Evaluation of land suitability for Yam (*Dioscorea alata*) in Cangkringan, Sleman, Special Region of Yogyakarta

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Abstract. Cangkringan Subdistrict is one of areas in Southern flank of Mount Merapi, Special Region of Yogyakarta which is prone to eruptions. Landuse changes due to eruptions often occur in this area. As a result, the Cangkringan area is prone to food security, due to the damage and landuse changes that have occurred. Yam is a tuber crop that is resistant to nutrient-poor land and has not been widely cultivated. The prospect of developing Yam is very large as a way of diversifying food. Therefore, an effort is needed to evaluate the land for cultivation of Yam on marginally lands affected by the eruption by determining the characteristics of the land as the basis for determining land suitability. The research was conducted using analytical descriptive method and analyzed using the matching method between land quality and land characteristics as parameters with land suitability class criteria. The results showed that the actual land suitability class in Cangkringan sub-district for Yam cultivation was S3nr, na, eh, tc with limiting factors for nutrient retention, total N content, land slope, and temperature. While the potential land suitability is S3eh, tc with limiting factors for land slope and temperature. Improvements that can be made include the addition of organic matter, fertilization, making terraces and planting on land that is not shaded.

Keywords: Cangkringan sub district, evaluation land, land suitability, yam

1. Introduction

Indonesia has many active volcanoes, one of which is Mount Merapi. This mount has a short eruption period, which is 2-6 years [1]. There are two patterns of eruption of Mount Merapi, namely effusive and explosive. Effusive eruption is the process of magma discharge occurring in the form of lava flows, while explosive, the process of releasing magma in the form of an explosion [2-4].

Cangkringan District is one of the districts in Sleman Regency. This area is located at the top of the southern slope of Mount Merapi. and is an area that is prone to being affected by the eruption of Merapi. This area is the area most severely affected by Merapi eruption in 2010, which is one of the largest eruptions in the history of the eruption of Mount Merapi [5]. The eruption of Merapi in 2010 had a negative impact on people's lives, including its natural resources. The threat of environmental and land damage raises the potential for food insecurity in the Cangkringan District and can cause the District to become dependent on food supplies from other regions. Therefore, the increase in food security in Cangkringan District must be returned immediately so that it is not dependent on food supplies from other areas.
Tubers are an alternative source of foodstuffs containing carbohydrates, have strategic potential as a food reserve in the future. However, the role of tubers in food consumption is noticeably decreasing in line with the consumption pattern of the community which focuses on rice [6]. One type of tuber that has a high enough potential is Yam. Yam (*Dioscorea alata*) belongs to the uwi-uwian (*Dioscorea* spp.). In the world, *Dioscorea* spp. is included in the 15 important agricultural commodities, and is ranked 4th in the group of important tuber crops after potatoes, cassava and sweet potato. *Dioscorea* spp. about five million hectares are produced in 59 countries in tropical and subtropical regions. A total of 56.5 million tons of *Dioscorea* spp. of which were produced in the world in 2012, 96.2% were in Africa [7].

Problems faced in the use of tuber crops as a source of substitute food for rice include: a culture of dependence on one type of staple food (rice), lack of information on the content of food substances in tubers, limited information on superior properties and relative resistance to pests and diseases as well as a lack of technological information on tuber cultivation, especially uwi ranging from soil, climate and other physical environmental characteristics.

From the description above, it is necessary to evaluate the suitability of land in the slopes of Merapi for cultivation of uwi plants as an alternative food when a disaster occurs to anticipate a food crisis. On the other hand, uwi also has high economic value when seen from the data on world uwi production which is still very low. This study aims to determine the suitable land characteristics for uwi cropping in Cangkringan District and evaluate the land suitability level for uwi cultivation in Cangkringan District.

2. Materials and Methods

This research used descriptive quantitative method, based on secondary data and laboratory analysis which is matched with the suitability criteria of Yam fields. This research was conducted from April to July 2020 in Cangkringan Subdistrict, Sleman Regency, Special Region of Yogyakarta. Representative samples were taken from differences altitudes in 3 villages (Glagaharjo, Umbulharjo, Kepuharjo), which is 800-900, 900-1,000, and 1,000-1,100 m above sea level (Figure 1). The research data uses primary data and secondary data. Primary data were obtained through analysis of land conditions and soil analysis according to the land suitability parameters of Yam plants [8]. Meanwhile, secondary data includes climate data, namely temperature, humidity, and rainfall obtained from the Sleman Central Bureau of Statistics [9]. Soil samples were taken to a depth of 100 cm, according to the root depth of the Yam. Soil analysis was carried out using the method issued by the Soil Research Institute [10].

The data analysis used in this research is weight factor. Weight factor is is a matching method based on the heaviest limiting factor of land suitability class parameters. Determination of land suitability based on the land suitability classification structure [8;11], which are: S1 (very suitable); S2 (quite suitable); S3 (marginally suitable); and N (not suitable). The land suitability criteria of Yam are presented in Table 1.

3. Results and Discussions

Cangkringan District is located at 07 ° 39'50.6 "South Latitude and 110 ° 27'41.1" East Longitude. Cangkringan sub-district has a tropical climate with cool weather because it is a highland area. The highest temperature recorded in Cangkringan Subdistrict is 29.5 ° C with the lowest temperature of 22 ° C, has an average humidity of 87.3% and an average rainfall of 2,332 mm/year in 2018 [9]. The land area in Cangkringan District is 47.99 km². An altitude of location are 449-1,200 meters above sea level. Land use in Cangkringan District is mostly used for paddy land of 1,083 Ha (22.57%), non-paddy agricultural land of 2,911 Ha and non-agricultural land of 805 Ha.

Average of temperature in Cangkringan for the last eight years was 25.62 °C with a maximum temperature of 36 °C, and a minimum temperature of 20 °C [9]. However, if you look at the temperature based on the altitude, at an altitude of 800-900 m asl the average temperature for the last 10 years is 20.73 °C, at an altitude of 900-1000 m asl it is 19.79 °C, and 1000-1100 m asl is 19.34 °C. In the land suitability criteria for Yam plants, at an altitude of 800-900 m asl it is included in S2 (suitable), while at an altitude of 900-1100 m asl, it is categorized as S3 (marginally suitable). This shows, although the cultivation of Yam plants can be carried out at various altitudes, even up to an altitude of 2000 m asl [14], it is not recommended to be cultivated in areas that have temperatures below 20 °C.
Table 2 showed, Cangkringan sub-district has a fairly high annual rainfall. Based on the Central Bureau of Statistics of Sleman, the average rainfall for the last 10 years is 3122.4 mm/year. The average number of wet months was 8.2 months, while the average number of dry months was 3.6 months. Based on the land suitability criteria for yam [13] on water availability, Cangkringan is included in the S2 (Suitable) criteria. Meanwhile, based on the number of dry months, included in S1 (very suitable). Land suitability criteria for Yam plants, an area is considered very suitable if it has rainfall of 1200-2000 mm/year with the number of dry months of less than 5 months. Yam plants are root crops, so too much water will cause rot.

The level of drainage in Cangkringan District is in the medium to good category. Moderate drainage is found at an altitude of 800-900 m asl, while good drainage is at an altitude of 900-1100 m asl. This is influenced by the type of soil in the area, which is dominated by sandy soil. The study area is an area affected by volcanic material when the Merapi eruption occurred in 2010. However, there is not much coarse material found in this area. As much as 33.7% of the crude material is found at an altitude of 800-900 m asl, while at an altitude of 900-1100 there is no coarse material. In areas where there is no coarse material with a soil depth of more than 100 cm, it is very suitable for plant cultivation, including Yam. Cangkringan sub-district has a land slope of between 8-15% with the danger of erosion included in the criteria of light-medium. In addition, in the area there has never been any floods found.

Based on nutrient retention data, the Cangkringan area has a cation exchange capacity of 6.97 - 20.96 c mol (+) kg-1 which is included in the land suitability class is very suitable (S1) to marginally suitable (S3). The cation exchange capacity contained in this area depends on the content of clay and organic matter in the soil. Most of the land in the Merapi area is young land, so the cation exchange capacity contained varies widely. The average soil pH falls into the suitable class (S2). Yam plants require a pH between 5.5 - 6.5 for optimal growth. However, in the Cangkringan area, the average measured pH is around 7. The organic matter content in Cangkringan is 0.65 - 3.81% and is dominated by the S2 class (suitable). The existing organic matter content is influenced by the vegetation in the area, as well as the existing topographical conditions.

The nutrient content available in the Cangkringan Area varies widely. The results of the analysis showed that the total N content in Cangkringan was 0.04 - 0.51% with the most average content found in Umbulharjo. The P content measured moderate to very high, and the K content measured 17-71.7 c mol (+) kg-1. One of the sources of nutrients in the Cangkringan area comes from weatherable minerals.
from Mount Merapi. Based on FAO [11], Merapi material contains plagiclasts which can be a source of nutrients for plants. Based on the land suitability criteria [12], the nutrient content of N, P, K is included in the very low - very high criteria. At an altitude of 1000-1100 m.asl is the area with the highest nutrient content compared to an altitude of 900-1000 and 800-900 m.asl. Based on the land suitability criteria, the nutrient retention in Cangkringan District is on average included in the S2 class (suitable) for yam cultivation.

Table 1. Criteria of land suitability for yam [10, 12]

| Use Requirements / Land Characteristics | Classes of Land Suitability | N |
|----------------------------------------|----------------------------|----|
| **Temperature (tc)**                   |                            |    |
| Average Temperature (°C)               | 22-25                      | 20-22 |
|                                        | 25-30                      | 30-32 |
|                                        | > 32                       | < 18  |
| **Water availability (wa)**            |                            |    |
| Rainfall (mm) during the growth period | 1200 - 2000                | > 5000 |
|                                        | 2000 – 5000                | < 5000 |
|                                        | 800-1200                   | 600-800 |
|                                        | < 5                       | > 7  |
| Duration of dry period (months)        | 5-6                        | 6-7  |
|                                        | < 5                       | > 7  |
| LGP                                    | 180-210                    | < 150 |
|                                        | 150-180                    | < 150 |
| **Oxygen Availability (oa)**           |                            |    |
| Drainage                               | Good                       | moderate |
|                                        | moderate                   | Inhibited, rather fast |
|                                        | Inhibited, very inhibited, fast, very fast |
| **Root condition (rc)**                |                            |    |
| Texture                                | rather soft, moderate      | Rough, rather rough, soft, very soft |
|                                        | soft, very soft            | -    |
| Rough material (%)                     | < 15                       | 15 - 35 |
|                                        | 35 – 55                    | > 55  |
| Depth of land (cm)                     | > 75                       | 50-75  |
|                                        | 25-50                      | > 25  |
| Peat moss:                             |                            |    |
| Thickness (cm)                         | < 50                       | 50-100 |
|                                        | 100-150                    | > 150 |
| Maturity                               | Saprik                     | saprik, hemik |
|                                        | Hemik                      | Fibrik |
| Nutrient retention (nr)                |                            |    |
| CEC (cmol)                             | > 16                       | 5-16  |
|                                        | 5-16                       | <5    |
| Base Saturation (%)                    | -                          | -     |
| pH H2O                                 | 5.5-6.5                    | 6.5-7.5 |
|                                        | 7.5-8.5                    | > 8.5 |
|                                        | 5.0-5.5                    | 4.5-5.0 |
|                                        | <4.5                       | -     |
| C-Organic (%)                          | >1.2                       | 0.8-1.2 |
|                                        | <0.8                       | -     |
| Available Nutrients (na)               |                            |    |
| N total (%)                            | Moderate                   | Low   |
|                                        | Very Low                   | -     |
| P2O5 (mg.kg⁻¹)                         | Moderate                   | Low   |
|                                        | Very Low                   | -     |
| K2O (cmol (+).kg⁻¹)                    | High                       | Moderate |
|                                        | Low-Very low               | -     |
| Danger of Erosion (eh)                 |                            |    |
| Slope (%)                              | < 3                        | 3-8   |
|                                        | 8-15                       | > 15  |
| Danger of Erosion                      | -                          | Very low |
|                                        | Low-moderat               | heavy-very heavy |
| Danger of flooding / inundation during the planting period (fh) | | |
| Height (cm)                            | -                          | 25    |
|                                        | 25-50                      | > 50  |
| Duration (days)                        | -                          | < 7   |
|                                        | 7-14                       | > 14  |
| Land preparation (lp)                  |                            |    |
| Rocks on the surface (%)               | < 5                        | 5 - 15 |
|                                        | 15 - 40                    | > 40  |
| Rock outcrop (%)                       | < 5                        | 5 - 15 |
|                                        | 15 - 25                    | > 25  |
Table 2. Land Suitability Class for Yam in Cangkringan

| Land Characteristic | Glagaharjo (m asl) | Kepuharjo (m asl) | Umbulharjo (m asl) |
|---------------------|--------------------|-------------------|-------------------|
|                     | 800-900            | 900-1000          | 1000-1100         | 800-900            | 900-1000          | 1000-1100         | 800-900            | 900-1000          | 1000-1100         |
| Temperature (°C)    | S2                 | S3                | S3                | S2                 | S3                | S3                | S2                 | S3                | S3                |
| Water availability (wa) | S1               | S1                | S1                | S1                 | S1                | S1                | S1                 | S1                | S1                |
| Rainfall (mm)       | 3122.4 (S2)        | 3122.4 (S2)       | 3122.4 (S2)       | 3122.4 (S2)        | 3122.4 (S2)       | 3122.4 (S2)       | 3122.4 (S2)        | 3122.4 (S2)       | 3122.4 (S2)       |
| dry period (month)  | 4 (S1)             | 4 (S1)            | 4 (S1)            | 4 (S1)             | 4 (S1)            | 4 (S1)            | 4 (S1)             | 4 (S1)            | 4 (S1)            |
| Oxigen availability (oa) | S2            | S1                | S2                | S2                 | S1                | S1                | S2                 | S1                | S1                |
| Drainage            | moderate           | good              | moderate          | good               | moderate          | good              | moderate           | good              | good              |
| Root condition (rc) | S2                 | S2                | S2                | S2                 | S2                | S2                | S2                 | S2                | S2                |
| Texture             | Rough (S2)         | rather rough      | rather rough      | rather rough       | rather rough      | rather rough      | rather rough       | rather rough      | rather rough      |
| Rough material (%)  | 0 (S1)             | 0 (S1)            | 0 (S1)            | 33.7 (S2)          | 0 (S1)            | 0 (S1)            | 8.4 (S1)           | 0 (S1)            | 0 (S1)            |
| Soil depth (cm)     | >100 (S1)          | >100 (S1)         | >100 (S1)         | >100 (S1)          | >100 (S1)         | >100 (S1)         | >100 (S1)          | >100 (S1)         | >100 (S1)         |
| Nutrient retention (nr) | S3             | S2                | S2                | S2                 | S2                | S2                | S2                 | S2                | S2                |
| CEC (cmol.kg⁻¹)     | 3.32 (S3)          | 16.77 (S1)        | 11.20 (S2)        | 6.97 (S2)          | 12.58 (S2)        | 17.46 (S1)        | 4.69 (S3)          | 20.96 (S1)        | 12.15 (S2)        |
| Base saturation (%) | 0 (S1)             | 0 (S1)            | 0 (S1)            | 0 (S1)             | 0 (S1)            | 0 (S1)            | 0 (S1)             | 0 (S1)            | 0 (S1)            |
| pH H₂O              | 7.10 (S2)          | 7.12 (S2)         | 7.08 (S2)         | 5.60 (S1)          | 7.15 (S2)         | 7.11 (S2)         | 7.12 (S2)          | 7.11 (S2)         | 7.09 (S2)         |
| C-organic (%)       | 1.80 (S1)          | 0.81 (S2)         | 0.65 (S3)         | 0.81 (S2)          | 1.20 (S2)         | 1.00 (S2)         | 2.02 (S2)          | 3.81 (S1)         | 1.20 (S2)         |
| Nutrient availability (na) | S3          | S2                | S1                | S3                 | S2                | S2                | S2                 | S1                | S1                |
| N total (%)         | Very low (S5)      | Low (S2)          | Moderate (S1)     | Very low (S3)      | Low (S2)          | Moderate (S1)     | Low (S2)           | High (S1)         | Moderate (S1)     |
| P₂O₅ (mg/100mg)     | Very high (S1)     | Very high (S1)    | Very high (S1)    | Very low (S3)      | Low (S2)          | Moderate (S1)     | High (S1)          | Very high (S1)    | Very high (S1)    |
| K₂O (mg/100mg)      | Low (S2)           | High (S1)         | Moderate (S1)     | High (S1)          | Moderate (S1)     | Low (S2)          | Low (S2)           | Moderate (S1)     | Moderate (S1)     |
| Erosion hazard (eh) | S3                 | S3                | S3                | S3                 | S3                | S3                | S3                 | S3                | S3                |
| slope (%)           | 8-15 (S3)          | 8-15 (S3)         | 8-15 (S3)         | 8-15 (S3)          | 8-15 (S3)         | 8-15 (S3)         | 8-15 (S3)          | 8-15 (S3)         | 8-15 (S3)         |
| erosion hazard      | Light-moderate (S3)| Light-moderate (S3)| Light-moderate (S3)| Light-moderate (S3)| Light-moderate (S3)| Light-moderate (S3)| Light-moderate (S3)| Light-moderate (S3)| Light-moderate (S3)|
| Land preparation (lp) | S1           | S1                | S1                | S1                 | S1                | S1                | S1                 | S1                | S1                |
| Rocks on the surface (%) | 0 (S1)       | 0 (S1)            | 0 (S1)            | 0 (S1)             | 0 (S1)            | 0 (S1)            | 0 (S1)             | 0 (S1)            | 0 (S1)            |
| Rock outcrop (%)     | 0 (S1)            | 0 (S1)            | 0 (S1)            | 0 (S1)             | 0 (S1)            | 0 (S1)            | 0 (S1)             | 0 (S1)            | 0 (S1)            |
| Actual Land Suitability Class | S3nc,na,eh | S3tc,eh            | S3tc,eh           | S3na,eh            | S3tc,eh           | S3tc,eh           | S3ur,eh        | S3tc,eh           | S3tc,eh           |
| Potential Land Suitability Class | S3eh | S3tc,eh            | S3tc,eh           | S3eh               | S3tc,eh           | S3tc,eh           | S3eh               | S3tc,eh           | S3tc,eh           |
Based on Table 2 and Figure 2, the actual land suitability class in Cangkringan sub-district at an altitude of 800-900 m asl has limiting factors for nutrient retention, nutrient availability, and erosion hazard. Whereas at an altitude of 900-1100 m asl, the actual land suitability class is S3, with temperature limiting factors and erosion hazards. Improvements that can be made to nutrient retention are adding organic matter to increase cation exchange capacity, while improvement in nutrient availability can be done by fertilizing. Improvement of erosion hazards can be done by making terraces in the area that will be used for yam cultivation. Meanwhile, the limiting factor of temperature and rainfall cannot be improved. After improvements, the potential land suitability in Cangkringan for yam is S3 with limiting factor for erosion, rainfall, and temperature (Figure 2).

![Figure 2. Comparison of actual (left) and potential (right) suitability map for yam cultivation in Cangkringan.](image)

4. Conclusion
The actual land suitability class for yam at an altitude of 800-900 m above sea level is S3 (marginally suitability) with a limiting factor nutrient retention, nutrient availability, and erosion hazard. The actual land suitability class for yam at an altitude of 900-1100 m above sea level is S3 (marginally suitability) with a limiting factor temperature condition and erosion hazard. The potential land suitability class for yam at an altitude of 800-900 m above sea level is S3 (marginally suitability) with a limiting factor erosion hazard. The potential land suitability class for yam at an altitude of 900-1100 m above sea level is S3 (marginally suitability) with a limiting factor temperature condition and erosion hazard.

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