Land evaluation of sweet potatoes with a parametric approach

N Juita and C Lopulisa
Department of Soil Science, Faculty of Agriculture, Universitas Hasanuddin, Jl. Perintis Kemerdekaan Km.10, Makassar, 90245, Indonesia
E-mail:nirmalajuitaa@gmail.com

Abstract. Sweet potato is a food commodity that has high economic value and is an alternative staple food because of its energy and nutrition content. This study was in the form of parametric approach by assigning weights to each of the characteristics of both land and climate required for sweet potato plant growth. Climate and land suitability analysis was performed using the square root method. The results of climate suitability analysis showed that there were two periods of sweet potato plant growth, namely in November-March (S2) and March-July (S3) with a limiting factor in relative humidity (RH) and the length of the sun's irradiation (n/N) which could not be improved. Land suitability analysis in the November-March growing period showed that there are two land suitability classes namely S3 (land units 1, 2, 5 and 6) and N (land units 3 and 4). The limiting factors were soil depth, organic carbon and climate (humidity and length of sun exposure). Organic carbon is improvable by adding cover crops, soil depth with a high level of management, while climate such as relative humidity and irradiation are not manageable.

1. Introduction
Food commodity is a commodity that is essential for the community since they are main sources of carbohydrates and proteins. Food has been a critical basic human needs as regulated in [1] which stated that the achievement of adequate food would determine the quality of human resources and national resilience at the same time. Therefore, food policy present to ensure the availability of food at any time sufficiently, evenly, safely, and more importantly, is affordable for the community.

One food commodity that has high economic value is sweet potatoes. As a source of carbohydrates for food, feed and industrial raw materials, the need for sweet potatoes in the future will increase sharply in line with the increasing population, the development of the livestock industry and other related industries [2]. Sweet potato is a source of carbohydrates that also functions as staple food as a support in developing food diversification programs [3]. Sweet potato has prospective and potential development in terms of land potential, cultivation technology and high productivity and profits at the level of farming [4].

Based on the statistics [5] sweet potato ranks 4th in high-yield food commodities after rice, cassava and corn, ie 2.30 million tons of wet tubers on a national scale. Sweet potatoes are very adaptive to dry land, can grow in an area with rainfall <1100 mm/ year [6]. Jeneponto Regency is one of the regencies that is classified as dry with rainfall of 1535mm / year. Therefore, it is challenging to see the potential of Jeneponto Regency for the development of sweet potato. Regional potential needs acknowledgement, so that food crop commodities in the area can be developed properly.
2. Methods
The research method used is a mixture of qualitative and quantitative methods. Soil sampling was conducted by purposive sampling. The approach method of this research was the parametric approach. The stages in this study were: 1) secondary data collection such as climate data and basic maps (administration, soil type, land use, geology, and slopes), 2) work maps development by overlaying the base maps, 3) preliminary surveys, 4) description of observation profile and soil sampling, 5) analysis of soil samples in the laboratory, 6) determination of growing period 7) climate and land suitability analysis [7]

Evapotranspiration (ETP) values were obtained using the FAO modified Penman Method as in the following equation:

\[
Eto = c \{ W . Rn + (1-W) . f(u) . (ea-ed) \} \tag{2.5}
\]

Where :
- \( c \) : weather changes due to day and night
- \( W \) : Severe factors that influence solar radiation in Potential Evapotranspiration
- \( (1-W) \) : weight factor as the effect of wind and humidity on Eto
- \( (ea-ed) \) : the difference in saturated water vapor pressure with real water vapor pressure (mbar)
- \( Rn \) : solar irradiation radiation in the ratio of evaporation or net solar radiation (mm / day)
- \( F (u) \) : the function of the effect of wind on Eto = 0.27 x \((1 + U^2 / 100)\) where \( U^2 \) is the wind speed for 24 hours in km / day at an altitude of 2 m.

Calculation of the climate index based on square root method by Khiddir [7]

\[
equation: Ic = Rmin \sqrt{\frac{A}{100}} \times \frac{B}{100} \times \frac{C}{100} \times \ldots \ldots \tag{2}
\]

\[
Rc = (0.9 \times Ic) + 16.67 \text{ (Jika, } 25 < Ic < 92.5) \\
Rc = (1.6 \times Ic) \text{ (Jika, } Ic < 25)
\]

Notes:
- Ic = Climate index
- Rc = Climate rating
- Rmin = Minimum rating
- A, B …… = Other ratings besides the minimum rating

Calculation of the land index based on square root method by Khiddir [7] equation

\[
I = Rmin \sqrt{\frac{A}{100}} \times \frac{B}{100} \times \frac{C}{100} \times \ldots \ldots \tag{3}
\]

Notes:
- I = Land index
- Rmin = Minimum rating
- A, B…. = Other ratings besides the minimum rating

3. Results and discussion

3.1. Determination of growing period
Calculation of the growing period was conducted by the FAO Penman modification method. The growth period is the period where rainfall is greater than \( \frac{1}{2} \) ETP. The growth period was carried out to determine the exact planting period of a plant, so that the plant can produce optimally.

According to Thirupathi et al [8] the growing period is defined as the long period of the rainy season including soil moisture in the rainy season and the dry season. The growing period is expected to meet the water needs of plants. Therefore, Long Growing Period (LGP) depends not only on the distribution of rainfall but also on the depth of the soil, water retention, soil type and air temperature.

The sweet potato crop growing period in Jeneponto Regency is in November to March and March to July. According to Sys [6] the age of sweet potato plants around 120-150 days. The sweet potato crop growth period in Jeneponto can be seen in figure 1 and table 1.

![Growing Period](image)

**Figure 1.** Growing period of sweet potato

| Month   | Rainfall | Eto   | \( \frac{1}{2} \) Eto |
|---------|----------|-------|------------------------|
| January | 266.5    | 116.49| 58.25                  |
| February| 213.9    | 107.60| 53.80                  |
| March   | 126.4    | 92.91 | 46.45                  |
| April   | 111.9    | 68.82 | 34.41                  |
| May     | 124      | 79.76 | 39.88                  |
| June    | 176.9    | 68.36 | 34.18                  |
| July    | 99.6     | 72.64 | 36.32                  |
| August  | 28.8     | 78.29 | 39.15                  |
| September| 96.3    | 97.17 | 48.58                  |
| October | 44.2     | 129.27| 64.64                  |
| November| 84       | 109.23| 54.62                  |
| December| 162.6    | 116.55| 58.28                  |

### 3.2. Climate suitability analysis

The results of climate suitability analysis in table 2 showed that the climate suitability class with two growing periods (November to March and March to July) is S2 (moderately suitable) and S3 (marginally suitable). The limiting factor in climate suitability is RH at harvest and n/N maturation
stage. This is because in November to July the intensity of the rain is still high enough so that the humidity will increase and the sun's radiation will decrease. According to Sys [6] good humidity for sweet potato plants is <60%, while good n / N for sweet potato plants is > 0.7.

### Table 2. Climate suitability analysis based on growing period

| Climatic Characteristics                          | Growing Cycle               |
|--------------------------------------------------|-----------------------------|
|                                                  | November-March | March-July |
| Annual precipitation (mm)                        | 97.59          | 66.53     |
| Number of dry months in growing cycle (P<1/2 PET)| 100             | 100       |
| Mean temp. of the growing cycle (°C)             | 97.1            | 94.75     |
| Mean min. temp. of growing cycle (°C)            | 94              | 94.33     |
| RH at harvest (%)                                | 60.5            | 59.92     |
| n/N develop. Stage                               | 75              | 55.43     |
| n/N maturation stage                             | 68.33           | 52.8      |
| Climate index                                    | 40.88           | 23.46     |
| Rc                                               | 53.46           | 37.54     |
| Climate Class                                    | S2              | S3        |

*S2 (moderately suitable)  
S3 (marginally suitable)*

3.3. Land suitability analysis

Land suitability in the November to March growing period (table 3) are S3 (marginally suitable) and N (not suitable). S3 land suitability classes are in land units of 1, 2, 5 and 6, while land suitability class N is in land units of 3 and 4. For land suitability results in the period of growing March to July classified into N which is found in all land units.

The limiting factors for land suitability are organic carbon, soil depth and climate. According to Sys [6] organic carbon content as a condition of growth needed by sweet potato plants is 2-3%. Organic carbon in the study area is only around 1% due to the lack of vegetation that grows around the observation area due to low rainfall. Low organic carbon is improvable by adding a variety of land cover crops.

The optimal soil depth for sweet potato plants is >100cm [6]. Soil depth is a limiting factor in land units 3 and 4 with a topography of 3-15% which makes the soil solum shallow with mild erosion indications. Effective depths generally cannot be improved except on soft and thin layers of soil by unraveling it at the time of tillage [9]. Limiting factors in terms of climate such as relative humidity and the length of the sun's irradiation cannot be improved due to limiting factors it is a natural condition that occurs naturally.
Table 3. Land suitability analysis in the November to March growing period.

| Land Characteristics | Land Units |
|----------------------|------------|
|                      | 1          | 2          | 3          | 4          | 5          | 6          |
| Rec                  | 53.46      | 53.46      | 53.46      | 53.46      | 53.46      | 53.46      |
| Topography (t)       |            |            |            |            |            |            |
| Slope (%)            | 98.75      | 98.75      | 95         | 81.88      | 98.75      | 98.75      |
| Wetness (w)          |            |            |            |            |            |            |
| Flooding             | 100        | 100        | 100        | 100        | 100        | 100        |
| Drainage             | 85         | 95         | 95         | 100        | 85         | 85         |
| Physical soil characteristics (s) |        |            |            |            |            |            |
| Texture              | 100        | 95         | 100        | 95         | 95         | 95         |
| Coarse Fragm (vol%)  | 100        | 100        | 100        | 100        | 100        | 100        |
| Soil depth (cm)      | 100        | 83         | 53.33      | 63         | 70         | 70         |
| CaCO3 (%)            | 88.87      | 65.4       | 85.27      | 95.93      | 96.75      | 96.1       |
| Soil fertility characteristics (f) |        |            |            |            |            |            |
| Apparent CEC (cmol/kg clay) | 100       | 100        | 100        | 100        | 100        | 100        |
| Base Saturation (%)  | 100        | 100        | 100        | 100        | 100        | 100        |
| Sum of basic cations (cmol/kg) | 100       | 100        | 100        | 100        | 100        | 100        |
| pH H2O               | 99.75      | 86         | 100        | 83.13      | 96.67      | 91.25      |
| Organic Carbon (%)   | 57         | 67.75      | 51.2       | 45         | 55.8       | 53         |

Land Index 34.82 28.38 23.98 20.57 28.85 27.11

Land Suitability Class S3 S3 N N S3 S3

4. Conclusions
Based on climate suitability analysis and calculation of growing period there are 2 planting periods, namely November-March with climate suitability S2 (moderately suitable) and March-July with climate suitability S3 (marginally suitable). The limiting factors in the climate suitability analysis are relative humidity (RH) at harvest and n/N maturation stage.

The results of land suitability analysis in the November-March period are S3 (land units 1, 2, 5 and 6) and N (land units 3 and 4), while land suitability in the March-July growth period is N for all land units with limiting factors organic matter, soil depth and climate (relative humidity and n/N maturation stage). Organic carbon is improvable by adding cover crops, soil depth with a high level of management, while climate such as relative humidity (RH) and n/N cannot be improved.

References
[1] Undang U 2017 Undang Undang No. 7 Tahun 1996 Tentang : Pangan J. Sos. Hum. 8 4
[2] Penelitian B, Kacang-kacangan T and Malang P O B Peningkatan produksi dan kualitas umbi-umbian 1–21
[3] Zuraida N Status Ubi Jalar sebagai Bahan Diversifikasi Pangan Sumber Karbohidrat 69–80
[4] Asmarantaka R W and Zainuddin A 2017 Efisiensi dan Prospektif Usaha Tani Ubi Jalar (Studi Kasus Desa Petir, Dramaga, Jawa Barat, Indonesia) J. PANGAN 26 23–36
[5] Badan Pusat Statistik 2017 Indikator Ekonomi Bul. Stat. Bln.
[6] Sys. C., Van Ranst. E. D J 1993 land evaluation Part 3, Crop Requirements
[7] Sys C, Van Ranst E and Debyeve J 1991 Land Evaluation, Part I: Principles in Land Evaluation
and Crop Production Calculations *Agric. Publ. 7, Gen. Adm. Dev. Coop. Brussels, Belgium* 280

[8] Merugu T and Mathyam P 2015 Variability Study on the Length of Growing Period (Lgp) Using Ground and Space Based (Modis) Data for the

[9] Widiatmaka Sarwono Hardjowigeno dan 2007 evaluasi kesesuaian lahan dan perencanaan tata guna lahan (Gadjah Mada University Press)