

# Analysis of Land Suitability for Sustainable Agriculture as an Effort to Improve Food Security in Semarang City

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## Abstract

Based on the performance of program indicators against the 2023 RKPD targets and the final targets of the Semarang City RPJMD (2021-2026) in the field of agriculture, challenges in agricultural activities are evident, such as a lack of supporting agricultural infrastructure, limited marketing of production, low institutional quality of farmers (6.7%), and the increasing narrowing of agricultural land due to the increase in built-up land. Facing the final challenge of converting agricultural land to non-agricultural use, through the Semarang City Regulation on Amendments to Regulation Number 14 of 2011 concerning the Spatial Plan (2011-2031), the Sustainable Food Agriculture Zone (KP2B) with an area of 2,602 hectares, consisting of Sustainable Food Agricultural Land (LP2B) with an area of approximately 1,633 hectares and Sustainable Food Agricultural Reserve Land (LCP2B) with an area of approximately 969 hectares spread across 7 districts in Semarang City. The research problem-solving approach was carried out by analyzing the suitability of KP2B and LCP2B land, both KP2B and LCP2B land in spatial aspects in the form of agricultural land suitability for KP2B designation as stipulated by the 2021 Semarang City RDTR and geophysical land suitability based on land units with reference to the Technical Guidelines for Land Suitability Assessment for Strategic Agricultural Commodities for food agricultural commodities. Research data collection was carried out using a grid system with 5 points which were then composited for laboratory testing. In addition, direct measurements of soil pH and temperature were also carried out. The results of laboratory tests and field parameter measurements showed that the suitability level of Teger land was classified as fairly suitable for corn cultivation, where there were inhibiting factors such as low total N content ( $>0.2\%$  for S1), critical  $P_2O_5$  that did not meet the requirements for corn cultivation (0.81–1.19 ppm), and low C -Organic content (0.81–1.19%). Furthermore, the suitability level of Salakan agricultural land is quite suitable for rice cultivation, with critical limiting factors in the form of very low C-Organic (0.087–0.17%) and low to very low available K (1.31–8.69 ppm).

**Keyword:** Land suitability, Sustainable agriculture, Food security

## 1. Introduction

The city of Semarang, as the capital of Central Java Province, is experiencing pressure due to urbanization, which has led to increased population activity within the city. Over the past 10 years, the population has increased by 8% (sutriani et al., 2022). The increase in population and other anthropogenic activities has led to an increase in food demand and land use, resulting in the conversion of agricultural land into residential areas (Azadi et al., 2021). Increased pressure on population activities has led to the conversion of agricultural land into non-agricultural land (Fahad et al., 2024)(Zhang et al., 2025). Based on the Performance of Program Indicators Against the 2023 RKPD Targets and the 2021-2026 RPJMD Final Targets for Agriculture, the challenges in agricultural activities in Semarang include a) lack of agricultural infrastructure, b) the El Niño climate phenomenon which has impacted crop yields, c) The urban agricultural marketing chain has not been established, so that commodity yields cannot be marketed optimally, d) Lower quality of farmer institutions, with 6.7% of the total 432 groups classified as intermediate and primary, d) Conversion of agricultural land to non-agricultural use, e) Decline in soil quality due to intensive use of chemicals (Prabhakar, 2021)(Fang et al., 2024).

Agricultural activities in Semarang City are divided into two categories: urban farming, which utilizes limited land around residential areas, and conventional farming, which is carried out by farmers who are members of farmer groups or individuals utilizing land on the outskirts of Semarang City (Handayani et al., 2018)(Pradana, 2023). Facing the challenge of agricultural land being converted to non-agricultural use, through the Semarang City Regional Regulation on Amendments to Regional Regulation No. 14 of 2011 concerning the 2011-2031 Semarang City Spatial Plan, the city has established a Sustainable Food Agriculture Area (KP2B) with an area of approximately 2602 hectares, consisting of Sustainable Food Agricultural Land (LP2B) with an area of approximately 1,633 hectares and Sustainable Food Agricultural Reserve Land (LCP2B) with an area of approximately 969 hectares spread across 7 districts in Semarang City (Semarang, 2021). Mijen District is one of the areas with the highest conversion of agricultural land to non-agricultural use in Semarang City over the past 20 years (Mubarok et al., 2022). The

purpose of establishing Sustainable Food Agricultural Areas (KP2B) is to support food security by protecting agricultural areas from the threat of land conversion to non-agricultural activities (Mubarok et al., 2022). Thus, agricultural activities on KP2B land can be guaranteed to be sustainable because they are protected by spatial planning regulations. Furthermore, the management of KP2B land faces challenges in the form of low farmer capacity, as indicated by the level of farmer groups and the determination of food crop commodities in accordance with land suitability (Zuliastuti & Wibisono, 2022).

A problem-solving approach was used to analyze the suitability of KP2B land, both KP2B and LCP2B land in spatial aspects, namely the suitability of agricultural land for the KP2B designation as stipulated by the 2021 Semarang City RDTR and the suitability of geophysical land based on land units with reference to the Technical Guidelines for Land Suitability Assessment for Strategic Agricultural Commodities for food crops that have been cultivated by farmers (Astuti, 2019). This research forms the basis for determining the partner areas of the Semarang State University to support food self-sufficiency and the circular economy in Semarang City through the preparation of a strategic plan (Kariada et al., 2024)(Widianarko et al., 2025). This is based on the principles of the tri dharma of higher education, especially the aspect of research, which is then continued with community service activities. The urgency of this research is motivated by the lack of information on land suitability, both spatially in terms of land use and geophysically based on land units, as well as its relationship with the agricultural commodities cultivated by farmers. The results of land suitability assessments provide information about land potential and suitability, constraints on land use, and improvement efforts needed to optimize the land (Navidi et al., 2022)(Bilas et al., 2022).

## 2. Method

### 2.1 Desain Penelitian

This research was conducted using mixed methods, combining qualitative and quantitative methods to obtain complete, reliable, and comprehensive data. The data required was primary and secondary data. Primary data was obtained through observation and interviews,

while secondary data was obtained through literature, both academic papers and publications from relevant government agencies, one of which was the Semarang City Spatial Plan. The objects or targets of this study were farmer groups managing KP2B in Mijen and Gunungpati subdistricts, the village government, and field assistants from the agricultural office.

### 2.2 Data Collection Techniques

The data required for this study consists of

primary and secondary data. Primary data was collected through field observations and interviews with land managers and local government officials. Secondary data was collected through a literature review of various relevant documents from various government agencies and by using a map of Semarang City's spatial patterns as a reference for KP2B land. The data requirements for this study are shown in the following table.

**Table 1. Research Data Requirements**

| Aspect   | Data Details *)                                     | Data Source   |
|--|---|---|
| Land suitability based on land units               | Soil temperature                                    | Field measurement   |
|  | Water availability land                             | Field measurement   |
|  | Rooting medium                                      | Field measurement   |
|  | Peat (Soil conditions)                              | Land map of Semarang City   |
|  | Nutrient retention                                  | Laboratory test   |
|  | Hara is available                                   | Laboratory test   |
|  | The danger of erosion                               | Field measurement   |
|  | Genangan  | Field measurement   |
|  | Flooding  | Interview   |
| Spatial-based land suitability                     | Detailed Spatial Plan Map Semarang City             | Semarang City Spatial Planning Agency   |
| Potential of agricultural land for food production | Types of food commodities                           | Farmer groups, Field assistants from the Department of Agriculture and Local government |
|  | Crop productivity                                   |   |
|  | Land cultivation methods                            |   |
|  | Farmer group institutions                           |   |
|  | Agricultural infrastructure                         |   |
|  | Farmers' access to agricultural development support |   |
|  | Pests/challenges in agricultural activities         |   |
|  | Distribution of harvest yields                      |   |

Source: Literature study, 2025

### 2.3 Teknik Analisis Data

Analisis data penelitian dilakukan untuk menentukan kesesuaian lahan dilakukan dengan

kombinasi kesesuaian lahan berbasis peruntukan rencana detail tata ruang dan berbasis unit lahan.

**Table 2. Evaluation of the Suitability of Irrigated Rice Field Agricultural Land**

| Land Requirements/Characteristics        | Use | Land Suitability Class         |                        |                                 |        |
|--|-----|--------------------------------|------------------------|---------------------------------|--------|
|  |     | S1                             | S2                     | S3                              | N      |
| <b>Temperature (tc)</b>                  |     |                                |                        |                                 |        |
| Average temperature                      |     | 25 - 28                        | >28 – 30               | 30 - 33                         | 33     |
| Annual (°C)                              |     |                                | 23 - <25               | 21 - <23                        | <21    |
| <b>Water availability (wa)</b>           |     |                                |                        |                                 |        |
| Number of wet month (>200 mm/month)      |     | 6-8                            | 4 - <6                 | 2 - <4<br>>8 - 10               | <2 >10 |
| <b>Rooting medium (rc)</b>               |     |                                |                        |                                 |        |
| Drainage                                 |     | Hindered,<br>Somewhat hindered | Somewhat good          | Very slow,<br>Good, Fairly fast | Fast   |
| Texture                                  |     | Smooth,<br>Somewhat smooth     | Currently              | A bit rough                     | Rough  |
| Rough material (%)                       |     | <3                             | 3 - 15                 | 15 - 35                         | >35    |
| Soil depth (cm)                          |     | >50                            | 40 - 50                | 25 - 40                         | <25    |
| <b>Peat</b>                              |     |                                |                        |                                 |        |
| Thickness (cm)                           |     | <50                            | 50 - 100               | 100 - 150                       | >150   |
| Maturity                                 |     | Saprik                         | Saprik,<br>Hemik       | Hemik                           | Fibrik |
| <b>Nutrient retention (nr)</b>           |     |                                |                        |                                 |        |
| Soil KTK (cmol/kg)                       |     | >16                            | 5 - 16                 | <5                              | -      |
| Base saturation (%)                      |     | >50                            | 35 -50                 | <35                             | -      |
| pH H <sub>2</sub> O                      |     | 5,5 – 7,0                      | 4,5 – 5,5<br>7,0 – 8,0 | <4,5<br>>8,0                    | -      |
| C-organic (%)                            |     | >1,2                           | 0,8 – 1,2              | <0,8                            | -      |
| <b>Hara is available (na)</b>            |     |                                |                        |                                 |        |
| N total (%)                              |     | Currently                      | Low                    | Very low                        | -      |
| P <sub>2</sub> O <sub>5</sub> (mg/100 g) |     | Height                         | Currently              | Low – very                      | -      |

| Land Requirements/Characteristics  | Land Suitability Class |                                  |                              |                   |
|--|------------------------|----------------------------------|------------------------------|-------------------|
|  | S1                     | S2                               | S3                           | N                 |
|  |                        |                                  | low                          |                   |
| K <sub>2</sub> O (mg/100 g)  | Currently              | Low                              | Very low                     | -                 |
| <b>Bahaya erosi (eb)</b>   |                        |                                  |                              |                   |
| Lereng (%)   | <3                     | 3 - 5                            | 5 - 8                        | >8                |
| Bahaya erosi   |                        | Very light                       | Lightweight                  | Moderate to heavy |
| <b>The danger of flooding/waterlogging during the planting season (fh)</b> |                        |                                  |                              |                   |
| Height (cm)  | 25                     | 25 -50                           | 50 - 75                      | >75               |
| Long (day)   | <1                     | 1 - <7                           | 7 - 14                       | >14               |
| <b>Land preparation (lp)</b>   |                        |                                  |                              |                   |
| Surface rocks (%)  | <5                     | 5 - 15                           | 15 - 40                      | >40               |
| Rock outcrop (%)   | <5                     | 5 - 15                           | 15 -25                       | >25               |
| <b>Temperature (tc)</b>  |                        |                                  |                              |                   |
| Average temperature  | 23 - 25                | >25 - 28                         | >28 - 32                     | >32               |
| Annual (°C)  |                        | 20 - <23                         | 18 - <20                     | <18               |
| <b>Water availability (wa)</b>   |                        |                                  |                              |                   |
| Annual rainfall (mm/year)  | 1.200 – 1.500          | 1.000 - <1.200<br>>1.500 - 1.900 | 800 - <1.000<br>>1.900-2.300 | <800 - >2.300     |
| Number of wet months (>200mm/month)  | 2 - 4                  | >4 – 6                           | >6 <2                        | -<br>-            |
| <b>Oxygen availability (na)</b>  |                        |                                  |                              |                   |
| Drainage   | Good, Fairly good      | A bit fast, A bit slow           | Hindered                     | Very slow, Slow   |
| <b>Rooting medium (rc)</b>   |                        |                                  |                              |                   |
| Texture  | Smooth, Somewhat       | Smooth, Somewhat                 | A bit rough                  | Rough             |

| Land Requirements/Characteristics        | Use | Land Suitability Class |                       |                  |                    |
|--|-----|------------------------|-----------------------|------------------|--------------------|
|  |     | S1                     | S2                    | S3               | N                  |
|  |     | smooth,<br>Moderate    | smooth,<br>Medium     |                  |                    |
| Rough material (%)                       |     | <15                    | 15 - 35               | 35 - 55          | >55                |
| Soil depth (cm)                          |     | >50                    | 30 - 50               | 20 - 30          | <20                |
| <b>Gambut</b>                            |     |                        |                       |                  |                    |
| Thickness (cm)                           |     | <50                    | 50 - 100              | 100 - 150        | >150               |
| Maturity                                 |     | Saprik                 | Saprik,<br>Hemik      | Hemik            | Fibrik             |
| <b>Nutrient retention (nr)</b>           |     |                        |                       |                  |                    |
| Soil KTK (cmol/kg)                       |     | >16                    | 5 - 16                | <5               | -                  |
| Base saturation (%)                      |     | >35                    | 20 - 35               | <20              | -                  |
| pH H <sub>2</sub> O                      |     | 5,5 – 7,5              | 5.0 -5.5<br>7,5 – 8,0 | <50<br>>8,0      | -                  |
| C-organic (%)                            |     | >1,2                   | 0,8 – 1,2             | <0,8             | -                  |
| <b>Hara tersedia (na)</b>                |     |                        |                       |                  |                    |
| N total (%)                              |     | Currently              | Low                   | Very low         | -                  |
| P <sub>2</sub> O <sub>5</sub> (mg/100 g) |     | Height                 | Currently             | Low – very low   | -                  |
| K <sub>2</sub> O (mg/100 g)              |     | Height                 | Currently             | Low – very low   | -                  |
| <b>Toksistas (xc)</b>                    |     |                        |                       |                  |                    |
| Salinity (ds/m)                          |     | <4                     | 4 - 6                 | 6 - 8            | >8                 |
| <b>Sulfidic hazard (xs)</b>              |     |                        |                       |                  |                    |
| Sulfuric depth (cm)                      |     | >100                   | 75 - 100              | 40 - 75          | <40                |
| <b>The danger of erosion (eb)</b>        |     |                        |                       |                  |                    |
| Slope (%)                                |     | <3                     | 3 - 8                 | 8 - 15           | >15                |
| The danger of erosion                    |     |                        | Very light            | Mild moderate to | Heavy – very heavy |
| <b>Dangers of flooding/waterlogging</b>  |     |                        |                       |                  |                    |

| Land Requirements/Characteristics      | Use | Land Suitability Class |         |     |   |
|--|-----|------------------------|---------|-----|---|
|  |     | S1                     | S2      | S3  | N |
| <b>during the planting season (fh)</b> |     |                        |         |     |   |
| Height (cm)                            | -   | -                      | 25      | >25 |   |
| Long (day)                             | -   | -                      | <7      | ≥7  |   |
| <b>Land preparation (lp)</b>           |     |                        |         |     |   |
| Surface rocks (%)                      | <5  | 5 - 15                 | 15 - 40 | >40 |   |

Source: Literature study, 2025

### 3. Result and Discussions

#### 3.1 Field Data Collection

Data collection was conducted from April 8 to April 21, 2025, involving research assistants at two research locations. In terms of data collection techniques, the research locations were divided into a 100x100m grid system to facilitate data collection. Each grid contained five sampling points for compositing, representing each research station. In addition to determining the research station grid, data collection was carried out using

several parameters, such as soil pH and soil temperature, to determine the actual soil conditions. There were a total of eight test samples for Teger Land and five test samples for Salakan Land. Next, each soil sample that had been composed from the research stations was then tested at the Agricultural Technology Development Center Laboratory, Central Java Province. The following image shows the field data collection activities.



Figure 1. Field Data Collection

#### 3.2 Analysis of Suitability of Corn Farmland

Laboratory tests were conducted on April 24, 2025, at the Central Java Provincial BPTP Laboratory with a total of 13 samples with test parameters of texture, organic C, KTK, potassium, Na, Ca, MG, macro and micro nutrients. The test results served as the basis for analyzing land suitability. Based on the laboratory test results and

evaluation using the LP2B Instrument, the following are the complete conclusions for 8 soil samples in the hilly areas of Mangunsari, Gunungpati, Semarang:

##### a. General suitability of land

Dominant Category: S2 (Fairly Suitable) for all samples (T-148 to T-155).

b. Supporting Factors

- Neutral soil pH (7.0): Ideal for corn (optimal range 5.5–7.5)
- High CEC (19.05–61.48 cmol/kg): Indicates the soil's ability to store nutrients.
- Temperature (26–29°C): Within the tolerance range for corn, although close to the upper limit.

Below the minimum standard (>0.2% for S1)

- Critical P<sub>2</sub>O<sub>5</sub> (0.81–1.19 ppm): Well below corn requirements (>20 ppm)
- Low C-Organic (0.81–1.19%): Does not meet minimum requirements (>1.2% for S1)

c. Inhibiting Factors

- Very low N-total (0.00056–0.00202%):

Next, the results of the analysis and spatial distribution of land suitability at the research site are presented in the following table and figure.

Table 3. Laboratory Testing of Teger Soil Samples

| Sample | Temperature | Texture | KTK | C-Organic | N-Total | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O | Conclusion |
|--------|-------------|---------|-----|-----------|---------|-------------------------------|------------------|------------|
| T-148  | S2          | S2      | S1  | S3*       | S2      | N                             | S2               | S2         |
| T-149  | S2          | S2      | S1  | S3*       | S3      | N                             | S2               | S2         |
| T-150  | S2          | S2      | S1  | S3*       | S3      | N                             | S1               | S2         |
| T-151  | S2          | S2      | S1  | S3*       | S3      | N                             | S2               | S2         |
| T-152  | S2          | S2      | S1  | S3        | S3      | N                             | S2               | S2         |
| T-153  | S2          | S2      | S2  | S3        | S2      | N                             | S2               | S2         |
| T-154  | S2          | S2      | S2  | S3        | S2      | N                             | S3               | S2         |
| T-155  | S2          | S2      | S1  | S3        | S3      | N                             | S2               | S2         |

Source: Analysis results, 2025

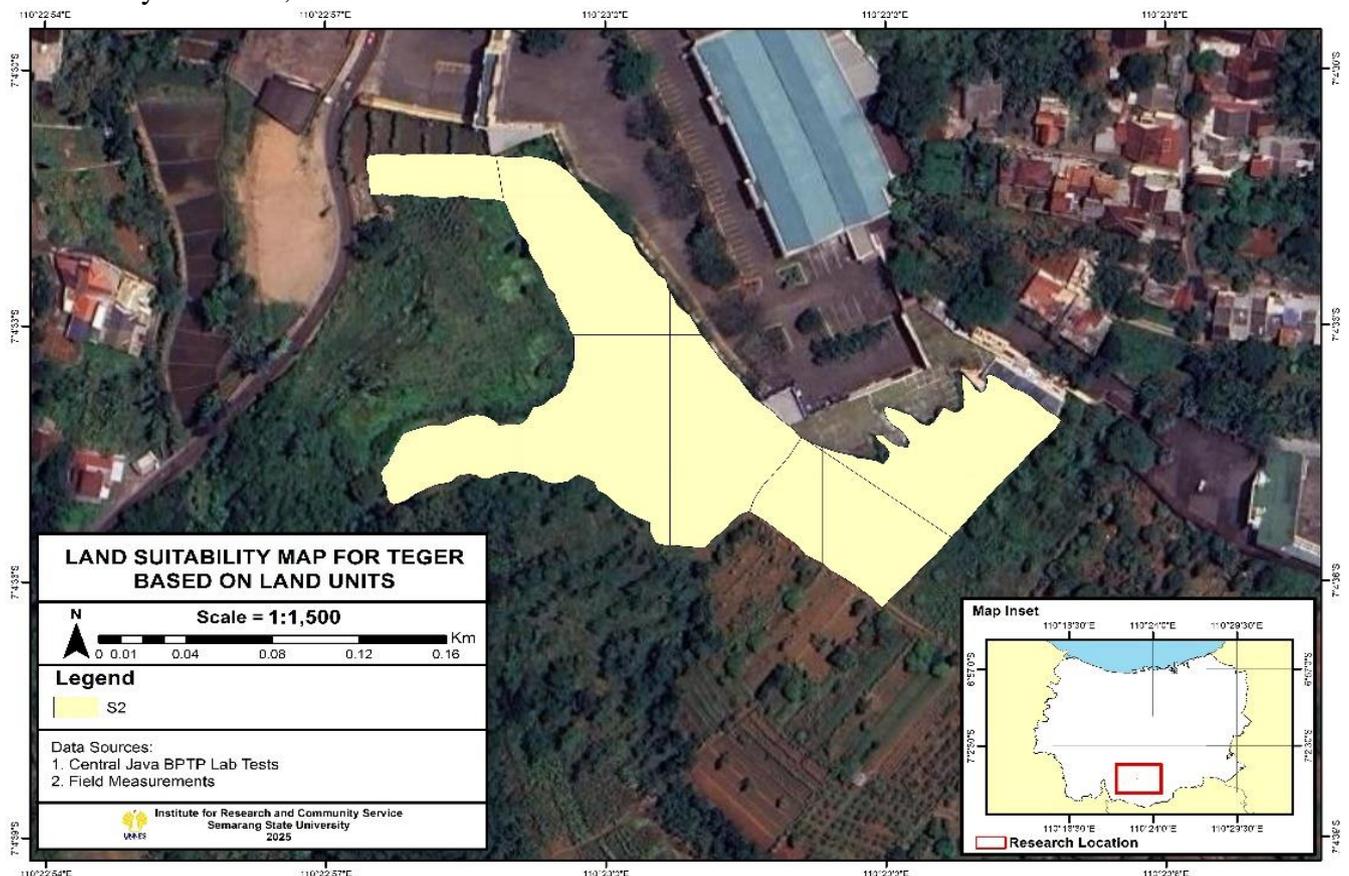


Figure 2. Teger Land Suitability Map Based on Land Unit

### 3.3 Analysis of Rice Farming Land Suitability

Based on laboratory test results, the rice fields at the study site are classified as S2 (Sufficiently Suitable) for irrigated rice cultivation (*Oryza sativa*). However, there are critical limiting factors, namely:

- Very low organic carbon (0.087–0.17%).
- K-availability is low to very low (1.31–8.69 ppm)

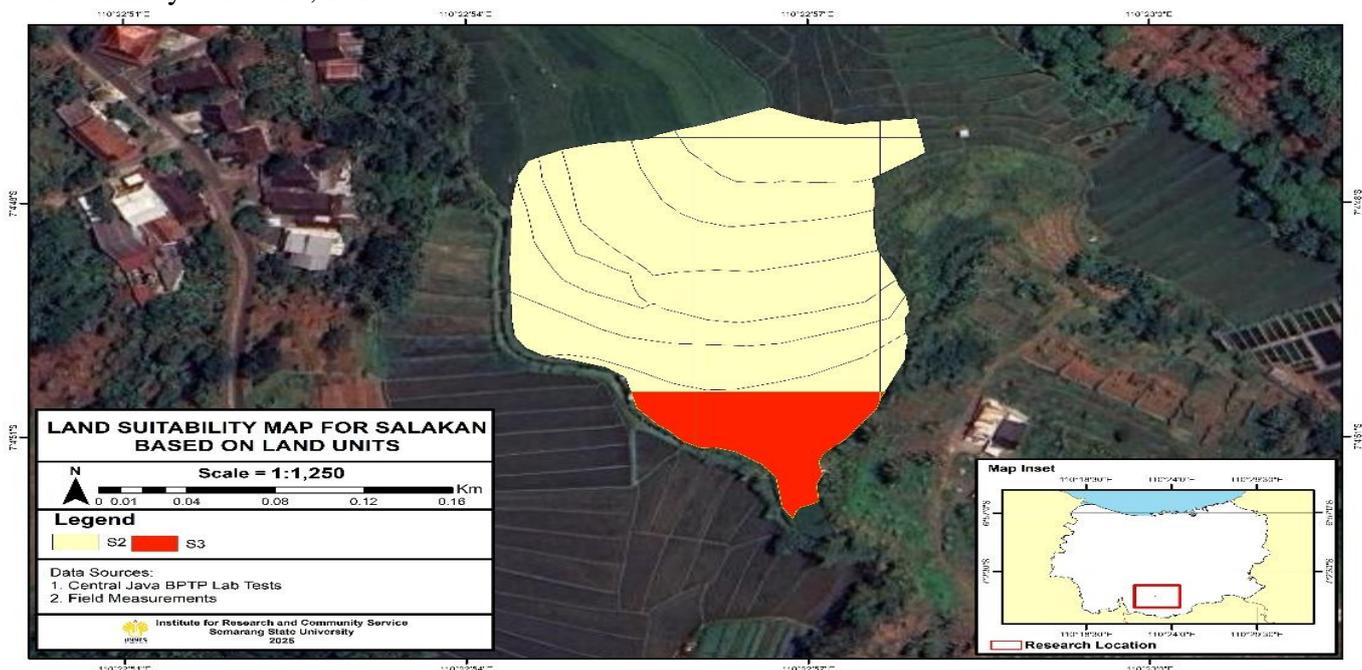
These two factors are the main obstacles to increasing land productivity to class S1 (very suitable). Organic carbon serves to improve soil structure, water retention, and microbial activity (Bashir et al., 2021), so it is important to maintain high levels of organic carbon. According to (Bahagia et al., 2022)(Hartmann & Six, 2023), the soil becomes compacted, nutrient storage capacity decreases, and fertilizer efficiency becomes suboptimal. Potassium enhances rice growth by

strengthening the stems, supporting photosynthesis, and increasing resistance to environmental stress (Baohua, 2022)(Suriyagoda, 2022). In addition, potassium also plays a role in the formation of high-quality grains. Potassium deficiency causes rice leaves to dry out at the tips, weak stems, and empty grains (Li et al., 2021)(Swain et al., 2025). Therefore, to improve paddy fields with low organic carbon and potassium levels, it is recommended to apply biofertilizers (mycorrhiza) along with crop rotation with legumes to increase nutrient absorption efficiency (Mehata et al., 2023)(Chen et al., 2024). Regular monitoring through soil testing and the application of an intermittent (wet-dry) irrigation system are necessary to maintain nutrient availability with dose adjustments according to specific site conditions. Next, the results of the analysis and spatial distribution of land suitability at the research site are presented in the following table and figure.

**Table 4. Salakan Land Laboratory Test Results**

| Sample | Temperature | pH | C-Organic | P-Available | K-Available | KTK | Texture | Class of Suitability |
|--------|-------------|----|-----------|-------------|-------------|-----|---------|----------------------|
| B1     | S1          | S1 | S3        | S1          | S3          | S1  | S1      | S2                   |
| B2     | S1          | S1 | S3        | S2          | S3          | S1  | S1      | S2                   |
| C1     | S1          | S1 | S3        | S1          | S3          | S1  | S1      | S2                   |
| C2     | S1          | S1 | S3        | S1          | S3          | S1  | S1      | S2                   |
| D2     | S1          | S1 | S3        | S1          | S3          | S2  | S1      | S3                   |

Source: Analysis results, 2025



**Figure 3. Salakan Land Suitability Map Based on Land Unit**

#### 4. Conclusion:

This study shows that the Sustainable Food Crop Farmland area in Semarang City, particularly in Teger and Salakan, is classified as S2 (moderately suitable) for corn and rice cultivation. The main supporting factors include neutral soil pH, high cation exchange capacity, and ideal temperature and soil texture conditions for food agriculture. However, several parameters such as organic C, total N, and available K are still relatively low, which could potentially limit crop productivity. Spatial analysis shows that most of the KP2B areas in Gunungpati and Mijen subdistricts are still in line with the provisions of the 2021 Semarang City Detailed Spatial Plan, although there is potential for conversion in peripheral areas that need to be monitored continuously. The results of this study emphasize the importance of integrated LP2B management, which not only emphasizes the physical aspects of land but also social, institutional, and policy aspects. In addition, this research reinforces the role of Semarang State University as a partner in agricultural community development through research and assistance activities in the target areas. This collaboration demonstrates a concrete model of university involvement in supporting urban food security, improving farmer capacity, and implementing sustainable agricultural practices based on land resource conservation.

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