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RESEARCH ARTICLE Open Access

The Spatial Land Suitability Evaluation for Corn (*Zea mays* L) Crops in Patilanggio District, Pohuwato Regency, Gorontalo Province

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Abstract

Agricultural land in Gorontalo had 60% suitable soil texture for maize crops. This shows the importance of agronomic interventions to support the optimization of maize production. The purpose of this study was 1) To assess the level of land suitability for corn cultivation in Patilanggio District; 2) To conduct a spatial analysis (map) of land suitability for corn cultivation in Patilanggio District; 3) To formulate strategies for sustainable corn land management in Patilanggio District. This research was conducted in one district, namely Patilanggio, located in Pohuwato Regency, which is known as the corn cultivation base area. The research method used site survey and soil sampling using a soil ring sampler, then tested and analyzed at the UGM Geography Soil Laboratory. The stages of GIS data analysis and synthesis include: (1) on-screen digitization; (2) overlaying tentative maps. Data analysis for land suitability was conducted using LCLP (Land Classification and Land Use Planning) software. The results showed that the level of land suitability varied, requiring agronomic interventions to improve land suitability. This level of land suitability indicates that Patilanggio District has considerable potential for corn cultivation. Spatial land suitability maps provide an overview of potential areas for corn development. Soil conservation-based land management strategies need to be implemented to maintain productivity and ecosystem sustainability, including crop rotation, balanced fertilization, and the use of adaptive high-yielding varieties.

Keywords: Corn, Land Suitability, Spatial Analysis, Sustainability

1. Introduction

Glutinous corn (*Zea mays* var. ceratina) is one of the corns that has the potential to be developed by farmers as a source of food diversification and industrial materials (Suarni, 2013; Girsang et al., 2023). Corn (*Zea mays* L.) is one of the important food commodities in Indonesia, including in Gorontalo Province. Patilanggio District in Pohuwato Regency has significant agrarian potential, making it one of the regions with the potential for corn cultivation development. However, to optimize production yields, land suitability analysis is required to provide an overview of the potential and biophysical constraints of the land in the area. In 2015, the productivity of maize crops in Patilanggio District reached 7.2 tons/ha, exceeding the district's productivity, which was only 6.4 tons/ha (BPS Kabupaten Pohuwato, 2016).

Land suitability evaluation is a process used to assess the extent to which a particular land or area is suitable for specific purposes, such as agriculture, forestry, or other types of development. This process involves the analysis of various physical, chemical, and biological soil factors as well as other environmental aspects to determine whether the land can support the planned activities effectively (Sari et al., 2021)

Land suitability evaluation is typically carried out using specific criteria, such as soil fertility, water availability, land slope, and the potential for pests and diseases. The results of this evaluation can be used to plan land use efficiently and sustainably, as well as to reduce negative environmental impacts. Land suitability evaluation can be categorized into several levels, such as highly suitable (S1), suitable (S2), moderately suitable (S3), and unsuitable (N), each of which describes the degree of suitability of the land for a specific type of use.

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A study by Rahim et al (2013) showed that Gorontalo has a vast land potential for corn cultivation, especially in areas with flat to gently sloping topography. The research identified that 60% of agricultural land in Gorontalo has soil texture suitable for corn, although some areas require improvements in soil pH levels and irrigation systems. This highlights the importance of agronomic interventions to support the optimization of corn production.

Recent research by Yusuf et al (2021) emphasizes a shift in land preferences for corn cultivation due to the increasing demand for land for other commodities. The study suggests that agricultural intensification using environmentally friendly approaches is essential to maintain corn production capacity in Gorontalo. Yusuf et al. also identified that local corn varieties, which are adaptive to specific agro-climatic conditions in Gorontalo, have great potential to increase yields while maintaining land ecosystem sustainability.

Patilanggio District, located in Pohuwato Regency, Gorontalo Province, was chosen as a center for corn development considering several strategic, ecological, and socio-economic factors. This area has significant potential to support agricultural development, particularly corn, which has become one of the nation's leading commodities.

Geographically, Patilanggio Sub-district has fertile land and topography that supports corn cultivation. The soil structure in this region is dominated by alluvial and latosol soil types, which are known to be excellent for corn production. Additionally, the rainfall in Patilanggio tends to be stable, with intensity levels suitable for corn cultivation needs. The combination of ideal soil conditions and climate makes this area highly potential for achieving optimal productivity.

Furthermore, Latif et al (2017) revealed that changes in rainfall patterns due to climate change have started to affect corn production in several regions, including in Gorontalo. Their study recommends the need for more detailed spatial analysis to understand land suitability distribution. Additionally, the use of GIS-based land mapping technology is increasingly being applied to identify the most potential areas. This study also emphasizes the importance of efficient water resource management to enhance corn productivity during the dry season.

In agriculture, land suitability evaluation aims to determine how land can be used according to the specific needs of crops, so that optimal yields can be achieved. According to Hapsari et al (2014), this evaluation is a method to estimate land use based on the requirements of specific crops, with the expectation of maximizing benefits.

Based on the explanation above, there is a need to conduct research on the spatial evaluation of land suitability for corn in Patilanggio District, Pohuwato Regency. The objectives of the spatial land suitability evaluation for corn cultivation in Patilanggio District, Pohuwato Regency, Gorontalo Province, are as follows: 1) To assess the level of land suitability for corn cultivation in Patilanggio District; 2) To conduct a spatial analysis (map) of land suitability for corn cultivation in Patilanggio District; 3) To formulate strategies for sustainable corn land management in Patilanggio District.

2. Material and Methods

2.1. Research Location

This research was conducted in one district, namely Patilanggio, located in Pohuwato Regency, which is known as the corn cultivation base area. Astronomically, Pohuwato is located between 0o.22’-0o.57’ North Latitude and 121o.23’-122o.19’ East Longitude. Pohuwato Regency is an area with average high around 143,8 meters of sea surface. Patilanggio was chosen as the research location because: (1) The region's typology is quite diverse in terms of geographical aspects, natural resources, administra-tion, population, land ownership, income, and human resources (education level); (2) Another reason is that the land in this subdistrict is located in a strategic development area for corn cultivation, recognized as the corn cultivation base of Pohuwato Regency, in line with the spatial planning of Pohuwato Regency; (3) Patilanggio District has land characteristics that meet the minimum criteria for corn growth.

2.2. Research Method

The research method begins with a location survey and soil sampling using a soil ring sampler, which is then taken to be tested and analyzed at the UGM Geography Soil Laboratory. The stages of SIG data analysis and synthesis are as follows: (1) On-screen digitization: This step involves converting analog data into digital data, including maps from interpretation and available thematic maps (used as input data for GIS); (2) Overlaying tentative maps: The maps obtained from the interpretation process are overlaid to produce land unit maps.

Data analysis for land suitability is performed using the LCLP (Land Classification and Land Use Planning) software. The advantage of the LCLP method lies in its ability to analyze land capability and suitability data, which is integrated with ArcView, making it easier for data processors to illustrate the results of land capability and suitability classification spatially (Worosuprojo, 2004). Ritung & Sukarman (2016) explain that this process aims to explore the potential of land resources and provide information that can support their appropriate utilization. This approach often involves spatial analysis using GIS to map land suitability more efficiently (Prasetyo et al., 2015).

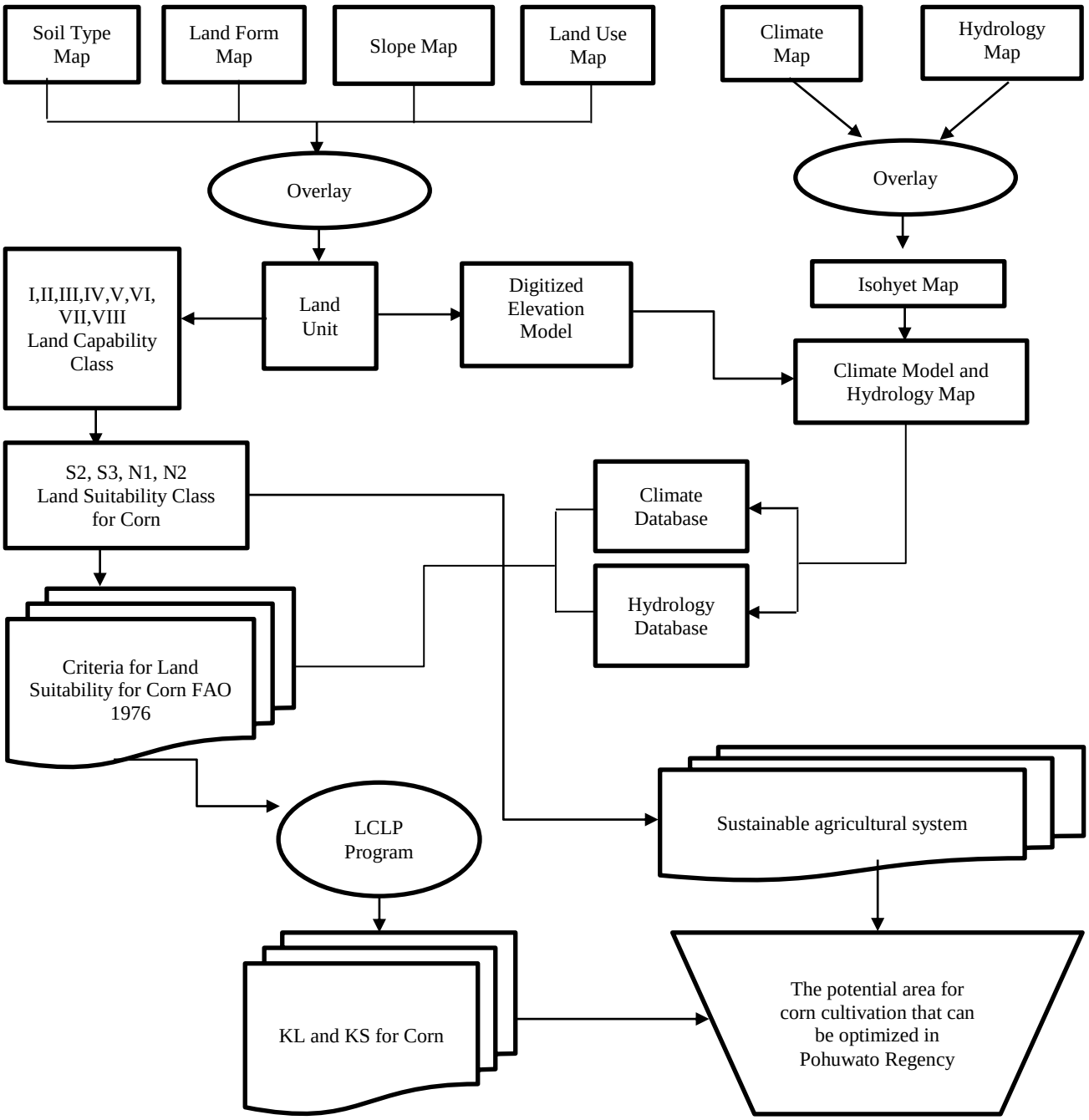

Figure 1. Flow chart of research implementation

3. Results and Discussion

3.1. Characteristics of Land in Patilanggio Distric

Based on the research findings, both from laboratory analysis and direct field observations, there are 18 land units in Ilohelumo Village (Patilanggio Subdistrict). According to the laboratory analysis, these 18 land units have the following characteristics and quality: (1). Slope: Ranges from 0-2% and 2-8%. (2). Effective Soil Depth: Ranges from 50-25 cm, 90-50 cm, and >90 cm. (3). Erosion Hazard: Includes both low and heavy categories. (4). Soil Types: Brown alluvial, Mediterranean, Humus Gley, Renzina, Podsolic, Grumusol, Latosol, Gray alluvial. (5). Annual Soil Erosion: Ranges from 17.64 tons/ha/year to 395 tons/ha/year. (6). Crop Management Factors: In addition to corn, crops such as cocoa, sugarcane, and other food crops are grown as intercropping.(7). Slope Length and Steepness: Ranges from 0.3 to 0.4. (8). Erodibility: The sensitivity of the soil to erosion ranges from 0.13 to 0.29. (9). Rainfall: Ranges from 1000-1500 mm per year and 1500-2500 mm per year.

One relevant study is "Analysis of Physical Land Characteristics in Corn Agriculture in Pohuwato District, Gorontalo Province," conducted by Bumulo (2017), This

research found that land suitability in Pohuwato District is highly variable, both in terms of physical and chemical soil properties. Several limiting factors in the development of corn cultivation include temperature conditions, soil texture, sulfidic depth, drainage, slope, and soil texture. Based on the analysis, there are two classes of land suitability: 1) Class S3 (Marginally Suitable), which includes 33 land units with limitations such as temperature, soil texture, sulfidic depth, drainage, and slope; and 2) Class N (Not Suitable), which includes 97 land units with limitations such as surface rocks, sulfidic depth, coarse materials, temperature, erosion potential, slope, and soil depth.

Overall, the study concluded that the physical land characteristics in Pohuwato District are not highly supportive of corn cultivation due to the high erosion vulnerability. According to research by Tilleke (2018), corn can grow up to an elevation of 1,200 meters above sea level, but the most ideal elevation for its growth is between 50 to 600 meters above sea level.

3.2. Corn Land Suitability Level in Patilanggio District

The following describes the evaluation of corn land suitability in Patilanggio District.

Table 1. Corn Land Suitability Evaluation in Patilanggio District

Subdistrict	Land Unit	Land Suitability	Limiting Factors	Land Improvement (Actions)	Production	Production Class
Patilanggio	S1IIT1BI	Quite suitable (S2)	Permeability, Gravel/Rocks	Moderate Conservation	89.441.18	High
	S1IIT4BI	Marginally Suitable (S3)	Permeability, Gravel/Rocks	Moderate Conservation	89.441.18	High
	S1IIT5BI	Not Suitable at the Moment (N1)	Permeability, Gravel/Rocks	Moderate Conservation	89.441.18	High

Based on Table 1 above, the corn land suitability in Patilanggio District consists of 3 classes: moderately suitable (S2), marginally suitable (S3), and currently unsuitable (N1). The limiting factors in these land units are permeability and gravel/rocks, while land improvement can be carried out through moderate conservation techniques.

This is in line with the research results of Wirosoedarmo et al (2011) , the suitability for corn crops in Blitar consists of three classes namely “very suitable” 85%, “moderately suitable” 10% and “marginally suitable” 5% of the 150961 ha area.

The land suitability classes based on land use types, include: 1) Local Maize in pattern C is very suitable with nutrient availability as a limiting factor (S1na); 2) Composite Maize in pattern B is very suitable with nutrient availability as a limiting factor; 3) Hybrid Maize dominant in pattern C is dominant moderately suitable with water availability as a limiting factor (Nurdin, 2012). Based on research result Ayalew (2015) Land unsuitability for groundnut and sweet potato crop production is due to: clayey soil texture (k), shallow rooting depth (r), available phosphorus (p), and low climate temperature (t). This map can help decision-makers in cultivating the land with the crops under study.

The results show that 79% of the study area is highly or moderately suitable for rice cultivation, while 21% of the area is not suitable for rice cultivation due to soil conditions and topography. The model was also validated with field studies. Based on statistical analysis, there is a significant positive relationship between land suitability class and rice yield. Grain yield was significantly influenced by land suitability class (Sezer & Dengiz, 2014).

According to Arsyad (2010), one form of moderate conservation is land management through terracing techniques, which function to reduce erosion rates and improve water infiltration.

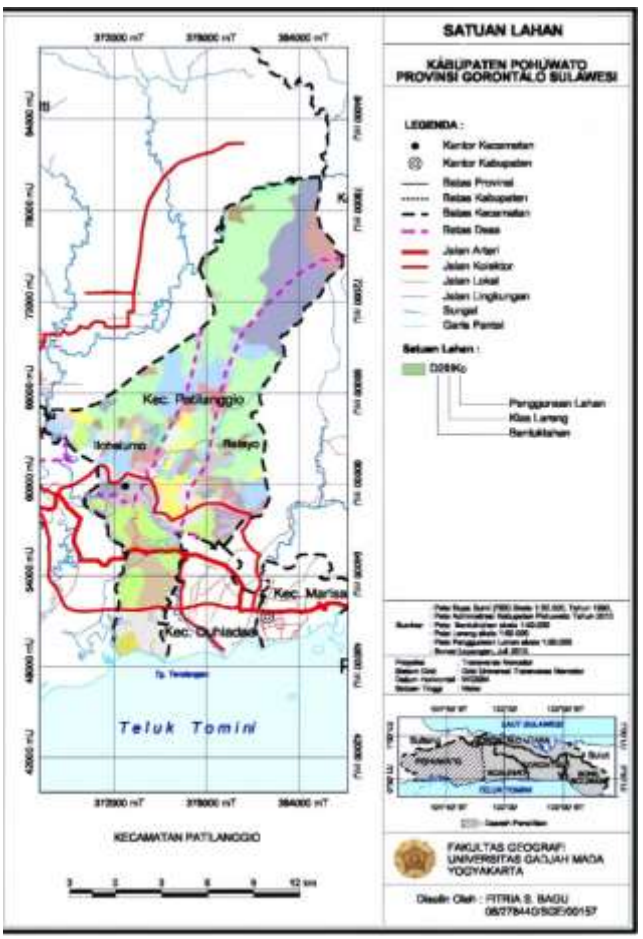

Figure 2. Land Suitability Map for Corn Cultivation

Terracing is done by creating steps on sloping land to control surface water flow and maintain soil fertility. This technique is very effective in managing land in mountainous areas or land with steep slopes.

Nair (1993) explains that agroforestry is a conservation system that combines woody plants, annual crops, and livestock components within a single land unit. This system not only enhances biodiversity but also helps reduce land degradation and maintain soil fertility. An example of its application is agroforestry, which could involve a combination of rubber trees with corn or vegetable crops on the same land.

Unlike the results of this study, which state that the land suitability level in Patilanggio District is classified into only three categories: (S2) moderately suitable, (S3) marginally suitable, and (N1) not suitable marginally, Rahim et al. (2021) classified the land suitability for maize cultivation in Patilanggio District into four categories: very suitable (S1), moderately suitable (S2), marginally suitable (S3), and not suitable (N). The results of the study show that approximately 55% of the land in Patilanggio District falls into the S1 and S2 categories. Land in these categories has ideal soil texture, adequate water availability, and flat to gently sloping topography. The main limiting factors in some areas of the S2 category are low soil pH and phosphorus deficiency, which require special management through fertilization and liming.

Yusuf et al (2021) added that about 35% of the area in Patilanggio District falls into the S3 category, meaning that this land requires more intensive intervention to support maize productivity. The limiting factors in the S3 area include relatively high land slopes (15-25%) and a significant risk of erosion. Furthermore, this study also found that the organic matter content in some areas within the S3 category was at a low level, requiring regular application of organic matter to improve soil fertility. The management strategies applied in this area involve using soil conservation techniques, such as creating ridges and terracing.

3.3. Sustainable Land Management Strategies in Patilanggio District

Sustainable land management strategies in Patilanggio District involve several steps. One key approach is implementing soil conservation techniques, such as terracing on sloped land and using cover crops to prevent erosion. Balanced fertilization, combining organic and chemical fertilizers, should also be carried out to maintain soil fertility while reducing the negative impact of excessive chemical use. Integrated pest and disease management, such as crop rotation and the use of plant-based pesticides, will support sustainable yields without damaging the environment.

Another important step is managing water resources, given the fluctuating availability of water. Efficient irrigation systems, such as drip irrigation or sprinklers, can help conserve water while improving its efficiency. Additionally, constructing reservoirs or rainwater harvesting ponds in some areas can be a solution for utilizing rainwater as a reserve during the dry season. Agricultural waste, such as leftover corn plants, can also be used as compost to reduce waste and improve soil quality.

Figure 3. Land suitability N1 (Currently not suitable) at the Research Location

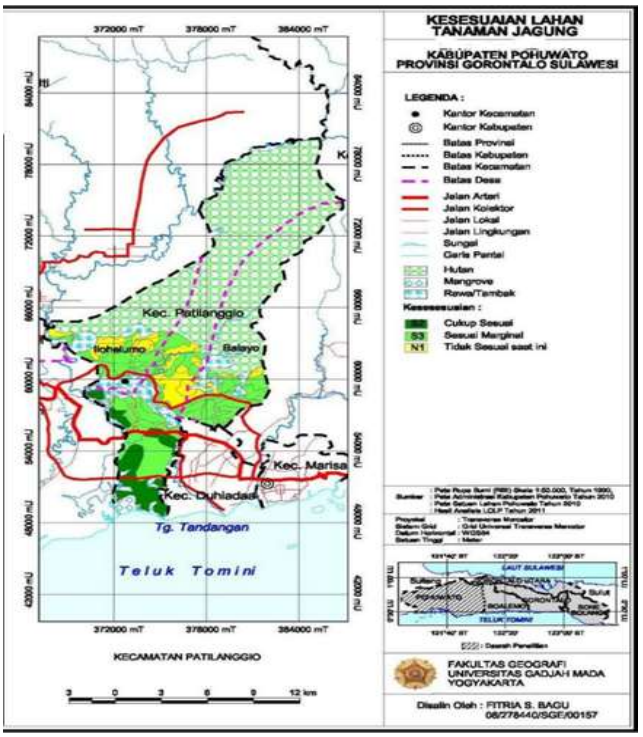

Figure 4. Land Suitability Map for Corn Cultivation

4. Conclusion

Based on the literature review and analysis results, the following conclusions are drawn regarding land suitability evaluation for corn cultivation in Patilanggio District, Pohuwato Regency:

1. Most of the land in this area has varying levels of suitability, namely moderately suitable (S2), moderately suitable (S3) and partly unsuitable (N1). However, there are some challenges that need to be addressed, such as low soil pH, high erosion rates and limited effective soil depth, which require agronomic interventions to improve land suitability. This level of land suitability indicates that the Patilanggio sub-district has considerable potential for maize cultivation.
2. By utilizing Geographic Information System (GIS) technology, a land suitability map was created to illustrate the spatial distribution of land suitability levels. These maps provide an overview of potential areas for maize development, taking into account factors such as slope, soil texture, soil depth and rainfall.
3. Soil conservation-based land management strategies need to be implemented to maintain productivity and ecosystem sustainability, including crop rotation, balanced fertilization, and the use of adaptive high-yielding varieties.

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