Garlic Land Suitability System based on Spatial Decision Tree

Imas Sukaesih Sitanggang[1], Andi Nurkholis[1], Annisa[1] and Muhammad Asyhar Agmalaro[1]
[1]*Department of Computer Science, IPB University, Darmaga,Jl. Meranti Wing 20, Level V,Bogor 16680, Indonesia*

Keywords: classification, decision tree, garlic, land suitability, spatial ID3 algorithm

Abstract: Domestic garlic needs are not equal to the production level that leads to high import of garlic to meet the domestic consumption. Land suitability identification for garlic is required in order to increase domestic garlic production. The spatial classification method can be used to determine garlic land suitability classes based on the garlic planting criteria. This study aims to develop a web-based application to visualize the garlic land suitability classes based on the spatial decision tree which was created using the spatial ID3 algorithm. The application has four main functions namely visualization of garlic land suitability in map, user profile management, land suitability information, and garlic varieties information.

1 INTRODUCTION

Garlic is one of the horticultural crops commodities that are needed by most of Indonesian, especially for consumption as a cooking spice and food flavoring. Local garlic production in 2016 is 21,150 thousand tons however the need of garlic reach 470,031 thousand tons and it increases 8.78% in average per year (BPS, 2017). Domestic garlic needs are not equal to the production level, therefore import is done in order to meet the domestic garlic consumption. The low garlic production is the basis for the government to launch a projection of garlic self-sufficiency. In 2020-2029 the government will develop an area for growing garlic. The plan aims to increase the level of domestic garlic production (Holtikultura, 2017). There is a problem in preparing the area for planting garlic, namely the lack of land for garlic, so identifying the land suitability of garlic id required (Statistik, 2015). Land suitability identification is conducted using land suitability analysis techniques.

Land suitability evaluation is the process of estimating land suitability classes and potential land uses for agriculture. Land suitability class describes the level of land suitability for a particular use. Land evaluation is conducted to assess the potential of land for a certain crop by providing the growth requirements for the crop.

Studies on land suitability have been done by many researchers in several countries including Indonesia.

A spatial model for land suitability evaluation for wheat crop integrated with Geographical Information System (GIS) was proposed (El Baroudy, 2016). The proposed model showed that about 71.44% of the total area fall within the highly suitable class and the moderately suitable class for wheat crop. (Chairani et al., 2017) determines the physical land suitability for civet Arabica coffee in Bandung and Bandung Barat, Indonesia based on the criteria temperature, rainfall, humidity, duration of dry season, slope, altitude, type of soil, soil texture, and erosion potential. Land suitability using GIS for annual crops: Thanh Tra pomelo, rubber, and stAcacia mangium in Thua Thien Hue province Vietnam was evaluated based on soil type, slope, terrain elevation, soil layer thickness, mechanical composition, humus content, bio-climatic conditions and irrigation (Dan, Ping and Lang, 2018). The level of suitability to shallot and lemon in Harian District, Samosir Regency Indonesia was determined in the previous study (Tampubolon et al., 2018). (Setyowati et al., 2018) estimates both production and productivity of rice, maize, and cassava using land suitability approach in Karangasem Regency, Bali Indonesia. This study applied remote sensing and GIS techniques. An assessment on a spatial basis was conducted using GIS for agricultural land suitability evaluation of rice (irrigated paddy field, rainfed rice) and corn (Ramlan et al., 2018). Spatial data used in this study include digital topographic map, soil survey, soil characteristics, as well as climate data.

GIS and remote sensing technology have been widely used in studies of land suitability evaluation. However, the land suitability evaluation requires large

Sitanggang, I., Nurkholis, A., Annisa, . and Agmalaro, M.
Garlic Land Suitability System based on Spatial Decision Tree.
DOI: 10.5220/0009908002060210
In *Proceedings of the International Conferences on Information System and Technology (CONRIST 2019)*, pages 206-210
ISBN: 978-989-758-453-4

spatial data of crop planting conditions especially for large study area. In order to obtain interesting patterns from the large spatial data in evaluating land suitability, spatial data mining can be applied. One of spatial algorithms that can be used in modelling land suitability for crop is spatial decision tree. A spatial decision tree is a classification model for determining the class label of objects based on their characteristics. Our previous study has been successfully a spatial decision tree for garlic land suitability in Magetan district, East Java province and Solok district, West Sumatra province Indonesia. However, the model could not easily be interpreted by users. Therefore, this study aims to develop a visualization module of spatial decision tree for garlic land suitability. The following discussion is divided as follows. Section 2 discusses data, study area, and briefly explain the methods applied in this study. Result and discussions are briefly discussed in Section 3. We summarize our work and future work in Section 4.

2 METHODS

2.1 Data

The study area is Magetan district, East Java province Indonesia with an area of 70,143 ha (dan Pengembangan Sumberdaya Lahan Pertanian (BBSDLP), 2017) and Solok district, West Sumatra province Indonesia with an area of 335,086.53 ha (dan Pengembangan Sumberdaya Lahan Pertanian (BBSDLP), 2017). The two districts are predicted to be the center for producing garlic for Indonesia in the future (Holtikultura, 2017). The data used in this study are provided in Figure 1.

Data	Source
Drainage, relief (%), base saturation (%), cation exchange capacity (cmol), soil texture, soil pH (°), and depth of soil mineral (cm)	BBSDLP (Indonesian Center for Agricultural Land Resources Research and Development, Indonesia)
Rainfall (mm) and temperature (°c)	BMKG (Meteorological, Climatological, and Geophysical Agency. Indonesia)
Elevation (masl) in raster format	USGS (United States Geological Survey)

Figure 1: Data and Its Source.

2.2 Research Step

This study was conducted in several steps including data preprocessing, spatial decision tree model and developing a visualization module for garlic land suitability. In the data pre-processing stage, we performed spatial interpolation for weather data using the ordinary co-kriging (Adhikary et al., 2017). In addition, spatial operations were applied on Digital Elevation Model (DEM) data to produce an elevation layer in vector format. Explanatory and target layers for spatial task relevant data were prepared after spatial feature validity test was performed.

Spatial decision tree was created on the garlic planting criteria dataset using the algorithm the spatial ID3 algorithm (Sitanggang et al., 2013). The use of spatial decision tree algorithms is based on the importance of considering spatial data relations (i.e., position, distance, orientation, etc.) in the analysis of geographically referenced data carried out in this case of land suitability (Rinzivillo and Turini, 2004). The tree was developed by splitting the spatial dataset into smaller datasets by selected the best feature for data partition. The measurement used to select the splitting feature is spatial information gain in which the features with the highest spatial information gain will be selected as the label of root of sub tree in each iteration.

The visualization module of spatial decision tree was developed in order to provide the classification model for garlic land suitability. There are four main functions available in the system namely 1) visualization of garlic land suitability in map, 2) user profile management, 3) Land suitability information, and 4) Garlic varieties information. The system was developed using the following software:

- Laravel as the backend framework to integrate database and the user interface
- Bootstrap as the front end to provide webbased interface
- Leaflet.js is used as the API frontend of map at web-based interface
- PostgreSQL with the PostGIS extension as spatial database management system

3 RESULTS AND DISCUSSION

The spatial ID3 algorithm (Sitanggang et al., 2013) was implemented on the garlic spatial dataset to result a spatial decision tree for garlic land suitability. The dataset contains ten explanatory layers and one target layer which is Land suitability. The attributes of each layer for two study area namely Magetan dan Solok are provided in Figure 2.

Layers name	Attributes
Elevation (masl)	Low (≤600), slightly low (601−850), slightly high (851−1000), high (>1000)
Drainage[a]	Slightly swift, good, slightly good, slightly hamper, hampered
Relief (%)	Flat (0), slightly flat (1−3), slightly slope (4−8), slope (9−15), slightly steep (16−25), steep (26−40), very steep (>40)
Base saturation (%)	Very low (<20), low (20−35), medium (36−60), high (61−80)
Cation exchange capacity (cmol)	Very low (<5), low (5−16), medium (17−24), high (24−40)
Soil texture[a]	Smooth, slightly smooth, medium, slightly coarse
Soil pH (°)	Acid (4.5−5.5), slightly acid (5.6−6.5), neutral (6.6−7.5)
Depth of soil mineral (cm)	Very shallow (<25), shallow (25−50), medium (51−75), deep (76−100), very deep (>100)
Rainfall (mm)	Low (≤ 250), slightly low (251−300), slightly high (301−350), high (>350)
Temperature (°c)	23, 24, 25, 26
Land suitability	Highly suitable, moderately suitable, marginally suitable

Figure 2: Spatial Data of The Garlic Planting Criteria.

The rules in land suitability evaluation can be extracted from garlic planting criteria dataset using the classification method. The class labels of the dataset in this classification task represent garlic land suitability classes namely S1 (highly suitable), S2 (moderately suitable), and S3 (marginally suitable).

The implementation of spatial ID3 algorithm on Magetan dataset result as many 33 rules whereas on the Solok dataset result as many 66 rules. The examples of rules generated from Magetan dataset are as follows:

- IF relief = steep AND elevation = high AND temperature = 24° c AND rainfall = high AND depth of soil mineral = deep AND Soil pH = slightly acid AND soil texture = medium AND cation exchange capacity = low AND base saturation = medium THEN land suitability = S1 (highly suitable)
- IF relief = steep AND elevation = low THEN land suitability = S2 (moderately suitable)
- F relief = flat AND rainfall = rather low AND depth of soil mineral = very deep THEN land suitability = S3 (marginally suitable)

The examples of rules generated from Solok dataset are as follows:

- IF soil texture = smooth AND cation exchange capacity = height AND depth of soil mineral = very deep THEN land suitability = S1 (highly suitable)
- IF soil texture = smooth AND cation exchange capacity = very low AND relief = slightly steep AND elevation = rather high AND temperature = 25°c AND rainfall = high THEN land suitability = S2 (moderately suitable)
- IF soil texture = slightly coarse AND Soil pH = acid and base saturation = height THEN land suitability = S3 (marginally suitable)

Figure 3 shows the Garlic land suitability in Solok dan Magetan district. The area of garlic land suitability for each class is illustrated in Figure 4, Figure 5 and Figure 6. While land suitability description and garlic varieties recommended by the Indonesian government are shown in Figure 7 and Figure 8.

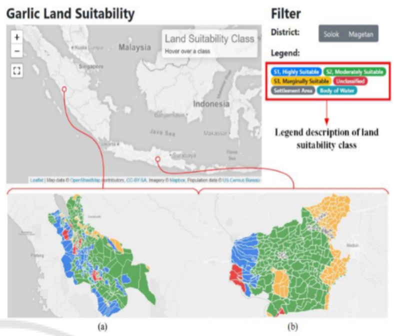


Figure 3: Garlic land suitability in (a) Solok dan (b) Magetan

Figure 4: The area of garlic land suitability class S1 (highly suitable) in Solok

The garlic varieties menu in Figure 8 provides information on garlic varieties recommended by the Ministry of Agriculture, which produces reliable seed varieties with a yield of at least 9 tons/ha. This feature can be used to obtain recommendation of garlic commodities to be cultivated in Indonesia, for the achievement of selfsufficiency in garlic by 2033.

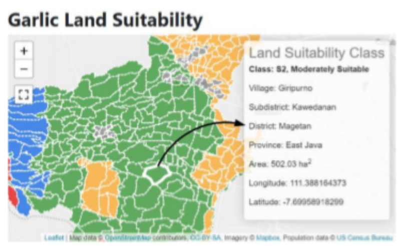


Figure 5: The area of garlic land suitability class S2 (moderately suitable) in Magetan

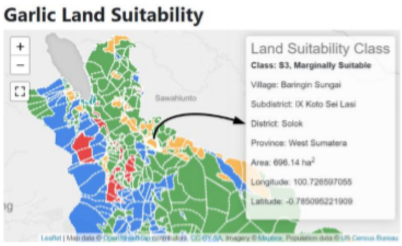
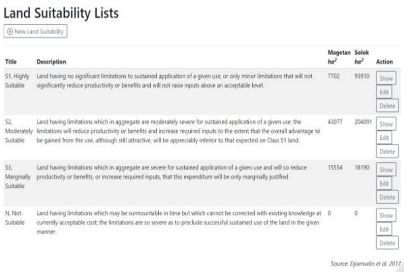


Figure 6: The area of garlic land suitability class S3 (marginally suitable) in Solok



Land Suitability Lists

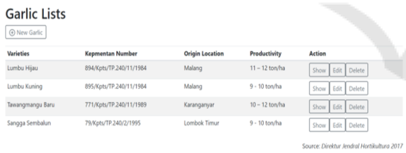
New Land Suitability

Title	Description	Magetan ha²	Solok ha²	Action
S1, Highly Suitable	Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.	7702	93910	Show Edit Delete
S2, Moderately Suitable	Land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land.	43077	204091	Show Edit Delete
S3, Marginally Suitable	Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.	15554	18190	Show Edit Delete
N, Not Suitable	Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in the given manner.	0	0	Show Edit Delete

Source: *Djaenudin et al. 2017*

Figure 7: Land suitability description

The land suitability description menu in Figure 7 provides information on land suitability classes and their area in Solok and Magetan district. With this feature, it is expected to provide information to relevant parties (farmers, private sector, and Indonesian government) in knowing the capabilities of Solok and Magetan district for garlic farming.



Garlic Lists

New Garlic

Varieties	Kepmentan Number	Origin Location	Productivity	Action
Lumbu Hijau	894/Kpts/TP.240/11/1984	Malang	11 – 12 ton/ha	Show Edit Delete
Lumbu Kuning	895/Kpts/TP.240/11/1984	Malang	9 - 10 ton/ha	Show Edit Delete
Tawangmangu Baru	771/Kpts/TP.240/11/1989	Karanganyar	10 – 12 ton/ha	Show Edit Delete
Sangga Sembalun	79/Kpts/TP.240/2/1995	Lombok Timur	9 - 10 ton/ha	Show Edit Delete

Source: *Direktur Jendral Hortikultura 2017*

Figure 8: Garlic varieties recommended by the Indonesian government

Although land suitability analysis produces suitable class for garlic plant, it does not give a guarantee that this area can be used for planting garlic. This is because not all existing land use is used to grow garlic. Figure 3 to Figure 6 show that there are labels other than land suitability class (highly suitable, moderately suitable, marginally suitable), namely settlement area, water body, and unclassified. Therefore, we need to decide the exiting land uses that can be used for garlic plants. Figure 9 provides area of land suitability class for garlic in Magetan and Solok district.

District	Land suitability class	Area (ha)	%
Magetan	S1, highly suitable	7,702.11	10.98
	S2, moderately suitable	43,077.36	61.41
	S3, marginally suitable	15,554.01	22.17
	Settlement area	1,570.02	2.24
	Water body	35.65	0.05
	Unclassified	2,203.85	3.14
	Total	**70,143**	**100**
Solok	S1, highly suitable	93,910.69	28.03
	S2, moderately suitable	204,091.87	60.91
	S3, marginally suitable	18,190.07	5.43
	Water body	6,717.61	2
	Unclassified	12,176.29	3.63
	Total	**335,086.53**	**100**

Figure 9: Area of Land Suitability Class for Garlic.

In Figure 9 it can be seen that there are area that cannot be planted with garlic because it has a function as settlement area and body of water. Settlement area information indicates that cultivation/planting of garlic in the area cannot be carried out due to social conditions (the area is a community settlement), while water body is an area that cannot be planted with garlic because the terrain/location is water. The unclassified area label is an area where the rule based model can not predict the land suitability classes. Unclassified cases can be caused by the non-representative dataset in creating classification models, so that when the resulting rules are applied to data for spatial visualization, the data cannot be classified into a land suitability class.

A desktop application for Indonesian crop land suitability has been developed based on the fuzzy inference system (Insani et al., 2015). In addition, an expert system based on fuzzy genetic was built for land suitability of paddy and corn (Hartati and Sitanggang, 2010). Both studies do not include the spatial relations that appear in the data of growing requirement of crop. The advantage of this proposed system is its ability to include the spatial relations as the important aspect in the land suitability evaluation.

The development of geographic information system of garlic land suitability in this study is expected to be used as an interactive mapping visualization that can be directly accessed by the community. This application may support the target of the Indonesian government in achieving garlic self-sufficiency in 2033 which one way to reach this target is to expand the existing garlic farmland. The application developed in this study is expected to facilitate the determination of suitable land areas for garlic farming, especially in Magetan and Solok district. Information on land suitability class is expected to reduce errors in determining the area to be used as garlic farming which is very important, because it will affect the amount of garlic production.

The main advantage of this system is that the system provides more specific information about land suitability, namely to the village level. The result of this study also shows that a village can consist of more than one land suitability class. The system has been able to accommodate this situation by providing information on the area of a land suitability class in a village. Thus, users are expected to know the area of land suitability S1 / S2 / S3 in a village in detail. An example can be seen in Figure 2., which shows the Garabak Data village has two land suitability classes, namely S1 (blue legend) and S2 (green legend), where S1 has an area of 3,774.49 ha. It is also made easier by the availability of longitude and latitude information that will show users to get to a location more accurately.

4 CONCLUSIONS

This study has been successfully implemented the visualization module for spatial decision tree representing garlic land suitability. The spatial ID3 algorithm results 33 rules on Magetan dataset and 66 rules on Solok dataset. Those rules were implemented in a web-based application that represent the area of garlic land suitability classes in Magetan and Solok Indonesia. System testing will be conducted as the future work by comparing the output of the application to the knowledge from experts and real garlic land suitability in the study area.

ACKNOWLEDGEMENTS

The authors would like to thank to Directorate of Research and Community Service, Ministry of Research, Technology and Higher Education, Republic of Indonesia for the research grant.

REFERENCES

Adhikary, S. K., Muttil, N., and Yilmaz, A. G. (2017). Cokriging for enhanced spatial interpolation of rainfall in two australian catchments. *Hydrological processes*, 31(12):2143–2161.

Chairani, E., Supriatna, J., Koestoer, R., and Moeliono, M. (2017). Physical land suitability for civet arabica coffee: Case study of bandung and west bandung regencies, indonesia. In *IOP Conference Series: Earth and Environmental Science*, volume 98, page 012029. IOP Publishing Ltd.

dan Pengembangan Sumberdaya Lahan Pertanian (BBSDLP), B. B. P. (2017). Peta tanah semidetail kabupaten solok besar skala 1: 50.000. bogor (id).

Hartati, S. and Sitanggang, I. S. (2010). A fuzzy based decision support system for evaluating land suitability and selecting crops. *Journal of Computer Science*, 6(4):417.

Holtikultura, D. J. (2017). Pengembangan bawang putih nasional.

Insani, F., Sitanggang, I. S., et al. (2015). Expert system modeling for land suitability based on fuzzy genetic for cereal commodities: Case study wetland paddy and corn. *Telkomnika*, 13(3).

Ramlan, A., Baja, S., Arif, S., and Neswati, R. (2018). Gis-based agroecological assessment of land suitability for food crop development at a regional scale: A study case of buton island. In *IOP Conference Series: Earth and Environmental Science*, volume 157, page 012024. IOP Publishing.

Rinzivillo, S. and Turini, F. (2004). Classification in geographical information systems. In *European Conference on Principles of Data Mining and Knowledge Discovery*, pages 374–385. Springer.

Setyowati, H., Murti, S., Nurani, R., Susanti, E., Puspitasari, S., Ariyani, R., Firdausi, A., et al. (2018). Applied geo-eye imagery and gis for estimating crop production based on land suitability in karangasem regency, bali. In *IOP Conference Series: Earth and Environmental Science*, volume 165, page 012025. IOP Publishing.

Sitanggang, I. S., Yaakob, R., Mustapha, N., and Ainuddin, A. (2013). Classification model for hotspot occurrences using spatial decision tree algorithm. *Journal of computer science*, 9(2):244.

Statistik, B. P. (2015). Produksi, luas panen dan produktivitas sayuran di indonesia. *Badan Pusat Statistik dan Direktorat Jenderal Hortikultura, Jakarta*.

Tampubolon, E. et al. (2018). Evaluation of land suitability for shallot (a. ascalonicum l.) and orange (orange sp.) at harian district of samosir regency. In *IOP Conference Series: Earth and Environmental Science*, volume 122, page 012035. IOP Publishing.