Evaluation of Land Suitability for Corn in Muntuk, Bantul, Special Region of Yogyakarta

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Abstract. Food security is one of the strategic issues in the development of a country. The community's reliance on a single staple food, particularly rice, necessitates food diversification aligned with local potential. One commodity as an alternative food is corn, as it not only serves as a source of carbohydrates but also has high economic value. Muntuk is a hilly area, but this region has the potential to develop dryland food crops, particularly corn. The purpose of this study was to examine the characteristics and determine the suitability of corn. The method of the study used the purposive sampling method on land with a slope of <15%. Data analysis using the matching method of land suitability tables for corn. The results of the analysis show that Muntuk has high rainfall, slow drainage, very shallow effective depth, low total K, and high erosion hazard levels. Based on the results of the analysis, corn can be developed in Tangkil, Karangasem, and Seropan III. Improvement of corn plants requires the effective depth and level of erosion hazard to be determined by dismantling soft hard soil, making a slit trench, adding organic materials, improving the planting system through intercropping with annual plants, and planting crops parallel to the contour.

1 Introduction

Food security is a condition where food is available for the country and individuals, as reflected in the availability of sufficient food, both in quantity and quality, which is safe, diverse, nutritious, evenly distributed and affordable and does not conflict with the religion, beliefs and culture of the community, so that they can live healthily, actively and productively in a sustainable manner [1,2]. One indicator of a country's stability depends on the availability of food stocks. Agricultural development in Indonesia faces challenges, including rising food demand driven by population growth, climate change, and limited productive agricultural land. These conditions encourage the use of dry and

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marginal land to support national food security. One strategic commodity that continues to be developed is corn, as it serves as a source of carbohydrates, industrial raw materials, and a key component of animal feed. [3,4]. The Indonesian government has also prioritized corn as a commodity to strengthen national food diversification. The Indonesian Ministry of Agriculture notes that national corn demand continues to increase for both household and industrial consumption [5].

Muntuk is a village in the Dlingo sub-district, Bantul, with an undulating to hilly topography [6, 7]. Based on data from Marlina [8], the area of rice fields in Dlingo is 115.84 hectares, consisting of semi-irrigated and rain-fed rice fields. Furthermore, the dryland area is 537.77 hectares, consisting of dry fields, yards, and residential areas. The Bantul Regency Central Statistics Agency [9] and regional statistical documents indicate that agriculture remains a primary source of livelihood for the local community.

Corn is the second most important food crop after rice. In fact, in some areas, corn is the main staple food, replacing rice or mixed with rice. This crop has great potential for development in dryland areas due to its relatively good adaptability to seasonal rainfall conditions and soil management. Furthermore, its relatively short harvest period and economic value make corn an important choice for farmers in hilly areas. However, corn productivity is strongly influenced by land suitability factors, particularly water availability, slope gradient, effective soil depth, texture, and soil nutrients [10,11]. Evaluation of these parameters is necessary so that corn development not only increases yields but also maintains the sustainability of land resources.

A land suitability assessment for corn cultivation in Muntuk Village is crucial, given that land use remains traditional and not based on the characteristics of the land's resources. This situation results in suboptimal productivity and frequent seasonal yield declines. A land evaluation approach can provide guidance on suitable locations for corn cultivation as well as management recommendations, such as soil conservation, fertilisation, and appropriate cultivation techniques.

2 Material and Method

2.1 Research Location

The research was conducted in Muntuk Village, Dlingo District, Bantul, located at coordinates 07°53'15'' S to 07°56'45'' S and 110°25'50'' E to 110°27'40'' E. This area has an area of 1,284.63 ha with undulating to hilly topography with an altitude of 200-500 m above sea level. Annual rainfall ranges from 1,800 to 2,200 mm, which will affect water availability, especially on rainfed land. The dominant agroecosystems are dry fields, mixed gardens, and yards. The soil develops from limestone and sedimentary parent rocks, with textures ranging from sandy loam to clay and varying effective depths.

2.2 Research method

The study used a field survey approach and biophysical-based land suitability evaluation. The evaluation framework refers to the Food and Agriculture Organization guidelines

and modified national criteria for corn commodities [12]. Representative samples were purposively selected based on area conditions with a slope of less than 15%, covering an area of 233.75 ha at a scale of 1:750,000. Sample points were determined using ArcGIS 10.3, which was also used to create thematic maps (**Fig. 1**). Soil sampling was carried out at a depth of 0-30 cm, which corresponds to the corn plant roots. Soil sample analysis was conducted based on the analytical method issued by the Ministry of Agriculture [13].

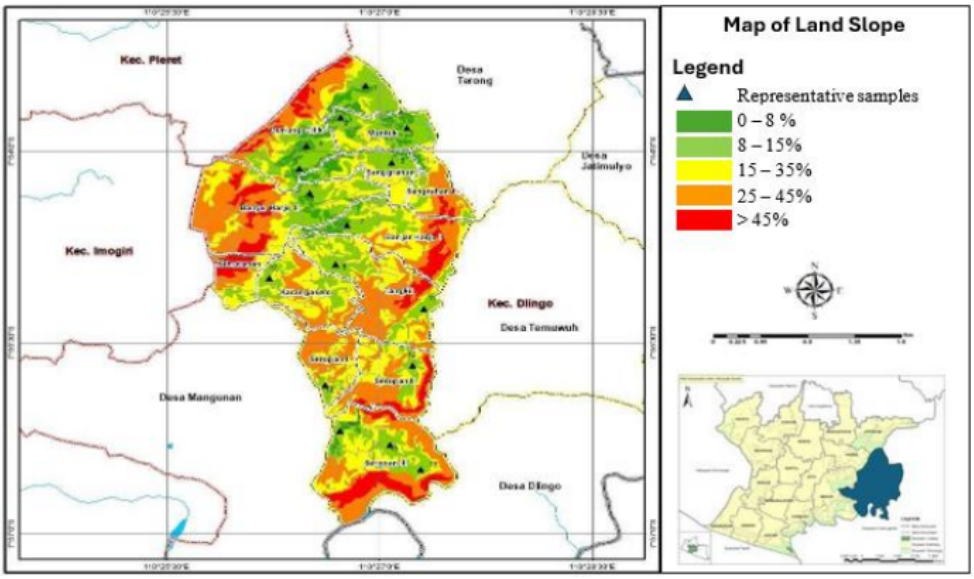

Fig. 1. Map of location and representative sample points

2.3 Data Analysis

The data obtained were analysed using a weighting factor method based on the most severe limiting factor [14, 15]. Limiting factors are defined as deviations in land characteristics and quality from their optimal state that significantly affect various types of land use. The level of land suitability for corn is determined by [16] and [12].

3 Result and Discussion

Muntuk Village is the largest village in Dlingo District, located in a hilly area and dominated by dry land. Average temperatures range from 25-30°C, and rainfall ranges from 1,800-2,200 mm/year. Land use in this area is still dominated by dry fields and yards managed by the community for small-scale agricultural enterprises.

Based on the analysis, the limiting factors for corn cultivation in Muntuk Village are water availability (wa), nutrient retention (nr), available nutrients (na), rooting media (rc), and one major limiting factor, erosion hazard (eh), in several locations with N suitability or non-suitability classes (**Table 1**). Of the 16 representative samples, 10 areas had the N-eh limiting factor (erosion hazard) (Fig. 2). This is related to the land slope in these areas. In addition to slope, other influencing factors include slope length, rainfall,

soil characteristics, and land management practices used by farmers. Land with slopes approaching 15% tends to have greater erosion potential, especially if not equipped with soil and water conservation efforts. In addition, the type of soil commonly found in hilly areas is generally more susceptible to erosion when the soil surface is not protected by adequate vegetation or ground cover [17]. Given the relatively high rainfall in the Dlingo area (2198.76 mm/year), erosion risk can be mitigated by constructing water-retention ditches (rorak) along each slope belt. Slit trench serves to trap rainwater and eroded soil sediment, while also serving as a place for water infiltration into the soil. Another approach is to construct terraced benches to retain water and facilitate access for crop cultivation, especially for annual crops. Intercropping with annual crops can also be practised, thus preventing erosion. Once improvements have been made, land suitability can increase to S3wa-eh (marginal suitability with limiting factors of water availability and land slope) (**Fig. 3**), allowing it to still be used for corn cultivation.

Table 1. Land Suitability Analysis Results

No.	Hamlet	Actual Land Suitability	Potential Land Suitability
1.	Gunung Cilik (1)	N-eh; S3-wa-rc-nr-na	S3-eh
2.	Muntuk (1)	N-eh; S3-wa-rc-nr-na	S3-eh
3.	Muntuk (2)	N-eh; S3-wa-rc-nr-na	S3-eh -eh
4.	Gunung Cilik (2)	N-eh-rc; S3-wa-nr-na	S3-eh-rc
5.	Gunung Cilik (3)	N-eh; S3-wa-rc-nr-na	S3-eh
6.	Banjarharjo II (1)	N-eh; S3-wa-rc-nr-na	S3-eh
7.	Banjarharjo I (2)	N-eh; S3wa-rc-na	S3-eh-rc
8.	Sanggrahan I (1)	N-eh; S3-wa-rc-nr-na	S3-eh
9.	Tangkil (1)	S3-wa-rc-na-eh	S3-eh-wa
10.	Karangasem	S3-wa-rc-na-eh	S2-wa-rc-na-eh
11.	Tangkil (2)	N-eh; S3-wa-rc-nr-na	S3-eh
12.	Seropan II	S3-wa-rc-nr-na-eh	S2-wa-rc-na-eh
13.	Seropan I	N-eh; S3-wa-rc-nr-na	S3-rc-eh
14.	Seropan III (1)	S3-wa-rc-nr-na-eh	S2-wa-rc-na-eh
15.	Seropan III (2)	S3-wa-rc-nr-na-eh	S3-rc
16.	Seropan III (3)	S3-wa-rc-nr-na-eh	S2-wa-rc-na-eh

Water availability is a limiting factor due to the relatively high rainfall. Corn cultivation does not require excessive water. Based on land suitability criteria [16], high rainfall in Muntuk, exceeding 2,000 mm/year, requires the construction of drainage ditches to retain water and prevent damage to corn roots. In addition to disrupting root growth, high rainfall causes high humidity, which can increase the risk of disease [18].

The next limiting factors are nutrient retention and availability. The low soil's ability to bind and supply nutrients to plants is influenced by a combination of local geology, topography, and climate factors [19]. Soils that develop from limestone parent rock generally undergo further weathering, resulting in low cation-binding capacity.

Furthermore, Muntuk's mountainous topography results in low organic matter content due to erosion of the organic-rich topsoil, coupled with the region's relatively high rainfall. This topsoil generally contains high levels of organic matter and nutrients. To improve nutrient retention, organic matter can be added during corn planting. This addition will increase nutrient reserves and soil absorption capacity [20].

Another limiting factor is low nutrient availability (nutrient available-Na). The low nutrient content in this area is due to the dominance of limestone parent material, which leads to high calcium-mediated nutrient fixation. Dlingo is an area with a high level of weathering, so it is dominated by kaolinite clay, which results in a low cation exchange capacity. On the other hand, hilly topography with high rainfall causes nutrient leaching, resulting in low nutrient content required by corn plants [7, 11, 21, 22]. This can be improved by adding organic matter and inorganic fertilisers. Integrating organic matter with inorganic fertilisers is the best solution to overcome low nutrient retention and soil nutrient content [20]. Actual land suitability for corn is presented in **Fig. 2**, while improvements in land suitability class after improving soil characteristics are presented in **Fig. 3**.

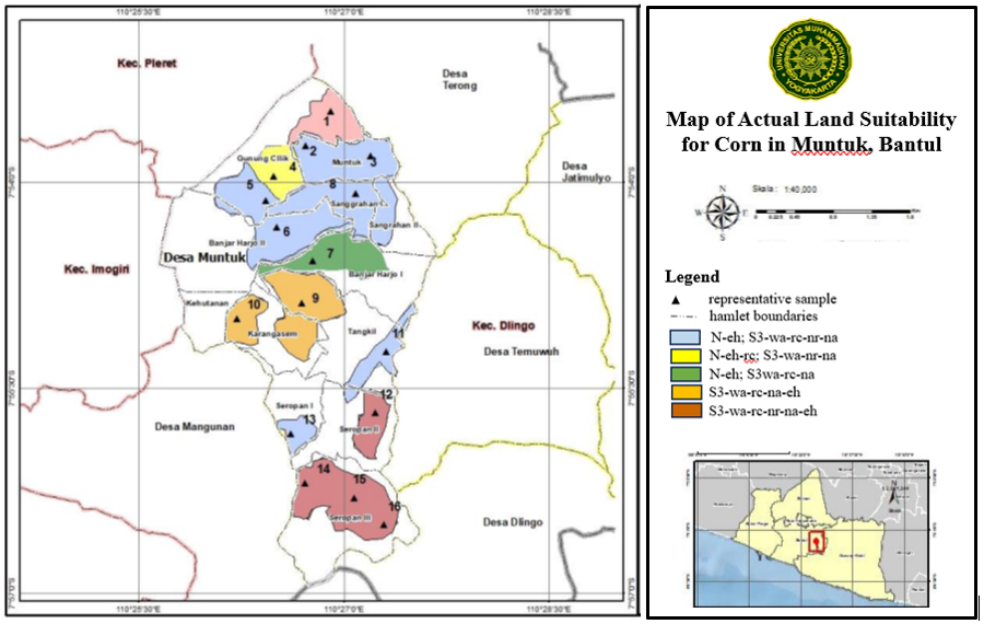

Fig 2. Actual Land Suitability Map for Corn Crops

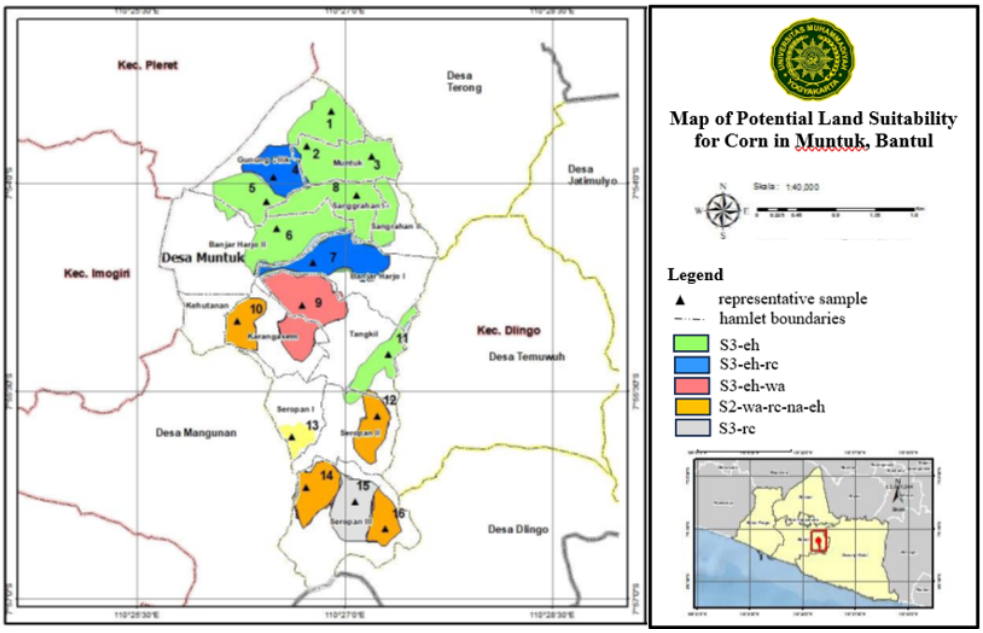

Fig 3. Map of Potential Land Suitability for Corn Crops

4 Conclusion

Muntuk Village is located in a hilly area with limiting factors in the subclasses of water availability, rooting media, nutrient retention, available nutrients, and erosion hazard. Most of the area has actual land suitability that does not meet the limiting factor of erosion hazard. Improvements can be made by creating a slit trench, adding organic matter, and improving the cropping system through intercropping with annual crops. Once improvements have been made, land suitability increases to marginal, with limiting factors of erosion hazard and water availability.

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