Land suitability evaluation for sorghum (*Sorghum bicolor* L.) at Gunungkidul, Yogyakarta, Indonesia

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Abstract. Gunungkidul, Yogyakarta is a dry area with limited water availability for farming. To support food security problems that may be resulted by climate change impact in the future, various possible commodities with the low water requirement, including sorghum, should be evaluated. This study aims to evaluate the land suitability of Gunungkidul in Yogyakarta, Indonesia for sorghum (*Sorghum bicolor* L.). This research was conducted in Purwodadi Village, Tepus District, Gunungkidul in Yogyakarta with purposive sampling and survey method at four land units. The results showed that the area was classified as marginally suitable (S3) due to the slope of more than 20% which is prone to erosion hazard, and not suitable (N) because of the loamy sand soil texture which may inhibit the root growth. However, constructing terraces and adding soil ameliorant such as organic fertilizer for rather long period are potential to increase the status to moderately suitable (S2) and S3, respectively. Overall, the sorghum farming at the area is feasible since the revenue cost ratio (R/C ratio) was bigger than 1 (1.46).

1. Introduction

Indonesia is occupied with large dry land, which covers approx. 148 million hectares [1]. The development of dry land agriculture in Indonesia in the future has enormous potential in realizing a tough agriculture. The dry land also covers some Purwodadi Village, Tepus District (Gunungkidul Regency) farming lands. The main problem of dry land in Gunungkidul area is the water insufficiency for farming. The climate change had pushed farmers into more harder situation since it promotes water scarcity in the surroundings karst area. Hence, the alternative of crops which is resistance on dry area is urgent to support food security.

One of which is sorghum (*Sorghum bicolor* L.). The results by Massoud and Amal [2] reported that sweet sorghum (*Sorghum bicolor* L.) only need 1/3 and 1/2 of water than sugarcane and corn water requirement, respectively, also with less fertilizer requirements. Sweet sorghum (*Sorghum bicolor* L.) has short period of about 3-5 months for growth and grows at diverse climate and soil conditions. Capriyati *et al* [3] found that sorghum (*Sorghum bicolor* L.) can grow in low land areas up to the plateau with dry tropical to wet climates.

However, the production of sorghum (*Sorghum bicolor* L.) in Indonesia is still very low, which is approx. 1 year/ha while it is 3.6 years/ha in US [4]. Given the high potential of sorghum, it is necessary to study the evaluation of the suitability of sorghum land in Gunungkidul, since the area
may strongly support the growth and development of sorghum. To date, no study found regarding the assessment of land suitability of sorghum at Gunungkidul’s dry land farming areas. Therefore, this study aims at assessing the suitability of land in Purwodadi Village, Tepus District, Gunungkidul, Yogyakarta for sorghum (*Sorghum bicolor* L.).

2. Materials and method
The study was conducted from March to October 2016 at Purwodadi Village, Tepus District, Gunungkidul, Yogyakarta, Indonesia (110°37’44.5” E; 8°5’34.7” S) with an area of approximately 2,169.48 ha. The slope ranged 0-45%, with soil type Mediterranean. Based on maps overlay (geological, soil type, slope and land use map), 4 (four) land units were determined, presented in Figure 1. Based on Oldeman [5] the climate type was C3 with the number of wet and dry months is 5 and 4, respectively.

The method used was survey and purposive sampling. The observation parameters according to Sys *et al* [6] were the land requirement sunshine hours, temperature regime, annual rainfall, soil drainage, soil nutrient levels, pH, organic matter content, slope angle and length, soil permeability, rocks cover, Al and Fe content. The matching method was applied between the standard land requirement for sorghum with the actual land condition. Land suitability class is divided into four criteria, namely S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable) and N (not suitable) [7]. In addition, economic analysis (*R/C* ratio) was also carried out to determine the feasibility of farming. The *RC* ratio was calculated using equation (1).

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R/C = \frac{\text{Return}}{\text{Cost}}
\]

Note: *R* = Return; *C* = Cost; *R/C* < 1 not feasible; *R/C* = 1 balance; *R/C* > 1 feasible

**Figure 1.** Land unit map (Geology: Wonosari formation; Soil type: Mediterranean; landuse type: upland)
3. Results and discussion

The actual and potential of land suitability of sorghum (Sorghum bicolor L.) at study site is presented in Table 1 and Figure 2.

Table 1 and Figure 2 show that the actual land suitability for sorghum crop is classified into S3 (marginally suitable) and N (not suitable) classes. The limiting factors at the study sites were slope and erosion hazard, root medium (soil texture). Moderate to steep slope caused the land suitability ranged from S3 and N, because the slope was 20% (land unit 3) 29% (land unit 4). The suggested efforts to improve the actual land suitability level is by terracing, which is bench terrace as an alternative. According to Marhendi [8] that the terrace bench is recommended for land with a slope of 20-30%. At land unit 1, the erosion hazard can be overcome by planting cover crop [9], such as shrub because fast growing, resistant to pets and diseases and tolerant to various soil types, as well as preserving biodiversity [10].

Table 1. Actual and potential land suitability classes for Sorghum (Sorghum bicolor L.).

| Land unit | Actual | Limiting Factor/s | Potential | Recomendation |
|-----------|--------|------------------|-----------|---------------|
| 1         | S3     | na2, na3, eh2    | S2        | Addition of fertilizer P, Addition of fertilizer K, and Planting cover crop |
| 2         | N      | rc1              | S3        | Addition of organic material |
| 3         | N      | eh1              | S3        | Making teracing |
| 4         | N      | eh1              | S3        | Making teracing |
| Final Land Suitability | N | rc1, eh1 | S3 | Addition of organic material, and Making teracing |

Note: N: not suitable; S3: marginally suitable; S2: moderately suitable; rc1: texture; na2: P2O5; eh1: slope; eh2: erosion hazard

Figure 2. Actual (a) and Potential (b) land suitability map for sorghum.

Another limiting factor is soil texture (rc1), which leads to unsuitable (N) especially land unit 2 due to the Loamy Sand (LS) texture. Improvement efforts suggested is by the application of organic materials, but need a long process [11]. This will need big cost and can not be done by farmers alone but needs the support by the government.

The economic analysis of sorghum (Sorghum bicolor L.) is presented in Table 2 and Table 3. Based on Table 2, the total cost be incurred in the first planting season is IDR 7,082,000 while for second planting season and third planting season equal to IDR 5,682,000. This is because in the first planting season the improvement of terrace and soil texture so that the cost to be incurred by
farmers is high. High costs will affect farmers income. The revenue of sorghum is by selling the seeds and stem of IDR 9,000,000 for each season. During the interview, farmers informed that they did not sell directly, but the collectors came and bought it. Table 3 shows that the total income in the first year was IDR 27,000,000 from seeds and stems sale. The cost in the first year was IDR 18,446,000, while the net income was IDR 8,554,000.

The analysis of annual income from sorghum farming system is presented in Table 4. Table 4 shows the annual R/C ratio of 1.46 and is considered to feasible. However, the cost to be spent for farming is also rather big, because of the improvement of terrace and soil texture by using loan capital of IDR 10,000,000 and interest rate of 9% in the first year. The source of capital also affect the net income because it determines the value of interest.

**Table 2.** Production Cost and Revenue of Sorghum (*Sorghum bicolor* L.) of 1 ha in IDR

| Description of Cost | Volume  | Unit Price | Total  |
|---------------------|---------|------------|--------|
| Means of Production |         |            |        |
| Seeds               | 1 kg    | 6,000      | 6,000  |
| Manure              | 1 ton   | 500        | 500,000|
| Liquid Fertilizer   | 14 liter| 5,000      | 70,000 |
| Ropes               | 1 roll  | 6,000      | 6,000  |
| **Total A**         |         |            | **582,000** |
| Labor               |         |            |        |
| Terrace repair      | 20 WD   | 40,000     | 800,000|
| Soil texture improvement | 15 WD  | 40,000     | 600,000|
| Soil preparation/land preparation | 10 WD  | 40,000     | 400,000|
| Basic curing and fertilizing | 10 WD  | 40,000     | 400,000|
| Weeding I dan II    | 10 WD   | 40,000     | 400,000|
| Aftershocking I dan II | 10 WD  | 40,000     | 400,000|
| Harvesting and transporting | 5 WD   | 40,000     | 200,000|
| Drying and thesising | 5 WD   | 40,000     | 200,000|
| Miling and cleaning | 5 WD   | 40,000     | 200,000|
| Packing seed        | 10 WD   | 40,000     | 400,000|
| **Total B**         |         |            | **4,000,000** |
| Others              |         |            |        |
| Land rent           | 1 year  | 2,500,000  | 2,500,000|
| **Total C**         |         |            | **2,500,000** |
| **Total cost of production (A+B+C)** | | | **7,082,000** |
| Sales (Income)      |         |            |        |
| Sorghum seeds       | 1 ton   | 6,000      | 6,000,000|
| Sorghum stalks      | 600 bundles | 5,000 | 3,000,000|
| **Total Revenue**   |         |            | **9,000,000** |

Note: WD: Working Days

**Table 3.** Revenue, cost and net income of Sorghum (*Sorghum bicolor* L.)

| No. | Description     | Total (IDR) | Total IDR/Year |
|-----|----------------|-------------|----------------|
|     | CS I | CS II | CS III |                  |
| 1.  | Total revenues | 9,000,000  | 9,000,000 | 9,000,000 | 27,000,000 |
| 2.  | Total cost      | 7,082,000  | 5,682,000 | 5,682,000 | 18,446,000 |
| 3.  | Net income      | 1,918,000  | 3,318,000 | 3,318,000 | 8,554,000  |

Note: CS: Cropping Season
Table 4. Annual Income from Sorghum (Sorghum bicolor L.)

| No. | Description                          | Total (IDR)/Year |
|-----|--------------------------------------|------------------|
| 1.  | Total revenue                        | 27,000,000       |
| 2.  | Total cost                           | 18,446,000       |
| 3.  | Net income (1-2)                     | 8,554,000        |
| 4.  | Interest on loan capital             | 900,000          |
| 5.  | Net income (3-4)                     | 7,654,000        |
| 6.  | Return to Family Labour (5-4)        | 6,754,000        |
| 7.  | R/C ratio (1/2)                      | 1.46             |

In the first year, the net income was IDR 7,654,000, which is still relatively low. This is because the cost in the first year was bigger than revenue, hence resulting in low profit. In addition, farmers still have to return capital borrowed at 9% interest for 4-5 years because the soil texture improvements takes a long time. The market price is also a huge problem for farmers, because the decline in prices resulted in loss. Market prices relate to market demand for the commodity. The more demand for the commodity, the selling price increases and vice versa. Arta et al. [12] found that the production of sorghum farmers in the Gunungkidul still relatively low (1,913 tons/ha) with rather low price (IDR 1,700/kg) due to very limited post-harvest management and marketing issue. Instead of processing the sorghum to flour, most of the seeds were only sell for bird feed. Therefore, efforts to increase production must be supported by improved post harvest handling and marketing network.

Land area is also become one of the barriers, since it is one of the capital for conducting farming. The land area is closely related to how large the farming scale is run by the farmers [13]. The land area is significantly affected because the greater the land area, the more sorghum plants can be planted, so that the production of sorghum will increase. This will followed by an increase in farmers income.

4. Conclusion

The actual land suitability class in Purwodadi Village, Tepus District, Guungkidul, Yogyakarta for sorghum (Sorghum bicolor L.) was N (not suitable), but the potential land suitability was S3 (marginally suitably). The main limiting factors were steep slopes and loamy sand soil texture, which can be improved by terracing the amendment of organic materials, respectively. Sorghum farming is feasible because the R/C ratio was 1.46.

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