



Research Paper

Development of Land Suitability Assessment Applications for Sorghum, Sweet Potato and Sugarcane

Supli Effendi Rahim¹, Muchtarudin Muchsir¹, Rosmiah¹, Iin Siti Aminah¹, Abid Djazuli², Ahmad Affandi Supli³, Nurhayati Damiri⁴, Nur Aslamiah Supli⁵

¹Agrotechnology Department, Agriculture Faculty, University Muhammadiyah Palembang, South Sumatra, Indonesia

²Faculty of Economics, University Muhammadiyah Palembang, South Sumatra, Indonesia

³Digital Media Technology Department, Xiamen University, Bandar Sunsuria, Sepang, Selangor, Malaysia

⁴Plant Pest and Disease Department, Faculty of Agriculture, Sriwijaya University, Indralaya, Ogan Ilir, South Sumatra Indonesia

⁵Faculty of socio and political science, University of Sriwijaya, Palembang, South Sumatra Indonesia

*Corresponding author: supliarahim31760@gmail.com

Article History: Received: February 13, 2024, Accepted: April 29, 2024

Abstract

Cultivation of food crops should be done on suitable land based on the results of the soil suitability assessment. The Soil Suitability Assessment Framework was initiated by the Food and Agriculture Organization (FAO). Today, smartphones have become a ubiquitous technology for solving problems in most environments, including: Assessment of soil suitability for food crops, plantations and many others. This white paper aims to address these benefits by transforming the framework into a mobile app. This solution aims to help land users conduct land valuations more effectively and efficiently. A rule-based system (RBS) algorithm is used to build the framework into a set of rules that are interconnected to draw land suitability conclusions. Regulations relate to annual rainfall, land topography, drainage, soil type, pH, flood risk, soil fertility, soil depth, etc. Only three of his food crops, sorghum, sweet potato, and sugarcane, will be evaluated in this study. Agroclimatic data governing crop suitability have evolved into generic and crop-specific criteria. An application that assesses land suitability for three food crops will be available on the Play Store for smartphones. Usability models were surveyed by 35 respondents who used the app. The user-friendliness of the app was evaluated as "very good."

Keywords

FAO framework, Food crops, Land suitability evaluation

1. INTRODUCTION

Soil is a complex, dynamic system that forms at the Earth's surface through the weathering of rock and the decomposition of organic matter. It is a medium for plant growth and a habitat for a diverse community of organisms. Soil is also an essential resource for food production, water filtration, and carbon sequestration (Hillel, 2013). Soil can support plants, including food crops. This is because soils are characterized by climatic influences and biological effects on matrix materials over time and under specific conditions (Susanto, 2005). Land valuation is part of the land use planning process (Rahim, 2013). The core of the assessment is the comparison of land use type requirements with land characteristics and qualities. Thus, local suitability classes for types of local potential or local use are known (Hardjowigeno and Widiatmaka, 2007).

Development of food crops in many parts of Indonesia and other parts of the world. B. Sorghum, sweet potato, and sugar cane contribute significantly to increasing yield

and growing area. To know exactly where the suitable area or potential is for each type of food crop, including suitable areas for increasing harvested and production areas for sorghum, sweet potato and sugar cane. Research to assess soil suitability for food crops should continue. Much has been written about land suitability classification. This classification was introduced by FAO in the late 1970s FAO (1976), and the values themselves were essentially measured by manual comparison of land characteristics to standard crop evaluation data. However, computing and assigning all these variables is much more time-consuming and labor-intensive than one might imagine (Djaenuddin, 1995; Rahim et al., 2015, 2016).

Many workers use manual methods to assess floor suitability. For example, Hermawan (2011) examines the suitability of the Bukit Asam Tanjung Enim coal mining area in South Sumatra, Indonesia. According to his research, the land after mining is generally suitable for plantation crops. Rahim (2013) conducted another manual land assessment to assess the suitability of plantation crops on post-mining

land. There are additional studies on land suitability of food crops (Harahap et al., 2021; Dumipto et al., 2019). These three studies evaluated soil suitability for sorghum, sweet potato and sugarcane, respectively.

In this research, we selected sorghum, sweet potato, and sugarcane for evaluation of soil suitability due to their distinct agronomic characteristics and significance in global agricultural systems. Sorghum is a drought-tolerant cereal crop that plays a crucial role in food security, especially in arid and semi-arid regions (Hadebe et al., 2017); sweet potato is a resilient root crop valued for its high nutritional content and adaptability to a range of environmental conditions (Andrade et al., 2016); and sugarcane is a major cash crop with high economic importance for sugar and bioenergy production (Matsuoka et al., 2015). These crops also represent a range of plant families and life forms (cereal, root crop, and grass, respectively), providing diverse insights into soil-plant interactions. The selection was further guided by the need to address research gaps in optimizing land use for these staple and economically vital crops, which are often grown under suboptimal soil conditions that limit yield and quality.

In contrast to the above studies, this paper reports on studies that successfully developed a mobile application that makes measurements more effective and efficient when assessing the land suitability of food crops. Research focuses on his three food crops: sorghum, sweet potato and sugar cane. This is an extension of previous work (Rahim et al., 2016, 2017) on land suitability assessment in mobile applications focused on plantations and food crops. Therefore, to create this application developed from the FAO framework, it is important to know the details of the framework.

2. EXPERIMENTAL SECTION

Criteria for soils suitable for food crops are set according to criteria established by scientists, such as sorghum, sweet potato, and sugarcane. Therefore, the rule-based system algorithm chosen in previous studies is rule-based system (RBS) (Rahim et al., 2015). The algorithm builds a framework based on a set of related rules and is used as a rule-based system (RBS) to arrive at a suitability conclusion. This approach involves the creation of a framework based on a set of rules established by domain experts, which are then implemented into the system to make decisions about soil suitability for various food crops. This algorithm operates by applying a set of predefined rules to input data related to soil characteristics and agroclimatic conditions to determine the suitability of soils for specific food crops.

To be exact, the expert table knowledge base consists of a database or tables (see Table 1) containing information on various criteria for soil suitability for different food crops. This knowledge base includes data on parameters such as annual rainfall, land topography, drainage, soil type, pH,

flood risk, soil fertility, and soil depth, which are utilized by the expert system to make decisions. The expert rules used in the rule-based system (RBS) are derived from scientific knowledge and expertise in agriculture. These rules define the relationships between input variables such as soil characteristics and agroclimatic conditions and the suitability of soils for different food crops. The expert decision-making process in the rule-based system (RBS) follows a structured decision tree approach. This decision tree guides the system through a series of rule-based evaluations based on input variables, ultimately leading to a conclusion regarding soil suitability for specific food crops. The data collection technique employed in this study involved surveying agroclimatic data from multiple sources, including meteorological records, soil surveys, and possibly remote sensing data. Additionally, usability data was collected through surveys administered to 35 respondents who utilized the application.

3. RESULTS AND DISCUSSION

Tables 1, 2 and 3 show the land suitability criteria for food crops (sorghum, sweet potato and sugarcane). The drawback of this table is that only some users will understand each term. Therefore, in order to achieve the purpose of this study (moving to the mobile app), we first need to simplify each of the land property variables and their limiting conditions. All terms have been simplified into simpler language with thorough explanations for better understanding by the user. See the Screenshots section for examples of such simplifications.

The feature of the land is now a multiple choice question for the user to answer. However, one or two variables are not included in the app because they are difficult to measure, so default values are used for variables with similar values by soil type or region. For example, annual rainfall is typically between 600 and 2500 mm. This value also exceeds 22 °C for daily temperatures.

3.1 Suitability assessment of food crops (Application and screenshots)

Previous studies have proven that soil suitability assessment is convenient and easy with mobile applications. Manual approaches require more effort to extract data from soil laboratory analyses, geophysical data, and Indonesian climate information. The point is that many things can be solved by plants demanding each other (Rahim et al., 2015). In this work, the author focuses on creating apps that address general and specific criteria for his three food crops: sorghum, sweet potato, and sugar cane. At the same time, the study strongly encourages the Indonesian government, especially the Ministry of Agriculture, students and land use planners, to use this application due to its simplicity, effectiveness and efficiency in land suitability assessment. This app is a must for land managers in many areas of Indonesia. Very simple (see Figures 1 and 2 and easy to

Table 1. General Criteria for evaluation of land for sorghum, sweet potato, and sugarcane.

Land characteristics	Limiting factors and suitability classes			
	S1	S2	S3	N
Climate condition (c)				
Rainfall (mm)	500-1200	400-500	300-400	<300
Temperature (°C)	24-29	29-32	32-35	>35
Topography				
Topography of slope (%)	<3	3-5	5-8	>8
Erosion hazard	-	Very light	Light	Medium-heavy
Drainage	Slow	Good	Very Slow	Fast
Flood hazard				
Height of flood	25	25-50	50-75	>75
Length of time	-	<7	7-14	>14
Nutrient availability (f)				
pH H ₂ O	5.5-7.0	4.5-5.5	<4.5	-
C-organic	>1.2	0.8-1.2	<0.8	-
N-total (%)	Medium	Low	Very low	-
P ₂ O ₅ (ppm)	High	Medium	Low	-
K-exch (me/100g)	Medium	Low	Very low	-
Alkalinities (n)				
ESP (%)	<20	20-30	30-40	>40
Base saturation (%)	>50	35-50	<35	-
Peat				
Thickness (cm)	<50	50-100	100-150	>150
Maturity	Sapric	Sapric-hemic	Hemic-fibric	Fibric
Sulphidic danger				
Depth of sulphidic	>100	75-100	40-75	<40

Source: Harahap et al. (2021); Amelia (2015); Dumipto et al. (2019)

implement, this application provides criteria for properties that users want to rate. Accelerate the completion of land suitability classes and see immediate results (see Figure 3).

3.2 Ease of use of the application

Usability was tested to measure several criteria of delivered applications. The mobile usability model of Hussain et al. (2013) has been chosen. This model is used because it is particularly suitable for use in mobile applications. His three characteristics of good usability for this model are effectiveness, efficiency, and satisfaction (see Table 2). Each of these characteristics is categorized into several sub-characteristics and guidelines. Extensive experiments and investigations were performed to evaluate all properties. Users are asked to complete several tasks that are observed and evaluated for accuracy, time spent, error free, etc.

We have selected a useful sample before testing the usability of the application. Relevant respondents are selected from all agricultural students, agricultural service workers, lecturers and planners who wish to participate (Bougie

and Sekaran, 2010; Rahim et al., 2015; Hermawan, 2011). Additionally, you can use the following rule of thumb to determine your sample size: (1) 30 to 500 respondents are suitable for most studies. (2) Even simple experimental studies can recruit 10–20 respondents if strict experimental controls are applied (Roscoe, 1975; Rahim et al., 2016). The study recruited 35 people for usability evaluation. For the demographics of these respondents, see Table 3. We also provided information (via PowerPoint) on how to use the prototype and answer the questionnaire. Finally, they were asked to complete several tasks and usability his questionnaires, one at a time, at their own pace. The questionnaire we created used a 5-point Likert scale (see Figure 4).

As previously mentioned, we asked respondents to complete multiple tasks. Reviewers then measured and recorded several metrics based on usability model guidelines. These are (1) time taken, (2) number of failures, (3) number of first successful task attempts, and (4) number of successful tasks over time. Data were then analyzed with SPSS software using descriptive analysis and frequency

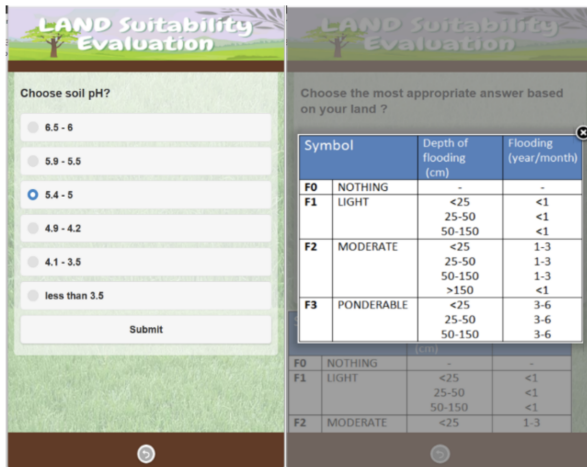


Figure 1. Soil pH and deep of flooding criteria questions

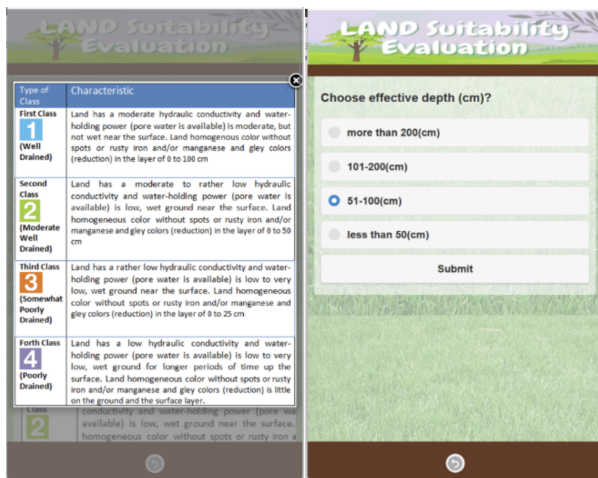


Figure 2. Land type class and effective depth (cm) criteria questions

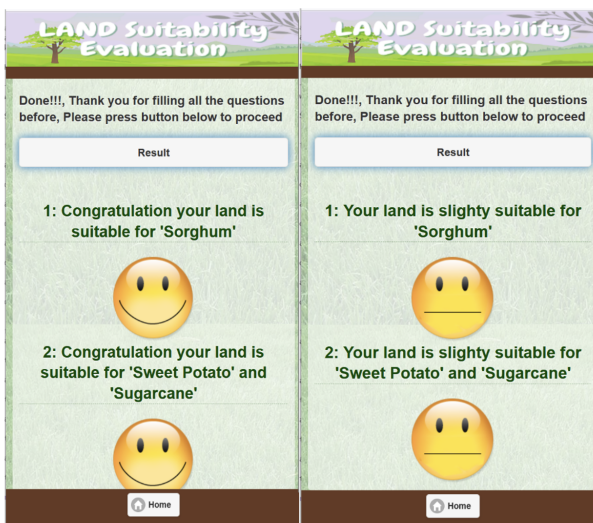


Figure 3. Example of results after filling all the criteria questions

Table 2. Usability Characteristics

Characteristic of the	Sub-Characteristic (Goal)	Guidelines
Effectiveness	Simplicity	- Ease to learn - Ease to input the data
	Accuracy	- Ease to use output - Ease to install
Efficiency	Time Taken	- Accurate - Should be error-free - Successful
	Features	- To respond - To complete a task - Support/help - Touch screen facilities - Voice guidance - System resources info - Automatic update
Satisfaction	Safety	- While using the application - While driving
	Attractiveness	User interface

Source: Modified from Rahim et al. (2016)

Table 3. Demography of respondents

Valid	Freq	Percent	Valid percent	% cumulative
Civil servant	7	20.0	20.0	28.6
Lecturers	10	28.6	28.6	48.6
Students	8	22.9	22.9	71.4
Farmers	10	28.6	28.6	100.0
Total	35	100.0	100.0	

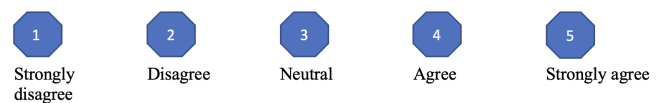


Figure 4. Likert Scale 5 Point

Table 4. Results of the sub characteristic statistic of the respondents

	Simplicity	Accuracy	Time taken	Features	Safety	Attractiveness
N Valid	35	35	35	35	35	35
N Missing	0	0	0	0	0	0
Mean	4.1232	3.812	4.3509	4.2108	4.1126	4.3579
Minimum	2.20	2.5	3.13	2.45	2.65	3.00
Maximum	5.00	5.00	5.00	5.00	5.00	5.00

Table 5. Results of quality characteristic

	Effectiveness	Efficiency	Satisfaction
N Valid	35	35	35
N Missing	0	0	0
Mean	3.9676	4.28085	4.23525
Minimum	2.35	2.78	2.825
Maximum	5.00	5.00	5.00

Table 6. The five-point Likert Scale

Range	Classification
1.00-1.80	Poor
1.81-2.61	Fair
2.62-3.41	Good
3.42-4.42	Very Good
4.43-5.23	Excellent

tools. This includes average, minimum, and maximum results for each maintainability characteristic. (See Tables 4 and 5).

Interpreting the results using the 5-point scale in Table 4, we found that all subcharacteristics scored 'very good scale', ranging from 3.812 to 4.357 points, based on our interpretation of Table 6. The result was an overall score of 'very good' for all three key dimensions of effectiveness, efficiency and satisfaction, reaching averages of 3.96, 4.28 and 4.23. From this we can conclude that all respondents have a good opinion of the usability of the system.

4. CONCLUSION

Tools have been developed to assess soil suitability for sorghum, sweet potato, and sugar cane. General and specific criteria for influencing crop soil suitability were developed from agroclimatic data from previous studies. Based on standards, mobile programs were designed and implemented with cross-platform technology. The usability of the app was surveyed among land users rated as 'very good', with average scores for all characteristics ranging from 3.812 to 4.357. The program is designed for cross-platform technology that allows the app to exist on his Android, iOS,

Windows and many other mobile operating systems. This app is important for land managers, farmers, agricultural service workers, food companies, especially those working in the food crop industry.

ACKNOWLEDGEMENT

The authors would like to thank the head of the institution for the many opportunities and financial support they provided during the development of the program and the writing of this paper.

REFERENCES

Amelia, S. (2015). Evaluasi kesesuaian lahan ubi jalar (*Ipomea batatas* L) melalui pendekatan zona agroekologi di Kecamatan Pariangan Kabupaten Tanah Datar

Andrade, M. I., A. Naico, J. Ricardo, R. Eyzaguirre, G. S. Makunde, R. Ortiz, and W. J. Grüneberg (2016). Genotype × environment interaction and selection for drought adaptation in sweetpotato (*Ipomoea batatas* [L.] Lam.) in Mozambique. *Euphytica*, **209**; 261–280

Bougie, R. and U. Sekaran (2010). *Research methods for business: A skill building approach*. Wiley, London

Djaenuddin, D. (1995). *Evaluasi lahan untuk arah pengembangan tanaman alternatif dalam mendukung kegiatan agribisnis*. Pusat Penelitian Tanah dan Agroklimat, Bogor

Dumipto, K., M. Rayes, and C. Agustina (2019). Evaluation of Land Suitability for Sugarcane in Wonosari Formation Karst Land (TMWL), Gedangan District, Malang Regency. *Journal of Soils and Land Resources*, **6**(2); 1361–1374

FAO (1976). *A Framework for Land Evaluation*. Soil Resources Development and Conservation Service Land and Water Development Division Food and Agriculture Organization of the United Nations

Hadebe, S. T., A. T. Modi, and T. Mabhaudhi (2017). Drought tolerance and water use of cereal crops: A focus on sorghum as a food security crop in sub-Saharan Africa. *Journal of Agronomy and Crop Science*, **203**(3); 177–191

Harahap, F. S., R. Rahmaniah, S. H. Sidabuke, and M. Zuhirsyan (2021). Evaluasi kesesuaian lahan tanaman sorgum (*shorgum bicolor*) di kecamatan bilah barat, kabupaten labuhanbatu. *Jurnal Tanah dan Sumberdaya Lahan*, **8**(1); 231–238

Hardjowigeno and Widiatmaka (2007). *Evaluasi kesesuaian*

- lahan dan perencanaan penggunaan lahan. Gadjah Mada University Press, Yogyakarta
- Hermawan, B. (2011). Peningkatan kualitas lahan bekas tambang melalui revegetasi dan kesesuaian sebagai lahan tanaman. In *Prosiding Seminar Nasional Pertanian. Urgensi dan Strategi Pengendalian Alih Fungsi Lahan Pertanian*. Bengkulu
- Hillel, D. (2013). *Introduction to soil physics*. Academic Press
- Hussain, A., N. L. Hashim, N. Nordin, and H. M. Tahir (2013). A Metric-Based Evaluation Model for Applications on Mobile Phone. *Journal of Information and Communication Technology (JICT)*, **12**; 55–71
- Matsuoka, S., J. Bressiani, W. Maccheroni, and I. Fouto (2015). Sugarcane bioenergy. In *Sugarcane*. Academic Press, pages 383–405
- Rahim, S. (2013). Klasifikasi kesesuaian lahan untuk pascatambang dan PT. Bukit Asam Tanjung Enim South Sumatra Indonesia. In *Makalah dipresentasikan dalam Seminar Lahan Pascatambang di Indonesia*. Universitas Sriwijaya
- Rahim, S., A. Supli, and N. Damiri (2016). Developing a land suitability evaluation in mobile android application for rubber, cocoa and oil palm. *Journal of the International Society for Southeast Asian Agricultural Sciences (J. ISSAAS)*, **22**(2); 80–90
- Rahim, S., A. Supli, and N. Damiri (2017). Soil Loss Prediction on Mobile Platform Using Universal Soil-Loss Equation (USLE) Model. In *MATEC Web of Conferences*, volume 97. page 01066
- Rahim, S., A. Supli, N. Shiratuddin, Nurhayati, and Z. Mukti (2015). A conformity tool for land evaluation in android mobile application. In *Paper presented in IJCIMBI Banda Aceh Indonesia*
- Roscoe, J. (1975). *Fundamental Statistic for Behavioural Science*. Holt, New York
- Susanto (2005). *Anak Muda dan Pertanian, redaktur Winangun, Wartoyo, Membangun Karakter Petani Organik Sukses di Era Globalisasi*. Penerbit Kanisius, Yogyakarta