil characteristics, slopes that do not support rice cultivation, as well as lack of irrigation and road infrastructure. Penajam Paser Utara District faces all of these challenges and also the conversion of agricultural land to non-agricultural land due to the development of IKN. On the other hand, spatial data used for land suitability analysis is lacking.

Several land suitability studies for paddy rice cultivation in Penajam Paser Utara District have been conducted (Fahmi et al, 2023; Sukarman, 2019). The studies focused on analyzing suitability of land for paddy rice cultivation using climate criteria, soil characteristics, and topography. However, specific studies related to wet-rice cultivation in food buffer areas such as PPU related to climate criteria, soil characteristics, topography, access to water sources, and access to roads have never been carried out. This study offers a different approach, by integrating spatial data and multi-criteria analysis based on Simple Additive Weighting (SAW) to determine the most suitable land for wet rice cultivation in Penajam Paser Utara District. It also provides policy recommendations to support land management for wet rice cultivation in the IKN food buffer area. The objective is to analyze land suitability zonation for rice field production using the criteria of climate, topography and soil properties, and infrastructure (distance from roads and distance from rivers) as well as to develop strategic recommendations for optimizing agricultural land in Penajam Paser Utara Regency to support IKN food security.

## 2. Methods

### Study Location

North Penajam Paser Regency is geographically located between 00°48'29" - 01°36'37" South Latitude and 116°19'30" - 116°56'35" East Longitude. The Regency has a total area of 3,333.06 km$^2$, comprising 3,060.82 km$^2$ of land and 272.24 km$^2$ of sea area. The sub-district with the largest land area is Penajam, covering 36.22% of the total land area. However, the sub-district with the smallest land area is Babulu, accounting for 11.99% of the total area. The Inset Location Map of the Study and the East Kalimantan Province Map is presented in Figure 1.

### *Land Suitability Evaluation*

Land suitability evaluation, as developed by FAO (1976), considers various potential limiting factors associated with climate, soil, and conditions. The Ministry of Agriculture also adopted a similar assessment method for food crops, based on FAO (1976), focusing on climate, soil, and regional conditions, which serves as a basis for land suitability evaluation in this study. The approach can be expressed as an index, offering insights into the primary factors constraining land suitability for a specific purpose in a given locality (Makungwe et al., 2021). Therefore, the primary goal of this study was to assess land suitability through a multi-criteria approach using SAW and Geographic Information Systems (GIS). Soil properties, land constraints, and specific requirements were integrated to formulate a unified index, represented cartographically as a map.

Previous studies (Makungwe et al., 2021, Adrian et al., 2022, Ayehu, 2015) and (Pertanian, 2017) have identified the main factors for evaluation. These include slope gradient, soil drainage, depth, and type, as well as annual rainfall, average growing season temperature, land use (Land Use Land Cover), distance from river, and distance from road.

### Source and Data Collection

The slope data used in this study originated from the NASA Shuttle Radar Topography Mission (SRTM30M) global 1-second arc (30m) Digital Elevation Model (DEM), obtained through USGS (2019) and accessible on the indonesiageospasial.go.id website (Makungwe et al., 2021). For annual average temperature and annual rainfall, data collected spanned from 2012 to 2022, downloaded from www.data-bmkgonline.go.id in CSV (comma-separated value) format and exported using ArcGIS 10.8.2 software with the IDW (Interpolation Distance Weighting) system. Soil maps were downloaded from the www.geoportal.penajamkab.go.id website, including soil drainage, depth, and texture. Soil-type data were obtained from the www.faosoil.org website and the river distance maps (water sources) were downloaded from www.geoportal.penajamkab.go.id. Furthermore, land cover maps for the year 2022 were downloaded from https://geoportal.penajamkab.go.id.

### Data Analysis

### Data Collection and GIS Layers Preparation

### Slope

The slope is a fundamental typographic element derived from the DEM and used in mapping land suitability for crops (Wubalem et al., 2019; Mendas et al., 2014; Pramanik, 2016; Moisa, 2023). The most commonly used source of DEM data is elevation information provided by the SRTM (Makungwe et al., 2021; Hanbali et al., 2022). For this study, a 30m spatial resolution DEM dataset was acquired from SRTM through USGS (http://earthexplorer.usgs.gov) and downloaded through https://indonesia-geospasial.go.id. Subsequently, the Spatial Analyst Toolbox in ArcGIS 10.8.2 was used to create the slope layer.

### Soil

Soil is an essential component of the ecosystem that provides nutrients to plants (Adrian et al., 2022, Makungwe et al., 2021,Ayehu, 2015). Moreover, it serves as a fundamental substrate for the cultivation of diverse crops, specifically rice. The assessment and mapping of land suitability heavily rely on the intricate physical and chemical attributes of soil (Ayehu, 2015). In this study, the parameters selected for

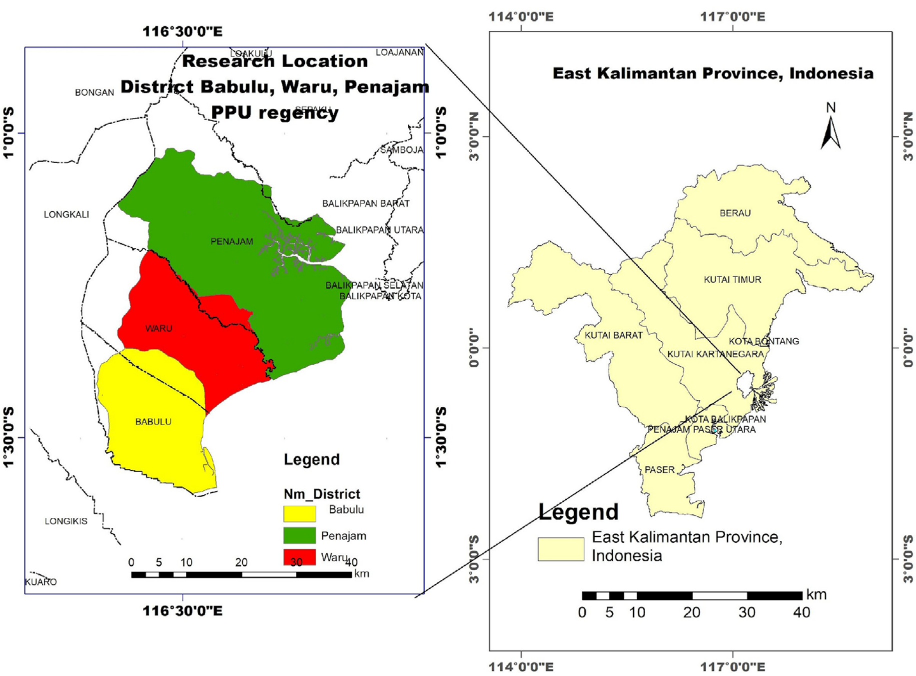


Figure 1. Inset Map of Study Location and East Kalimantan Province Map

evaluation included texture, drainage depth (Adrian et al., 2022, Makungwe et al., 2021), and type (Al-Hanbali et al., 2022). The information was obtained from digital soil maps available on the portal https://geoportal.penajamkab.go.id and www.faosoil.org, generating vector polygon layers delineating soil physical properties and types. Thematic layers for each parameter were rasterized using ArcGIS 10.8.2 software, in line with the attribute values.

### Climate Data

Climate, particularly temperature and rainfall, significantly influences the growth, development, and yields of crops, including rice (Ayehu, 2015, Al-Hanbali et al., 2022). In this study, annual rainfall and temperature were also used as climate factors. As a tropical and subtropical crop, rice grows at relatively high temperatures and high rainfall, ranging from 20°C to 40°C and 1250 mm/year to 2000 mm/year (Pertanian, 2017, Ayehu, 2015). Temperature and rainfall data for the past 10 years were obtained from the Meteorology and Geophysics Agency for the APT Pranoto, Sepinggan, Sanggu, and Kalimarau meteorological stations. These data were analyzed using the Inverse Distance Weighted (IDW) spatial interpolation method in the ArcGIS 10.8.2 platform.

### Distance Map from Roads

The road map was sourced from the official website of the Indonesian Geospatial Information Agency, namely http://tanahair.go.id, for disseminating geospatial information in Indonesia. Meanwhile, the data of distance from roads were collected as vector polylines and converted into a raster format. Spatial analysis was conducted to measure the distance using Euclidean Distance (Adrian et al., 2022), and the data obtained were reclassified according to Jamil et al., 2018.

### Distance Map from Rivers

The road and river maps were sourced from the official website of the Indonesian Geospatial Information Agency, namely http://tanahair.go.id. Information on the distance from rivers was gathered in the form of vector polylines and later transformed into raster format. Spatial analysis, through the Euclidean Distance method, was used to quantify the distances. Subsequently, the reclassification of distances from rivers was executed using the approach outlined by Pramanik (2016).

### Land Cover Map

Land cover map was downloaded from the website https://geoportal.penajamkab.go.id All data layers were converted into raster format, projected into the local coordinate system Adindan UTM 50 S, and resampled to a spatial resolution of 30 meters. Suitability levels for each criterion layer were determined based on (Pertanian, 2017, Al-Hanbali et al., 2022, Jamil et al., 2018, Pramanik, 2016, Subroto & Susetyo, 2016). Subsequently, these layers were reclassified into different suitability levels using ArcGIS 10.8.2 software as the basis for creating the maps. Suitability levels for each factor were ranked as Highly Suitable (S1), Moderately Suitable (S2), Marginally Suitable (S3), and Not Suitable (N), based on land suitability classification structure of FAO, 1976, and Ministry of Agriculture Regulation No. 79 of 2013.

### Map Standardization

The reclassified maps were standardized using the SAW method, which entails determining the weighted sum of performance ratings for each alternative across various attributes. This method requires normalizing decision matrices ($x$) for comparison with alternative ratings (Wulandari et al., 2022). Furthermore, it requires decision-makers to determine weights for each attribute (Simanaviciene & Ustinovichius, 2010). The calculation adheres to this method when the selected alternative fulfills the predetermined criteria (Pratiwi et al., 2019).

The steps using SAW method are shown below (Wulandari et al., 2022):

1. Determine the criteria and sub-criteria to be used as references in decision-making $Ci$.
2. Assign weight values to each criterion as W using the direct method. The weight value is determined by the decision maker. All criteria are weighted with the same value. Given that the desired weighting is balanced in this study, the direct method was used. The same weight value of 100% was used with the number of parameters 10, hence, each parameter has a weight of 10%. Provide suitability ratings for each alternative in individual criteria.
3. Create a decision matrix based on criteria.
4. Normalize the matrix based on the equation adjusted to the type of attribute (benefit or cost attribute). Benefit attributes are used when the highest value is the best, and cost attributes when the lowest value is the best.

   When j is a benefit attribute, the formula can be written as Eq. (1).

$$r_{ij} = \frac{x_{ij}}{Max_i x_{ij}} \quad \text{.......(1)}$$

   When j is a cost attribute, the formula can be written as Eq. (2).

$$r_{ij} = 1 - \frac{Min_i x_{ij}}{x_{ij}} \quad \text{.......(2)}$$

where $r_{ij}$ represents the evaluative measure adjusted to a standard scale for comparative analysis, $X_{ij}$ represents the attribute value associated with each criterion.", $Max_{ij}$ and $Min_{ij}$ are the maximum and minimum values for each row and column respectively. The conclusive outcome is derived through a ranking process, in which the normalized matrix R undergoes summation and multiplication with a weight vector. The alternative ($Ai$) that attains the highest value is selected as the optimal solution. The preference value formula can be written as Eq. (3).

$$v_i = \sum_{j=1}^{n} W_j R_{ij} \quad \text{.......(3)}$$

Where $V_i$ is the final value of the alternative, $W_j$ is the weight value of each criterion, and $R_{ij}$ represents the normalized performance rating.

### Weighted Overlay Analysis

The raster files were reclassified and the influence weights for each considered criterion were assigned. Subsequently, a weighted overlay analysis was performed in ArcGIS 10.8.2

Table 1. Parameter and Land Suitability Scores

| Parameter | Value | Class | Score | Source |
|---|---|---|---|---|
| Slope (%) | <3 | S1 | 4 | Ministry of Agriculture Regulation No. 79 of 2013 |
| | 3-8 | S2 | 3 | |
| | 8-30 | S3 | 2 | |
| | >30 | N | 1 | |
| Rainfall (mm/tahun) | >2000 | S1 | 4 | Susetyo and Sudibyo, 2012 |
| | 1500-2000 | S2 | 3 | |
| | 1000-1500 | S3 | 2 | |
| | <1000 | N | 1 | |
| Average Temperature (°C) | 24-29 | S1 | 4 | Ministry of Agriculture Regulation No. 79 of 2013 |
| | 22-24 | S2 | 3 | |
| | 18-22 | S3 | 2 | |
| | <18 | N | 1 | |
| Drainage | Slightly Hindered, Moderate | S1 | 4 | Ministry of Agriculture Regulation No. 79 of 2013 |
| | Hindered, Good | S2 | 3 | |
| | Very Hindered, Slightly Fast | S3 | 2 | |
| | Fast | N | 1 | |
| Texture | Fine, Slightly Fine | S1 | 4 | Ministry of Agriculture Regulation No. 79 of 2013 |
| | Moderate | S2 | 3 | |
| | Slightly Coarse | S3 | 2 | |
| | Coarse | N | 1 | |
| Depth | >50 | S1 | 4 | Ministry of Agriculture Regulation No. 79 of 2013 |
| | 40-50 | S2 | 3 | |
| | 25-40 | S3 | 2 | |
| | <25 | N | 1 | |
| Soil Type | Cambisol, Fluvisol, Luvisol, Vertisol | S1 | 4 | Hanbali, et al. (2022) |
| | Gleysol, Chernozems | S2 | 3 | |
| | Acrisols, Planosol, Arenosols | S3 | 2 | |
| | Leptosols, Regosols | N | 1 | |
| Distance from Roads (m) | 0-1000 | S1 | 4 | Jamil, et al., 2018 |
| | 1000-2000 | S2 | 3 | |
| | 2000-4000 | S3 | 2 | |
| | >4000 | N | 1 | |
| Distance from Rivers (m) | 0-500 | S1 | 4 | Pramanik et al., 2016 |
| | 500-1000 | S2 | 3 | |
| | 1000-2000 | S3 | 2 | |
| | | N | | |
| | >2000 | | 1 | |

for the reclassified raster files pertaining to each parameter. The overlay entailed the use of the weighted sum tool, amalgamating multiple raster files by multiplying cell values in each raster with respective influence weights. The subsequent step entailed summing the results to generate a consolidated output map (Makungwe et al., 2021).

## 3. Result and Discussion

### Annual Rainfall

The representation in Figure (2 (a)) shows the geographical distribution of annual rainfall in the study area. Based on the results, the overall rainfall levels always exceed 2000 mm per year, giving it a rating of 4. This high suitability designation stems from the critical need for sufficient water resources in rice cultivation, thereby justifying the increased score given. Table 1 shows the Parameter and Land Suitability Scores.

### Temperature

Figure 2 (b) shows the study area temperature distribution, with an annual average of 27°C based on BMKG data. The minimum and maximum temperature was 24°C and 29°C respectively. A temperature of 27$^0$C is classified as high suitability for growing rice fields according to (FAO, 1976, Ministry of Agriculture Regulation No. 79 of 2013). The entire study area had an annual average temperature of > 24$^o$C and was given a score of 4.

### Type of soil

Soil types in North Penajam Paser Regency consist of Fluvisols and Acrisols (Figure 2 (c)). Fluvisol soil has physical and chemical properties suitable for plant growth. This is due to the good drainage and a high nutrient content. This soil type can be found on flat topography periodically flooded and spreads over 43.9% of North Penajam Paser Regency, accounting for an area of 43.9%. Meanwhile, the Acrisol soil type with an area of 89888.5 accounted for 56.1% of the total area. This soil type is a layer that is rich in clay and located in a humid tropical climate. The low fertility and the amount of toxic aluminum pose limitations in agricultural use. It is typically used for silviculture, low-intensity pastures, and protected areas. Plants that can be cultivated are rubber trees, oil palm, coffee, and sugar cane (Hanbali, 2022). The Fluvisols soil type was given a score of 3 and the Acrisols had a score of 1.

### Soil Drainage

Figure (2 (d) ) shows that somewhat poorly drained soil is considered very suitable for cultivating rice fields, but only 1% of the total area in the study area of 3,323 ha is given a score of 4. Moderately drained, well-drained, and poorly drained soils are quite suitable for cultivating lowland rice, accounting for approximately 93.3% of the entire area and given a score of 3. Soil with very poorly drained drainage is quite suitable for cultivating rice covering an area of 0.6% or 1,654 ha and given a score of 2. Meanwhile, land with inappropriate drainage covering an area of 12,077 ha, or 4% of the entire study area was given a score of 1.

### Soil Texture

The study area (Figure 2 (e)) is characterized as slightly coarse, moderate, slightly fine, fine, and coarse. Moderate/medium, slightly fine, and fine soil is a suitable texture for the growth of rice plants. The coarse texture is not suitable for rice cultivation but only accounted for 0.8% of the entire study area (2,315 ha).

### Soil depth

Figure (2 (f)) shows soil depth, a critical factor for plant rooting. Shallow soil hampers water and nutrient accessibility, reducing land productivity. Soil depth also determines plant suitability and influences water and nutrient retention, with deeper soil having superior storage capacity compared to shallow soil (Hanbali, 2022). The depth of the soil in the study area comprised very deep covering an area of 140952 ha, accounting for 84.2% of the total area and given a score of 4. The deep soil category covered an area of 24,441ha accounting for around 14.6% of the total area and given a score of 3. Meanwhile, the slightly deep area covered 2049 ha accounting for 1.2% of the total area and given a score of 2.

### Slope

Soil slope was classified into four classes, namely 0-3%, 3-8%, 8-30%, and more than 30% ( Figure 2 (g)). Lowlands are the preferred environment for rice cultivation in North Penajam Paser Regency, hence, a slope of 0-3% was given a score of 4, while a score of 1 was given to >30%.

### Distance from Road

The proximity of rice fields to roads facilitates the convenient transport of harvests, as reported by Adrian et al. (2022). Figure (2 (h)) is an image of the distance from the road. The distance from the road 0-1000 m, covering an area of 161,579 ha and accounting for 96.5% of the total area was given a score of 4. The 1000-2000 m distance category covered an area of 47259.1 ha accounting for 28.2% of the total area and was given a score of 3. Meanwhile, the 1000-2000 m class covering an area of 30,722.6 or 18.3% of the total area was given a score of 2. The distance from the road > 2000 m covering an area of 5039.29 ha or 3.0% of the total study area was given a score of 4.

### Distance from River

Distance from the river is one of the important parameters in rice cultivation, showing the area of land close to a water source (permanently flowing river). The farther the distance from a water source, the lower the accessibility, and the higher the operational costs. Therefore, a location close to a water source (permanently flowing river) is preferred for rice cultivation (Wubalem, 2023). The distance from the river is between 0 and 500 m. Approximately 50.4 % (84,509.8 ha) of land was highly suitable for rice cultivation, 28.2 % (47,259.1 ha) of land was moderately suitable, 18.3 % (30,722.6 ha) was marginally suitable, and only 3.0 % (5,036 ha) ) was not suitable (Figure 2 (i).

### Land use/cover

Land use/cover map consists of ten classes, namely, shrubland, swamp shrubland, secondary dryland forest, secondary mangrove forest, secondary swamp forest, tree plantation, settlement, plantation, mining, dryland agriculture, mixed dryland agriculture, rice fields, fish ponds, bare lands, and transmigration (Figure 3). Land classified as swamp shrubland, secondary dryland forest, secondary mangrove forest, secondary swamp forest, tree plantation, settlement, mining, fish pond, and transmigration were given a score of at least 1 in the not-suitable category. Plantation land is marginally suitable and given a score of 2, while shrubland classified as moderately suitable was given a score of 3. Dryland agricultural land, mixed dryland agriculture, and rice fields were classified as very suitable and given a score of 4.

### Suitability Map

The area with moderate suitability was 4960 ha, accounting for 3.1% of the total area. In Penajam Paser Utara district, areas with high suitability for paddy rice cultivation are characterized by slope <3%, rainfall >2000 mm, temperature 24-29oC, soil drainage slightly hindered, moderate, soil texture fine, slightly fine, soil depth >50 cm, soil type fluvisol, distance from road 0-1000 m and distance from river 0-500 m. Abundant water availability and ease of irrigation water are crucial factors for intensive rice cultivation. Penajam Paser Utara Regency has 58 rivers as sources of irrigation water. The government should prioritize the development of technical and non-technical irrigation. The use of small rivers in Babulu sub-district for irrigation of agricultural land is considered to be suboptimal. Therefore, there is a need for additional sluice gates to maximize the use of small rivers for the irrigation of rice fields.

Based on the results, it is necessary to establish a farmer-owned irrigation system for paddy rice. Modern water management technologies such as automatic irrigation or sensor-based irrigation systems are important to ensure proper water distribution over the entire paddy field area. The irrigation automation recommendation is an automatic control system of an Arduino Uno microcontroller that allows farmers to open and close irrigation gates automatically (Fauziah et al., 2024). The proximity of land to the river makes it susceptible to flooding during the rainy season. Therefore,

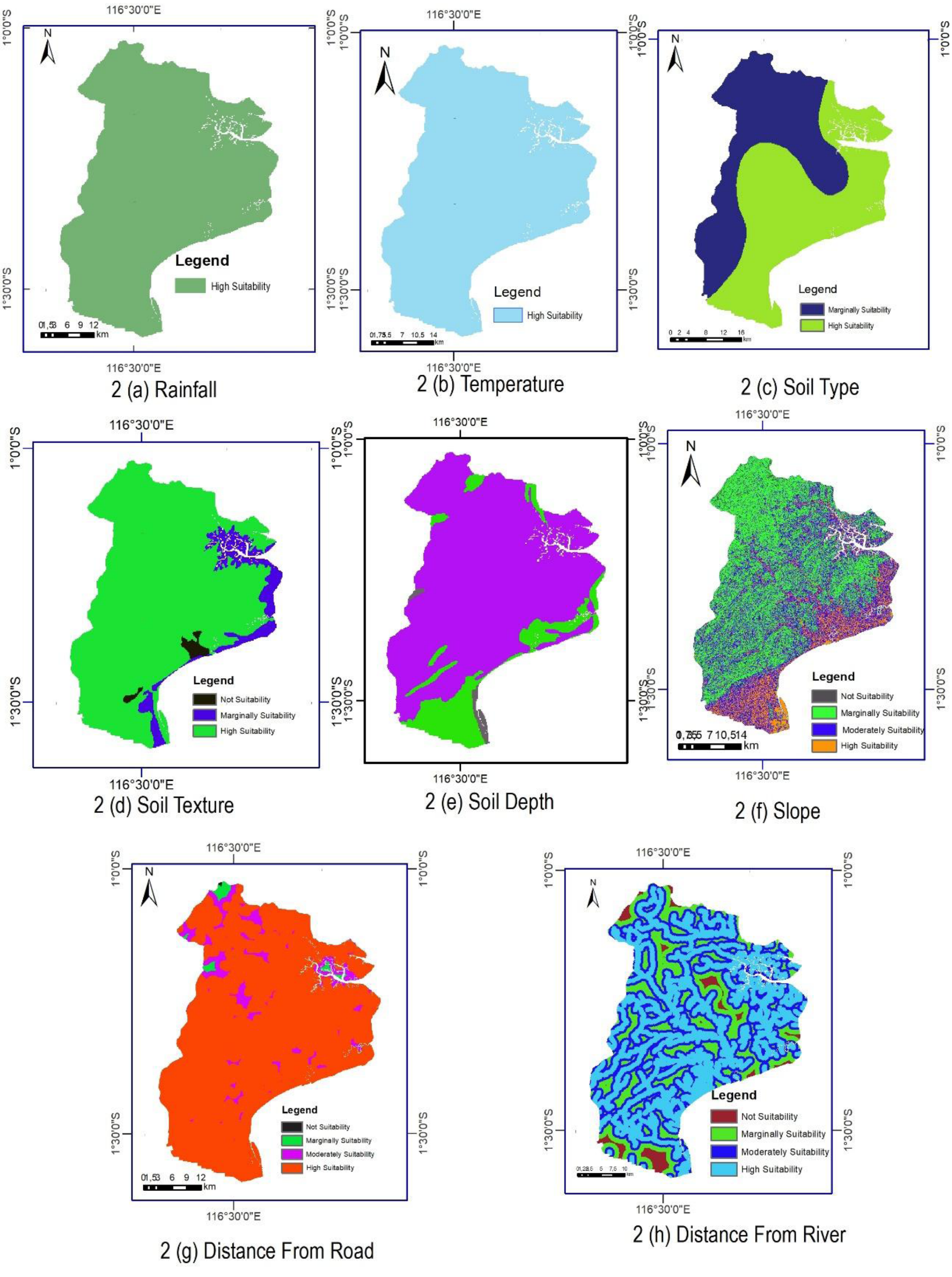


Figure 2. Maps Used in Land Suitability Evaluation

there is a need to construct canals for drainage during floods. Planting erosion control vegetation along the river banks can help prevent continued erosion (Muta'ali, 2012).

Land with moderate suitability class of 103708 ha (65.5%) was characterized by slope 3-8%, rainfall > 2000 mm, temperature 24-29oC, drainage hindered, moderate texture, depth 40-50 cm, fluvisol type, distance from road 1000-2000 m, and distance from river 500-1000 m. Land with a slope of 3-8% can be considered suitable for paddy cultivation. However, irrigation canals, erosion control, and drainage management are needed. Terraces and good maintenance of irrigation systems are key to maintaining productivity (Mutaali, 2012). Proper management is required because water flows faster from the soil surface. The results also showed that land 500-1000 m from the river had good water availability, but not as optimal compared to 0-500 m because river water cannot flow directly to land. Land is at risk of waterlogging and requires poorly designed drainage systems.

Governments and farmers need to regularly inspect and maintain irrigation infrastructure to keep it in good condition and functioning optimally (Widiatmaka et al., 2014). Appropriate fertilization with organic and inorganic fertilizers

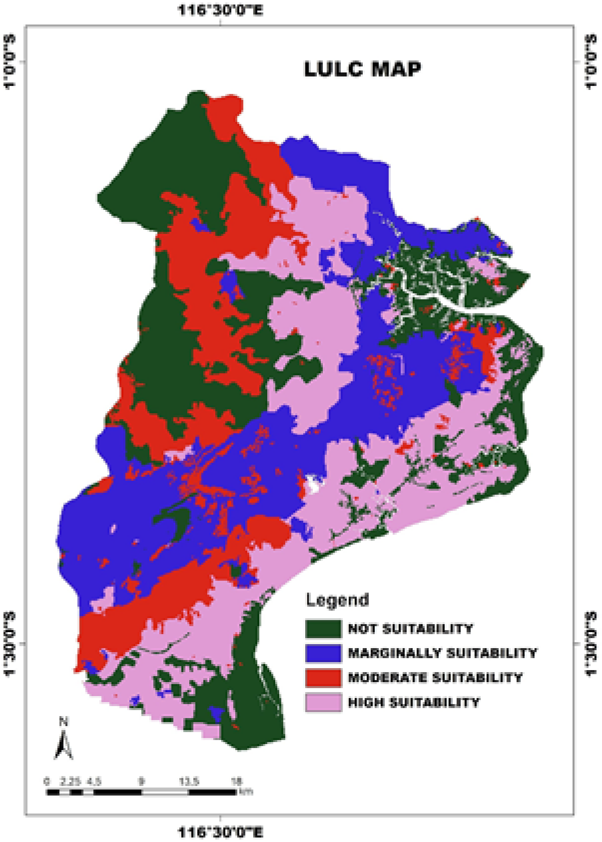

Figure 3. Land Use Land Cover

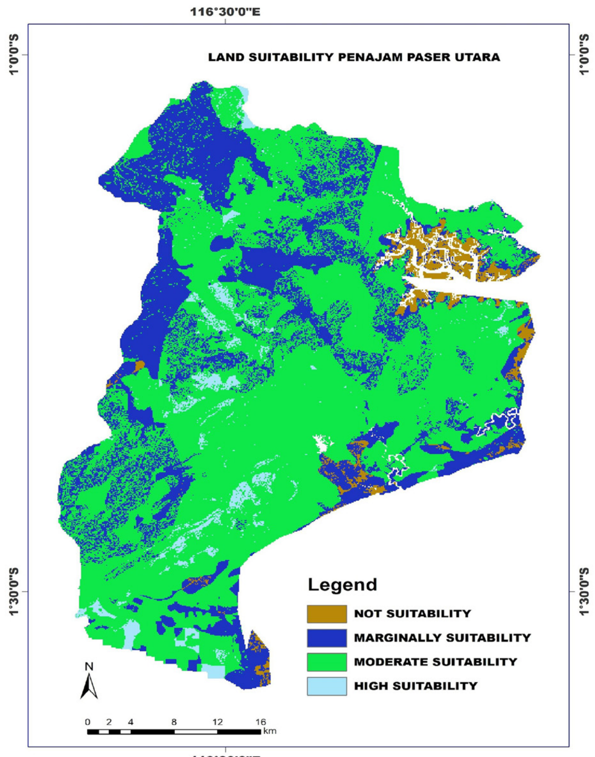

Figure 4. Land Suitability in North Penajam Paser Regency

can improve soil quality. Studies have shown that applying organic fertilizers along with inorganic fertilizers can reduce nitrogen demand while increasing rice yields in paddy fields (Li et al., 2016). Crop rotation techniques also help maintain soil fertility in field (Supriatin, 2018). Furthermore, construction, maintenance, and repair of roads are important to ensure smooth access for the transportation of agricultural products. There is a need to establish farmer group collaboration with transport service providers to transport large quantities of crops. Good agricultural road infrastructure is very important for ease of transportation.

Marginally suitable land (S3) covering an area of 44,849 ha (28.4%) was characterized by slope 8-30%, rainfall > 2000 mm, temperature 24-29oC, drainage very hindered, slightly fast, soil drainage, slightly coarse, soil depth 25-40 cm, Acrisol, distance from road 2000-4000 m, and distance from river 1000-

Table 4. Land suitability area for rice cultivation in North Penajam Paser Regency

| Suitability Class | Area ($km^2$) | Area (Ha) | Area (%) |
|---|---|---|---|
| Highly Suitability | 50 | 4.960 | 3,1 |
| Moderately Suitability | 1037 | 103.738 | 65,5 |
| Marginally Suitability | 449 | 44.889 | 28,4 |
| Not Suitability | 50 | 4.708 | 3,0 |

2000 m. Land with a slope of 8-30% poses great challenges for paddy cultivation but can still be used with the application of appropriate conservation techniques. According to a previous study, terraced rice fields can significantly increase water productivity and crop yields compared to non-terraced rice fields, specifically in water-scarce areas (Hossain et al., 2013).

Acrisol soils have limitations such as high acidity, low organic matter, and erosion risk. The use of organic fertilizers can increase soil organic matter content and improve air-holding capacity and soil fertility (Maroneze et al., 2014). The high acidity of Acrisol may be reduced by adding lime (dolomite or calcite), which helps raise soil pH to a level that supports plant growth. Kusnadi et al. (2022) showed that dolomitic lime not only increased soil pH, but also contributed to increased crop yields (Kusnadi et al., 2022). The long distance from the river affects the distribution of water to land. The policy implication is to use water pumps to bring water from the river to the farm. The government can plan to build embankments to store water during the rainy season for use in the planting season.

Land with suitability class N1 (unsuitable) covered 3% of the entire study area, characterized by slope >30%, rainfall >2000 mm, temperature 24-29oC, fast drainage, coarse texture, soil depth <25 cm, fluvisol soil type, distance from road >4000 m, and distance from river >2000 m. Land unsuitable for agriculture includes areas under dense vegetation, settlements, barren land, and open rocks.

## 4. Conclusion

In conclusion, land suitability for rice farming was assessed by considering several criteria using the GIS-based SAW method. This study was carried out in North Penajam Paser Regency as a food buffer zone for IKN rice. The results showed that 4,960 ha of the total area was very suitable for use as rice farming land based on factors of drainage, texture, soil depth, soil type, rainfall, temperature, slope, distance from road, distance from river, and land cover. Applying SAW with GIS effectively assessed current land resources, aiding decision-makers in planning rice cultivation development.

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