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# Land Suitability for Soybean Farming in Grobogan Regency, Central Java

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**Abstract**

Grobogan Regency has extensive agricultural land availability in Central Java Province, providing significant potential for soybean production as a food crop that can be rotated with rice and maize. However, in recent years, the planted area has fluctuated, resulting in the inability to fully meet community demand. Therefore, this study aims to identify the spatial distribution pattern for soybean development based on land suitability classes integrated with agricultural land conditions and cropping season effectiveness. Land suitability identification was conducted through land capability analysis, agricultural spatial planning analysis, soybean land suitability analysis, land distribution and cropping pattern analysis, as well as soybean planting typology analysis. The analytical methods employed include spatial and quantitative descriptive approaches using scoring, weighting, and weighted overlay techniques. The results indicate that the distribution of soybean cultivation areas includes 38.833 ha of rainfed rice fields in the first planting season, 8.489 ha of dryland and forest areas in the second planting season, and 34.236 ha of irrigated rice fields in the third planting season. Based on land suitability levels, the areas consist of 6.846 ha classified as highly suitable, 73.635 ha as moderately suitable, and 738 ha as marginally suitable, with a total potential area of 81.220 ha across all planting seasons. These findings suggest that soybean has strong potential for consistent production in each planting season. This study also highlights that soybean cultivation can be optimized through proper cropping pattern management and the utilization of various types of agricultural land, while considering limiting factors within land suitability classes to enhance the annual soybean production in Grobogan Regency.

**Keywords** agricultural land, cropping pattern, land suitability, soybean commodity

## 1. INTRODUCTION

Soybeans are a commercially valuable commodity with considerable potential for development and are recognized as one of the most important sources of plant-based protein worldwide (Aminah et al., 2020). In Indonesia, soybeans serve as the primary raw material for various processed products, including tempeh, tofu, and soy sauce. Therefore, soybean availability has become a critical issue, as the high level of national consumption has not been matched by domestic production, resulting in a relatively high dependence on imports. Soybean productivity in Indonesia averages only 1.38 tons/ha, which is lower than that of other soybean-producing countries, such as the United States (3.24 tons/ha), Brazil (3.10 tons/ha), and Argentina (2.84 tons/ha) (Paryanto et al., 2026). This situation underscores the need to increase soybean production through the sustainable optimization of agricultural land use based on land suitability in order to address agricultural land limitations (Radočaj et al., 2021). Determining the suitability of agricultural land for main crops such as soybeans can support efficient agricultural land management planning, considering the important role of soybeans in crop rotation systems involving rice and maize.

Land suitability is considered a key component of sustainable agricultural planning, as it assesses the extent to which a land unit is suitable for cultivation under specific environmental conditions (AbdelRahman et al., 2025). Environmental challenges related to soybean cultivation can become serious constraints if not addressed promptly. Land suitability assessment is an important tool for identifying agricultural potential, supporting planning processes, and guiding agricultural activities (Adnan et al., 2024). Land suitability assessment can be conducted using Geographic Information Systems (GIS) integrated with multi-criteria decision-making methods. Rapid population growth underscores the need to focus on agriculture in order to ensure an adequate food supply. Given the increasing demand for food, crops should be cultivated in the most suitable locations to facilitate adaptation and improve productivity (Almayyahi & Al-Atab, 2024). Challenges in agricultural production are also closely linked to climate change, which requires significant adaptation efforts.

These challenges are likely to drive changes in agricultural practices, with implications for productivity, economic viability, and food security (Jackson et al., 2025). Crops are highly sensitive to climatic variations and elevated temperatures can significantly reduce plant growth. Furthermore, appropriate crop rotation systems involving soybeans and either rice or maize can enhance sustainable soil management practices (Ordóñez et al., 2025). Low agricultural productivity is often observed in dryland areas where land use is not optimized due to reliance on rainfall as the primary water source. Innovations in cropping systems, such as intercropping or polyculture involving soybeans and other crops such as maize, are highly promising for implementation in dryland areas (Slameto et al., 2020). Intercropping between these crops can result in higher productivity because of their complementary effects compared with monoculture systems in dryland farming.

Grobogan Regency is one of the regions in Central Java that cultivates soybeans alongside rice and maize on agricultural land. In 2021, the regency contributed 33% of the total soybean harvest in Central Java, producing 25,057 tons from a harvested area of 10,215 hectares, with an average productivity of 2.45 tons/ha. One of the key factors supporting soybean production in Grobogan Regency is the cropping pattern adopted by farmers, commonly known as PAJALE, an acronym for padi-jagung-kedelai (rice-maize-soybean). As a result, rice, maize, and soybeans have become the major commodities produced in Central Java Province. Land with biophysical potential for agricultural activities includes paddy fields, dryland fields, plantations, grasslands, shrublands, and forests. The land types commonly used for soybean cultivation include irrigated paddy fields (40.74%), rain-fed paddy fields (32.17%), non-paddy land including dryland fields and forests (26.09%), and tidal swamp paddy fields (1%). Agricultural land refers to an environment characterized by specific atmospheric, soil, geological, hydrological, and biosphere conditions that support crop production for food, industrial raw materials, energy sources, and environmental management purposes (Latumahina et al., 2021). Agricultural land is generally classified into wetland and dryland areas. Wetlands are characterized by permanently or seasonally saturated soil conditions, whereas drylands are areas that remain free from flooding or inundation throughout most of the year (Hatta et al., 2018). These lands may consist of paddy fields or dryland areas located within agricultural land or forest areas outside protected forests, wildlife reserves, and national parks (Mulyani et al., 2009). Soybeans are classified as annual legume crops within the food subsector. Soybeans grow and produce optimally at temperatures ranging from 20–27°C, relative humidity levels of 60–70%, and full sunlight exposure for approximately 12 hours per day (Sebastian & Banjarnahor, 2019). Many farmers choose to cultivate soybeans because of their relatively short growth period of approximately 72–90 days. Soybeans can be grown in both rain-fed and irrigated paddy fields, as well as in dryland areas with sufficient water availability. Most soybean farmers apply a monoculture planting system rather than an intercropping system, accounting for 81.98% and 18.02% of cultivation practices, respectively (Badan Pusat Statistik, 2021). Monoculture is considered a relatively simple cultivation system because farmers only manage soybean crops, and it generally produces higher seed yields than soybean–maize intercropping systems (Andika, 2020). In contrast, the intercropping system commonly practiced in many regions involves cultivating soybeans together with maize.

Soybeans rank as the third-largest crop commodity in Grobogan Regency after rice and maize. Consequently, soybean cultivation is integrated into a rotational cropping system in which rice is alternated with secondary crops across the three planting seasons. However, soybean cultivation remains suboptimal, resulting in fluctuations in both production levels and cultivated areas over the past five years, making it difficult to achieve the expected production targets. According to agricultural statistics from Grobogan Regency, the soybean planting area fluctuated during the study period. The area declined to 18,324 hectares in 2019 and subsequently increased again to 12,964 hectares in 2021 following a previous decrease. Similarly, soybean production also fluctuated between 2019 and 2021. Production declined to 27,971 tons in 2019 and later increased again to 14,348 tons in 2021 following a previous decrease. These fluctuations may affect soybean productivity at the provincial level, as Grobogan Regency has consistently contributed the largest share of soybean production and planting area in Central Java over the past five years. The balance between soybean supply and demand is an important indicator in planning future soybean demand within the community (Andayanie, 2016). Therefore, efforts are needed to increase the soybean planting area and maintain planting consistency from year to year in order to support large-scale soybean production. Grobogan Regency has extensive agricultural land resources that can be utilized according to their capacity to reduce the risk of crop failure, minimize yield discrepancies, and improve agricultural productivity. Since 2018, Indonesia's Ministry of Agriculture has designated Grobogan Regency as a strategic area for supporting national food self-sufficiency targets by expanding soybean cultivation areas over the long term, with the expectation that the region will become a national soybean production center. However, this objective has not yet been fully supported by local farmers, as both statistical data and field observations indicate the existence of gaps that need to be addressed in order to optimize planting schedules. Previous studies have generally focused on productivity analysis, cropping patterns, or partial land suitability assessments without integrating comprehensive biophysical parameters and

decision-making aspects into a single analytical framework. In contrast to these studies, the present study integrates various land suitability parameters, including physical and environmental land characteristics, land suitability in relation to agricultural spatial planning, agricultural land types, and effective cropping patterns, into a Geographic Information System (GIS)-based analytical model. This approach enables a more objective assessment of the relative importance of each criterion while producing land suitability maps that are more accurate and applicable. Furthermore, this study specifically focuses on Grobogan Regency, one of the major soybean-producing regions in Central Java, thereby providing more contextual and operational spatial recommendations to support the optimization of soybean development. This study not only identifies land suitability levels but also proposes development priorities based on the feasibility and potential of individual land units.

Previous studies have examined land suitability for food crops in various regions of Indonesia. However, studies that comprehensively integrate biophysical land parameters for soybean development in Grobogan Regency remain limited. In addition, analytical approaches that combine multiple criteria within a spatial decision-making framework still require further development to generate more accurate and practical recommendations. Given these conditions, a comprehensive land suitability analysis is needed to identify the suitability of areas for soybean development in Grobogan Regency. Therefore, this study aims to analyze and map land suitability based on key biophysical factors in order to provide spatial recommendations that support sustainable soybean development planning while considering regional potential.

## 2. THEORETICAL REVIEW

### 2.1. LAND CAPABILITY FOR AGRICULTURAL SPATIAL PLANNING

In the spatial planning process, appropriate and proportional land allocation should consider the potential of land resources that can be utilized for agricultural development purposes (Bhermana et al., 2023). Appropriate land use should be implemented through planning that refers to land capability, which must be systematically assessed to support decision-making and determine suitable land use options. The sustainability of agricultural land plays an important role in developing regions by promoting environmental protection and improvement for future use through appropriate human activities and interventions. Land capability encompasses soil properties, topography, drainage, and other environmental conditions that support various activities on a given land area and is generally defined as the capacity of land for general land use purposes (Wirawan et al., 2019). Agricultural Spatial Planning Directives describe the results of identifying and characterizing land resource potential in order to determine appropriate development directions based on land designation (Kementrian PUPR, 2007). The criteria for Agricultural Spatial Planning Directives are regulated under Minister of Public Works Regulation 20/2007 concerning the Technical Analysis of Physical and Environmental, Economic, and Socio-Cultural Aspects in Spatial Planning Preparation. These criteria include protected areas, buffer zones, perennial crop areas, and annual crop areas. Delineation is conducted based on land capability classes and development capability.

### 2.2. LAND SUITABILITY FOR SOYBEAN CULTIVATION

Land suitability serves as an evaluation tool for developing predictive models that can be applied to a particular region by utilizing the physical and environmental characteristics of land to identify and map areas suitable for development (Nurkholis et al., 2024). Land suitability refers to the degree of suitability of land for annual and perennial crops based on environmental characteristics such as climate, soil, topography, hydrology, and drainage in relation to the requirements of specific crops (Kementrian Pertanian, 2013). According to Ministry of Agriculture Regulation 79/2013 concerning Guidelines for Land Suitability Evaluation of Food Crop Commodities, land suitability assessment can be conducted by aggregating scores from individual parameters and classifying the results into four suitability classes. The land suitability classification system developed by FAO (1976) distinguishes land according to its order and class. At the order level, land is classified as suitable (S) or unsuitable (N). Within the suitable order (S), land is further classified into highly suitable (S1), moderately suitable (S2), and marginally suitable (S3). Unsuitable land (N) is not subdivided into classes. To improve soybean productivity, cultivation should be prioritized in areas classified as S1 (highly suitable), S2 (moderately suitable), and S3 (marginally suitable). The assessment of land suitability for soybean (Glycine max.) cultivation is based on ten characteristics, including average temperature, rainfall during the growing season, humidity, drainage conditions, soil texture class, effective soil depth, soil pH, erosion hazard, land slope, and flood hazard. Changes in the physical conditions of a region due to climate change, particularly those associated with rainfall variability and extreme temperatures, are closely linked to droughts and floods that directly or indirectly affect agricultural systems (Harini & Ariani, 2023). Rapid climate change can negatively affect the production of legume crops such as soybeans, resulting in declining yields. Land suitability assessment is therefore essential for identifying the potential of available land resources to support optimal

soybean development (Sabila et al., 2019). Class S1 (highly suitable) has no significant limiting factors, allowing sustainable use without substantial reductions in productivity. Class S2 (moderately suitable) has limiting factors that may reduce productivity and require additional inputs, although these constraints can generally be managed by farmers. Class S3 (marginally suitable) contains dominant limiting factors that significantly affect productivity and require greater inputs than Class S2 land, often involving substantial investment to overcome these constraints. Class N (unsuitable) contains very severe limiting factors that are difficult to overcome. Consequently, land suitability assessment can serve as an important reference for the protection of Sustainable Food Agricultural Land.

### 2.3. AGRICULTURAL CROPPING PATTERNS

Cropping patterns can be defined as agricultural practices that regulate the sequence of crops cultivated on a particular area of land within a one-year period while considering water availability and soil physical conditions (Nganji & Simanjuntak, 2020). Three important components of cropping patterns are crop type, land area, and the time period of cultivation, all of which are considered to minimize the risk of crop failure. A cropping pattern refers to the arrangement of crop cultivation on agricultural land over a specified period to ensure optimal crop growth and development (Rahma et al., 2018). The effectiveness of cropping patterns is influenced by physical, socio-cultural, and economic conditions. Socio-cultural and economic factors include farmers' age, educational level, farming experience, labor availability, capital for production inputs, cultivated land area, land tenure status, and farm income. Cropping patterns can influence production levels, farm income, and employment opportunities. Agricultural production is determined by harvested area and productivity; therefore, increases in production are generally associated with increases in both harvested area and productivity (Juswadi et al., 2021). Successful cropping patterns are characterized by efficient resource utilization, increased crop diversity and yields, improved soil fertility and nutrient availability, reduced land degradation, and lower risks of crop failure. Cropping patterns are developed through resource optimization while considering physical, economic, social, and environmental aspects (Handayani et al., 2026). In 2020, Grobogan Regency introduced the "Hacking Kedelai" innovation as an effort to address domestic soybean production challenges, support soybean self-sufficiency, and increase farmers' incomes. Hacking Kedelai is an innovation aimed at increasing soybean production and ensuring a sustainable seed supply across planting seasons. The innovation is implemented throughout three planting seasons using an inter-field and inter-season seed network system, locally known as Jabalsim (Jalinan Benih Antar-Lapang dan Antar-Musim).

## 3. RESEARCH METHODS

### 3.1. RESEARCH FRAMEWORK

This study employs both spatial and descriptive approaches to provide a comprehensive analysis of soybean cultivation in Grobogan Regency and to enhance the understanding of the study context of the problem in the study area. The spatial approach is applied to identify and analyze the spatial distribution and extent of land capability classes, land suitability classes for soybean cultivation, agricultural land distribution, agricultural spatial planning directives, cropping patterns, and soybean cultivation typologies. Land capability is classified based on the criteria specified in the Regulation of the Minister of Public Works 20/2007 concerning the technical guidelines for the analysis of physical and environmental, economic, and socio-cultural aspects in spatial planning preparation, which defines nine land capability criteria: morphological, workability, slope stability, foundation stability, water availability, drainage capability, erosion susceptibility, waste disposal amend disaster hazard. Land suitability for soybean cultivation is evaluated using the classification provided in the Regulation of the Minister of Agriculture 79/2013 concerning guidelines for land suitability assessment for food crops, consist of ten criteria: average temperature, growing season rainfall, humidity, drainage conditions, soil characteristics, slope, erosion and flood hazards, as illustrated in Figure 3.1. The distribution of agricultural land types and soybean cropping patterns refers to the *Lahan Baku Sawah* (LBS, or the potential rice fields) classification, which includes irrigated paddy fields, rainfed paddy fields, dryland farms (*tegalan*). This classification is also used to identify the most suitable crops for each planting season within each agricultural land type.

Spatial data processing is conducted using a Geographic Information System (GIS) and a weighted overlay technique. The resulting outputs are classified into land suitability classes and subsequently integrated with agricultural land types and cropping patterns to generate soybean cultivation typologies. The spatial analysis utilizes both raster (.tif) and vector (.shp) datasets. The results are converted into area statistics for each class and subsequently analyzed quantitatively. In addition, a descriptive approach is employed to examine numerical data and observed phenomena. The numerical data

include planted area, harvested area, and cropping patterns. Overall, the research methodology is summarized in the research framework presented in Figure 3.1.

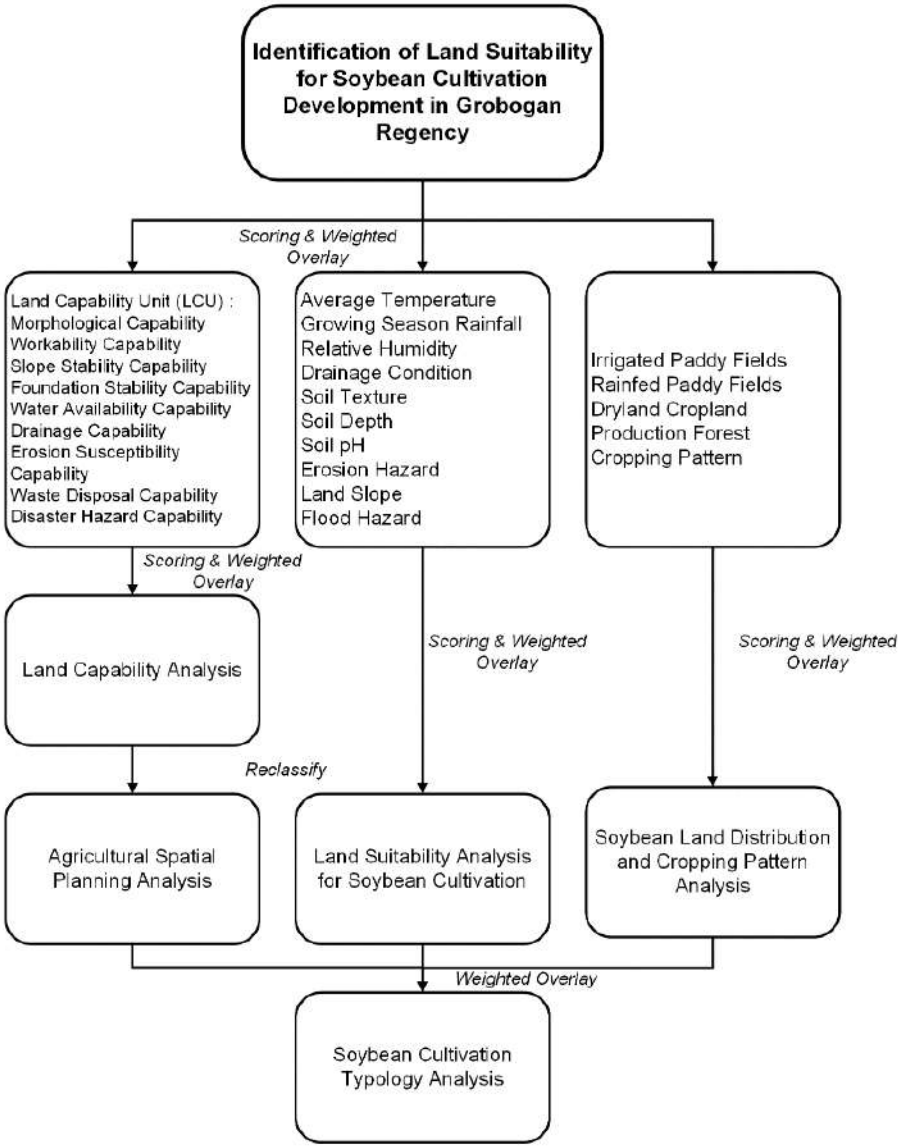



**Figure 3.1 Research Framework**

## 3.2. RESEARCH AREA

The study area is in Grobogan Regency, Central Java Province, which covers an area of 202,385 ha and has its administrative center in Purwodadi Subdistrict. The region extends approximately 37 km from north to south and 83 km from west to east. Geographically, Grobogan Regency is located between 110°15' E and 111°25' E longitude and between 7°00' S and 7°30' S latitude. Administratively, Grobogan Regency is divided into 19 subdistricts and is the second-largest regency in Central Java Province. The administrative area comprises the following subdistricts: Brati, Gabus, Geyer, Godong, Grobogan, Gubug, Karangrayung, Kedungjati, Klambu, Kradenan, Ngaringan, Penawangan, Pulokulon, Purwodadi, Tanggungharjo, Tawangharjo, Tegowanu, Toroh and Wirosari. Grobogan Regency shares administrative boundaries with Semarang Regency to the west; Demak Regency, Kudus Regency and Pati Regency to the north; Blora Regency to the east; Boyolali Regency, Sragen Regency and Ngawi Regency (East Java Province) to the south. An overview of the study area in Grobogan Regency is presented in Figure 3.2.

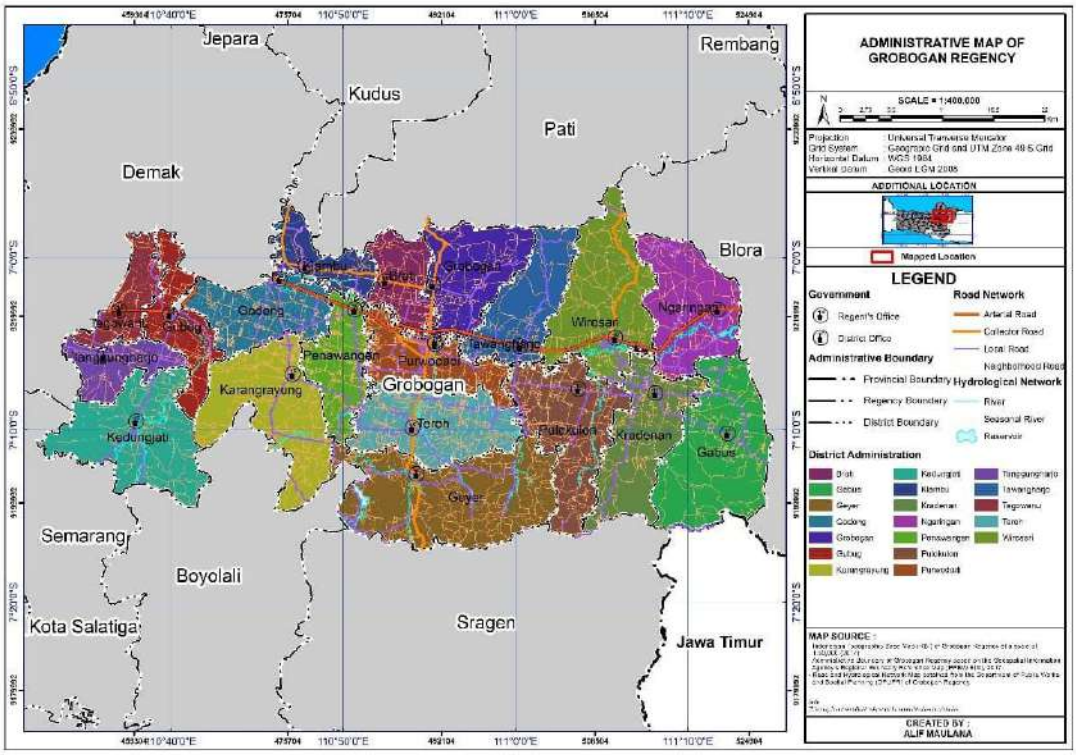



**Figure 3.2 Administrative Map of Grobogan Regency**

Land use in Grobogan Regency consists of 83,833 ha of paddy fields, 89,594 ha of non-paddy agricultural land, and 28,803 ha of non-agricultural land. The total agricultural land area reaches 173,421 ha (85,73% of Grobogan Regency Area), indicating the region's considerable potential for agricultural development with the majority of its population engaged in agriculture as their primary livelihood. According to data from the Grobogan Regency Agriculture Office, the planted area of soybean in 2021 reached 16,438 ha, accounting for approximately 9.48% of the total agricultural land in Grobogan Regency with a recorded production of 25,057 tons. In the following year, soybean production increased significantly to 42,867 tons, accompanied by an expansion of the planted area to 18,903 ha. This trend indicates that farmers in Grobogan Regency are not solely dependent on staple food crops such as rice and maize but have also diversified their cropping systems by cultivating soybean. Therefore, to optimally support soybean production in each planting season, spatial analysis is required to identify and mapping the areas with the greatest potential for soybean cultivation and future agricultural development.

## 4. RESULTS AND DISCUSSION

### 4.1. LAND CAPABILITY ANALYSIS

Land capability analysis is a systematic assessment process that evaluates all LCU (Land Capability Unit) components. This analysis is conducted to determine the level of land capability for development as a basis for sustainable regional development. The parameters used in assessing land capability include land use, rainfall, and soil properties (Widyatmanti & Umarhadi, 2022).

**Table 4.1 Land Development Capability Classification**

| Total Score | Land Capability Class | Development Capability Classification |
|---|---|---|
| 32–58 | A-Class | Very Low Capability |
| 59–83 | B-Class | Low Capability |
| 84–109 | C-Class | Moderate Capability |
| 110–134 | D-Class | Moderately High Capability |
| 135–160 | E-Class | Very High Capability |

Source: (*Kementrian PUPR*, 2007)

The resulting land capability classification is derived through a weighted overlay analysis of nine LCUs, namely Morphology, Workability, Slope Stability, Foundation Stability, Water Availability, Erosion Susceptibility, Drainage, Waste

Disposal Capacity, and Disaster Susceptibility. Following the completion of the scoring and weighting of the nine land capability criteria, the resulting total scores were classified into land capability classes based on the classification scheme presented in Table 4.1

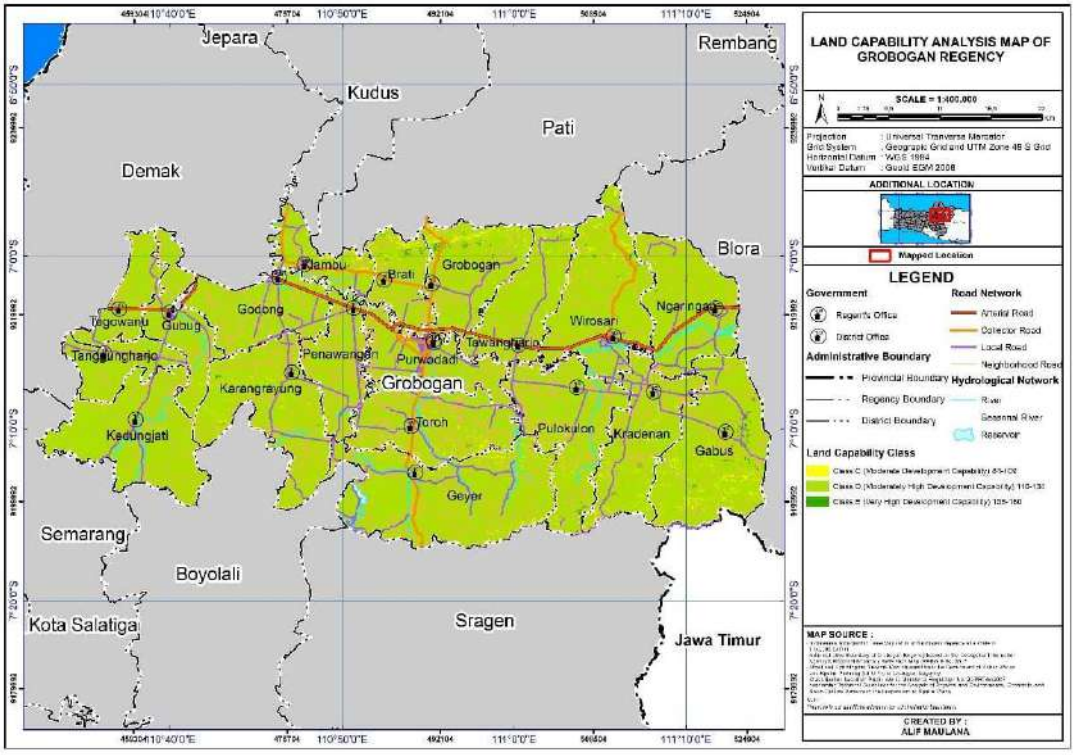



**Figure 4.1 Land Capability Analysis Map of Grobogan Regency**

Agricultural land in Central Java generally exhibits high land capability levels in both paddy fields and dryland areas, indicating substantial potential for agricultural activities (Widyatmanti & Umarhadi, 2022). As shown on Figure 4.1, land capability in Grobogan Regency is dominated by D-Class (Moderately High Capability), with scores ranging from 110 to 134. This class covers 198,557 ha, accounting for approximately 98% of the regency's administrative area and is distributed throughout all subdistricts. The remaining 2% is classified as either C-Class (Moderate Capability) or E-Class (Very High Capability). Areas classified as having moderately high and very high capability can be utilized for the cultivation areas of soybean, and so for rice cultivation, corns as well as other food crops. Land with very high capability covers only 892 ha, with the largest concentration located in Gabus Subdistrict (326 ha). Meanwhile, land classified as having moderate capability covers 2,830 ha, with the largest area found in Geyer Subdistrict (309 ha). Based on the land capability analysis, all 19 subdistricts in Grobogan Regency have the potential to support agricultural cultivation, including for soybean.

## 4.2. AGRICULTURAL SPATIAL PLANNING DIRECTIVES ANALYSIS

Agricultural Spatial Planning Directives are derived from the previously conducted Land Capability analysis, which produces land capability classifications that serve as the basis for determining agricultural development recommendations. The outputs of the Agricultural Spatial Planning Directives map include the designation of protected areas, buffer zones, perennial crop areas, and annual crop areas. In accordance with Law 26/2007 on Spatial Planning, land use functions are broadly classified into two categories: protected areas and cultivation areas. Perennial crops are crops that remain productive for more than one growing season, whereas annual crops complete their life cycle within a single growing season. The classification of agricultural spatial planning directives is presented in Table 4.2.

Agricultural land on the island of Java is highly dependent on paddy fields for food production, contributing more than 50% of the national food supply (Ambarwulan et al., 2023). Therefore, effective Agricultural Spatial Planning Directives are essential to ensure appropriate land utilization and maintain high agricultural productivity. As shown on Figure 4.2, The classification of Agricultural Spatial Planning Directives for annual crop areas is the dominant classification in Grobogan Regency, covering 199,449 ha or approximately 98.60% of the total area. Subdistricts designated without perennial crop areas include Godong, Tanggungharjo, and Tegowanu. Meanwhile, perennial crop areas covering less than 100 ha are

found in Gubug, Kedungjati, Ngaringan, Penawangan, and Purwodadi Subdistricts. These findings indicate that the Agricultural Spatial Planning Directives in Grobogan Regency are highly suitable for food crop cultivation, which are also classified as annual crops. This condition is consistent with the region's agricultural profile, as Grobogan has long been one of the major production centers for rice, maize, and soybeans in Central Java Province.

**Table 4.2 Agricultural Spatial Planning Directives Classification**

| Class | Land Capability | Agricultural Spatial Planning Directives | Value |
|---|---|---|---|
| Class A | Very Low Development Capability | Protected Area | 1 |
| Class B | Low Development Capability | Buffer Zone | 2 |
| Class C | Moderate Development Capability | Perennial Crop Area | 3 |
| Class D | Moderately High Development Capability | Annual Crop Area | 4 |
| Class E | Very High Development Capability | Annual Crop Area | 5 |

Source: (*Kementrian PUPR*, 2007)

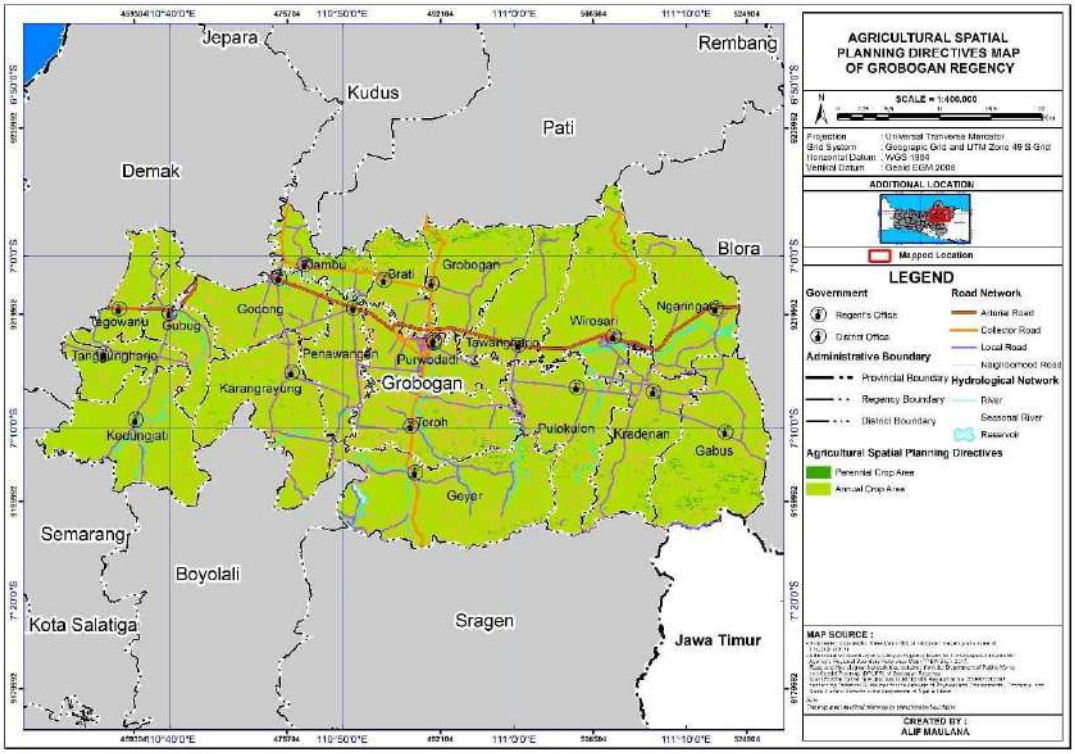



**Figure 4.2 Agricultural Spatial Planning Directives Map of Grobogan Regency**

## 4.3. SOYBEAN LAND SUITABILITY ANALYSIS

Land suitability analysis is used to assess the suitability of land for soybean cultivation in Grobogan Regency. The land suitability analysis for soybean cultivation was conducted by overlaying all ten land characteristic parameters. To determine the suitability level of each parameter, four land suitability classes were used, namely S1, S2, S3, and N. Each parameter was subsequently assigned a weight to determine the overall land suitability level for soybean cultivation. The classification of land suitability for soybean cultivation is presented in Table 4.3.

The weighting scheme applied in the land suitability analysis uses a scale ranging from 1 to 4. The Highly Suitable class (S1) is assigned the highest score of 4, followed by the Moderately Suitable class (S2) with a score of 3, the Marginally Suitable class (S3) with a score of 2, and the Unsuitable class (N) with the lowest score of 1. The maximum possible score obtained from the weighting process is 40, while the minimum score is 10. Based on these values, a frequency of 7.5 was calculated by subtracting the minimum score from the maximum score and dividing the result by the number of land suitability classes. Based on Table 4.3, This frequency was then used to determine the class intervals. Consequently, the S1 class ranges from 32.5–40.0, the S2 class from 25.1–32.4, the S3 class from 17.5–25.0, and the N class from 10.0–17.4.

**Table 4.3 Weighting of Land Suitability Parameters for Soybean Cultivation**

| Land Suitability Parameter | S1 | S2 | S3 | N |
|---|---|---|---|---|
| Flood Hazard | 4 | 3 | 2 | 1 |
| Erosion Hazard | 4 | 3 | 2 | 1 |
| Rainfall During the Growing Season | 4 | 3 | 2 | 1 |
| Soil Depth | 4 | 3 | 2 | 1 |
| Relative Humidity | 4 | 3 | 2 | 1 |
| Slope | 4 | 3 | 2 | 1 |
| Drainage Criteria | 4 | 3 | 2 | 1 |
| Soil pH | 4 | 3 | 2 | 1 |
| Soil Texture | 4 | 3 | 2 | 1 |
| Average Temperature | 4 | 3 | 2 | 1 |
| Total | 40 | 30 | 20 | 10 |
| Frequency | | 7.5 | | |
| Class Interval | 32.5-40 | 25.1-32.4 | 17.5-25 | 10-17.4 |

Source: (*Kementrian Pertanian*, 2013)

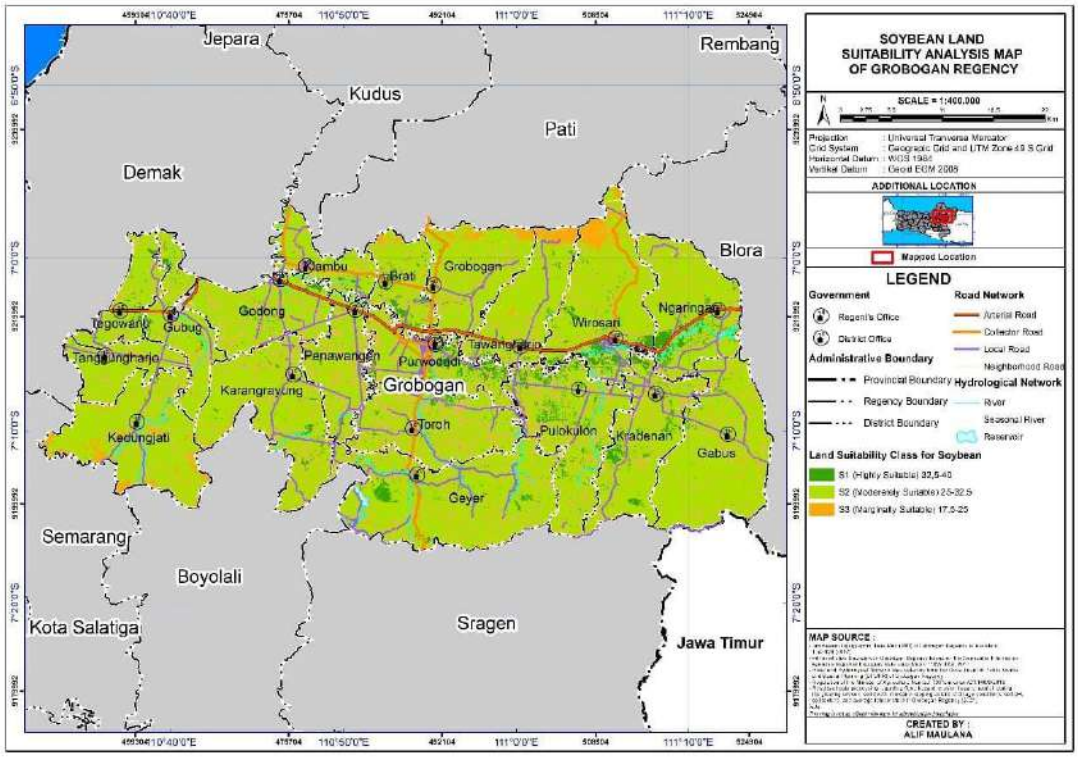



**Figure 4.3 Soybean Land Suitability Analysis Map of Grobogan Regency**

As shown in Figure 4.3, the agricultural land in Grobogan Regency is classified into land suitability classes for soybean cultivation ranging from Highly Suitable (S1) to Marginally Suitable (S3). The predominant class is Moderately Suitable (S2), with suitability scores ranging from 25 to 32.5. According to the Minister of Agriculture Regulation 79/2013 concerning land suitability guidelines for food crop commodities, the highest suitability level for soybean cultivation is represented by the Highly Suitable (S1) class. Land within this class has no limiting factors that significantly restrict crop growth and development, making it the most favorable area for soybean cultivation. The distribution of this suitability class is concentrated in the central part of Grobogan Regency, extending from Purwodadi Subdistrict to Ngaringan Subdistrict. Areas classified as Moderately Suitable (S2) can also support soybean cultivation; however, several limiting factors are present due to less favorable parameter conditions. These constraints may affect cultivation activities but can generally be overcome through appropriate management practices. This suitability class dominates most parts of Grobogan Regency. Meanwhile, areas classified as Marginally Suitable (S3) can still be utilized for soybean cultivation, although they contain more significant limiting factors that are relatively difficult to overcome. The distribution of this class is concentrated in a small portion of the northern region, extending from Grobogan Subdistrict to Wirosari Subdistrict, as well as in the southern part of Kedungjati Subdistrict. The Moderately Suitable (S2) class is the dominant suitability category, covering

approximately 187,000 ha. In comparison, the Highly Suitable (S1) and Marginally Suitable (S3) classes cover approximately 9,000 ha and 4,000 ha, respectively. These findings indicate that Grobogan Regency as a whole has considerable potential for soybean cultivation, with most limiting factors being relatively manageable.

## 4.4. SOYBEAN LAND DISTRIBUTION AND CROPPING PATTERN ANALYSIS

Land designated for soybean cultivation refers to areas with the potential to support soybean development based on biophysical requirements such as topography, slope, soil type, soil physical and chemical properties, climate, and water availability. These areas may consist of paddy fields or dryland located on agricultural land or within forest areas outside protected forests, wildlife reserves, and national parks. Soybean cultivation in irrigated paddy fields following rice harvest can improve land-use efficiency by increasing the Cropping Index (CI) from 2 to 3 through a shift from the rice–rice–fallow cropping pattern to rice–rice–soybean. In rain-fed paddy fields, soybeans are cultivated to establish productive crop rotations and optimize water availability before land inundation for rice cultivation (Saleh et al., 2022). This practice changes the cropping pattern from fallow–rice–maize to soybean–rice–maize in rain-fed paddy fields. In this change, the fallow period (up to three months) is substituted by soybean cultivation which generally needs 75 to 90 days after planting. In addition, the Grobogan soybean variety is cultivated in dryland and forest areas designated for food crop cultivation during Planting Season II using a relay intercropping system with maize. The implementation of this relay intercropping system alters the existing maize–maize–maize pattern into a maize–soybean–maize pattern. This cultivation system reduces the interval between the harvest of the previous crop and the establishment of the subsequent crop by inserting soybean seeds between the planting rows of the main crop shortly before harvest (Kisman et al., 2022). Agricultural land designated for soybean cultivation generally consists of irrigated paddy fields, rain-fed paddy fields, dryland fields, and forest areas designated for food crop cultivation, each corresponding to the characteristics and planting systems of the three soybean growing seasons. The determination of soybean planting seasons is based on the ten-day land water balance, which is used to identify wet and dry periods throughout the year (Herlina et al., 2018).

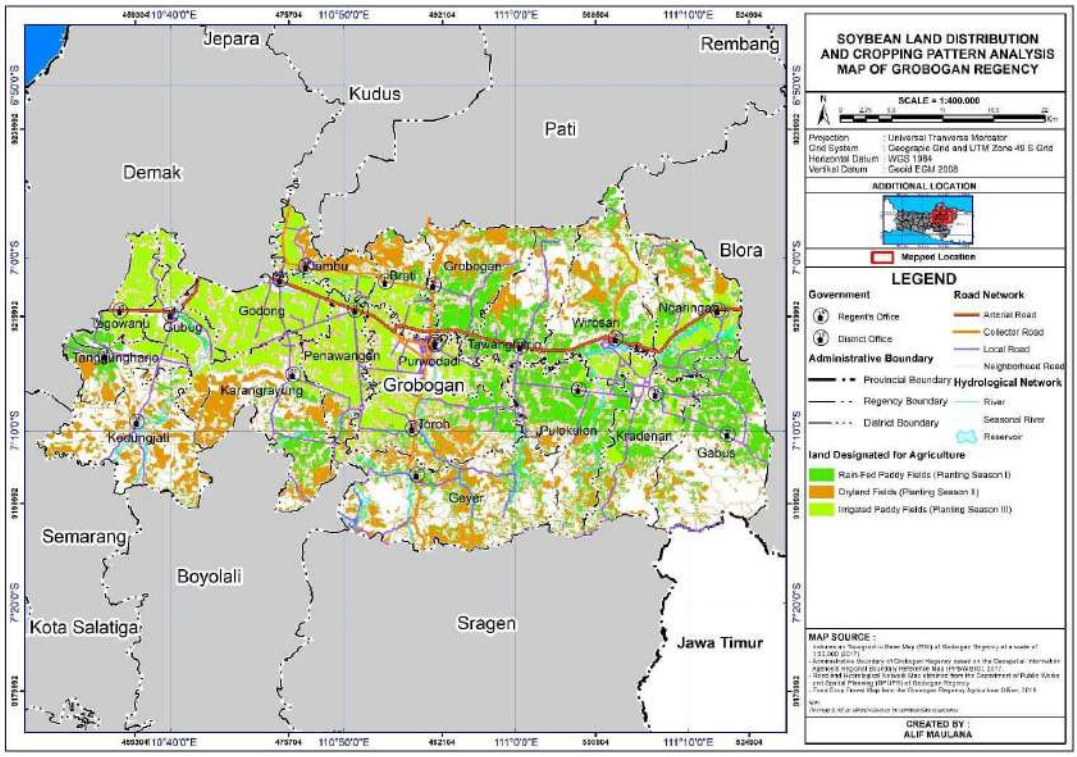



**Figure 4.4 Soybean Land Distribution and Cropping Pattern Analysis Map of Grobogan Regency**

As shown in **Figure** 4.4, agricultural land identified as having potential for soybean cultivation in Grobogan Regency was further classified into three planting seasons based on its physical and environmental characteristics. During Planting Season II, areas with soybean cultivation potential are located in Geyer, Karangrayung, Kedungjati, and Tanggungharjo Subdistricts. During Planting Season III, potential areas are found in Brati, Godong, Gubug, Klambu, Penawangan, Purwodadi, Tegowanu, and Toroh Subdistricts. Meanwhile, during Planting Season I, potential areas are concentrated in Gabus, Grobogan, Kradenan, Ngaringan, Pulokulon, Tawangharjo, and Wirosari Subdistricts. This spatial distribution is

determined by the most extensive agricultural land types within each area, allowing the identification of priority locations for soybean cultivation with the potential to achieve the highest production potential. The largest agricultural areas designated for soybean cultivation consist of rain-fed paddy fields cultivated during Planting Season I, irrigated paddy fields cultivated during Planting Season III, and dryland fields as well as forest areas designated for food crop cultivation during Planting Season II. The largest rain-fed paddy field areas are located in Pulokulon Subdistrict (5,681 ha) and Gabus Subdistrict (5,166 ha). Meanwhile, the largest irrigated paddy field area is found in Godong Subdistrict (6,478 ha). Areas of dryland fields and forest areas designated for food crop cultivation with high potential for soybean cultivation are concentrated in Geyer Subdistrict (4,578 ha) and Kedungjati Subdistrict (4,020 ha).

## 4.5. SOYBEAN CULTIVATION TYPOLOGY ANALYSIS

The soybean cultivation typology was derived from the overlay of Agricultural Spatial Planning Directives, land suitability, and land distribution and cropping pattern analyses conducted in Grobogan Regency. The results of the Agricultural Spatial Planning Directives analysis identified areas classified for annual crops, which were subsequently used to determine the distribution of soybean cultivation areas. Furthermore, land suitability analysis was conducted to assess the potential of agricultural land for soybean development. Areas classified as Highly Suitable (S1) represent the greatest development potential, while areas classified as Moderately Suitable (S2) and Marginally Suitable (S3) can also support soybean cultivation despite the presence of limiting factors. Meanwhile, the analysis of land distribution and cropping patterns was carried out to determine the most appropriate planting periods for soybean cultivation without disrupting the production activities of other agricultural commodities, thereby improving overall land productivity. Soybean production in neighboring Subdistricts within Grobogan Regency exhibits spatial interdependence (Rukini, 2017). Based on these analyses, soybean cultivation areas in Grobogan Regency can be grouped into three planting seasons: Planting Season I on rain-fed paddy fields, Planting Season II on dryland and forest areas designated for food crop cultivation, and Planting Season III on irrigated paddy fields. The typology of soybean cultivation in Grobogan Regency is presented in Figure 4.5.

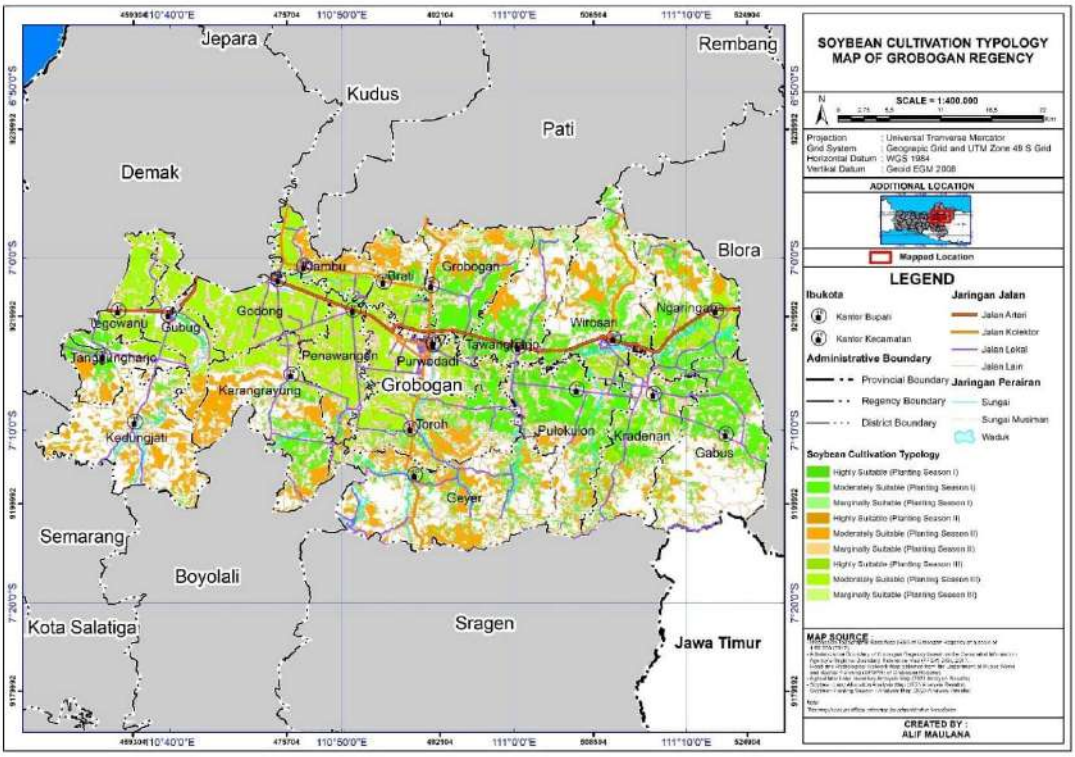



**Figure 4.5 Soybean Cultivation Typology Map of Grobogan Regency**

The first soybean planting season in Grobogan Regency occurs during October–January. The distribution of soybean cultivation areas during Planting Season I is concentrated on rain-fed paddy fields. This land type was selected because it does not experience excessive water accumulation during the rainy season, thereby providing sufficient water availability for soybean cultivation while utilizing fallow periods before rice planting. Planting Season I exhibits the highest potential for soybean cultivation among all planting seasons due to the extensive availability of suitable land, particularly across most of the eastern region and parts of the western region of Grobogan Regency. The total potential area during Planting

Season I reaches 38,660 ha, consisting of 3,000 ha classified as Highly Suitable (S1), 35,230 ha as Moderately Suitable (S2), and 429 ha as Marginally Suitable (S3). Potential soybean cultivation areas during Planting Season I are located in Gabus, Geyer, Grobogan, Karangrayung, Kradenan, Ngaringan, Pulokulon, Tawangharjo, Toroh, and Wirosari Subdistricts.

The second soybean planting season in Grobogan Regency occurs during February–May. The distribution of soybean cultivation areas during Planting Season II is concentrated on dryland fields and forest areas designated for food crop cultivation. These land types were selected to facilitate earlier harvesting schedules through advanced planting without altering existing cropping patterns, making relay intercropping suitable for implementation. In general, relay intercropping in soybean cultivation involves inserting soybean seeds into maize fields when maize plants are approximately 85 days old. By the time soybeans reach maturity, the maize crop has already been harvested, allowing maize to be replanted before soybean harvest. Among the three planting seasons, Planting Season II has the lowest potential for soybean cultivation due to the limited land area available, totaling only 8,344 ha. This area consists of 38 ha classified as Highly Suitable (S1), 7,997 ha as Moderately Suitable (S2), and 309 ha as Marginally Suitable (S3). Potential soybean cultivation areas during Planting Season II are located in Geyer, Karangrayung, Kedungjati, Gubug, and Toroh Subdistricts.

The third soybean planting season in Grobogan Regency occurs during June–September. The distribution of soybean cultivation areas during Planting Season III is concentrated on irrigated paddy fields. This land type was selected because residual soil moisture following rice harvest can be utilized to eliminate fallow periods and maximize land productivity before the next cropping cycle begins. Planting Season III also demonstrates considerable potential for soybean cultivation due to the availability of extensive suitable land. The distribution of soybean cultivation during this season is concentrated across much of the western region and smaller portions of the eastern region of Grobogan Regency. The total potential area available for soybean cultivation during Planting Season III reaches 34,216 ha, consisting of 3,808 ha classified as Highly Suitable (S1) and 30,408 ha as Moderately Suitable (S2). Potential soybean cultivation areas during Planting Season III are located in Brati, Godong, Gubug, Karangrayung, Klambu, Kradenan, Ngaringan, Penawangan, Purwodadi, Tegowanu, Toroh, and Wirosari Subdistricts.

## 5. CONCLUSION

Agricultural land in Grobogan Regency is among the most extensive in Central Java Province, demonstrating considerable potential for soybean cultivation in addition to rice and maize production. These three crop commodities can be integrated through appropriate planting schedules to avoid overlapping cultivation periods and establish cropping patterns for each planting season. Such an approach can directly contribute to maintaining soil fertility by supporting continuous agricultural production without prolonged fallow periods. Furthermore, soybeans can be cultivated on various types of agricultural land, including rain-fed paddy fields, dryland fields and forest areas designated for food crop cultivation, as well as irrigated paddy fields. With a relatively short growth cycle of approximately three months from planting to harvest, soybeans are well suited for crop rotation within annual cropping systems. The greatest development potential occurs during Planting Season I, although cultivation opportunities are also available during subsequent planting seasons. This finding demonstrates that optimizing the utilization of agricultural land types and implementing appropriate cropping patterns are key factors in increasing soybean production in Grobogan Regency. Future research may further explore soybean cultivation potential and related constraints at a more detailed spatial scale by focusing on subdistricts with the largest and smallest soybean cultivation areas.

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