

# Land suitability evaluation for clove plants in Bacan Island

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## Land suitability evaluation for clove plants in Bacan Island

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**Abstract.** Clove is a superior crop and the main source of income for farmers in South Halmahera, especially in Bacan island. There is an increase in the clove planting area since 2013. However, clove productivity in 2017 decreased by 32% from 2013 to 2017. The factors that influence clove production are the environment and the soil condition. Clove plants to be able to grow and produce require specific growing environmental requirements. Environmental factors that influence clove plants include climate, height and type of soil. This study aims to analyze the suitability of land for clove plants on Bacan Island. Methods for collecting land resource data include primary data surveys and secondary data collection. The land suitability evaluation was carried out according to the limiting approach. The results of land suitability analysis at the subclass level in several districts in the Bacan Island for clove plants showed that the suitability of land suitability varied (S1, S2, S3, and N) between districts with limiting factors are erosion hazard and the effective depth roots.

### 1. Introduction

Indonesia is the largest clove (*Syzygium aromaticum* L.) producer country in the world wherein 2016 Indonesia has produced 39.5 thousand metric tonnes of clove [1]. Clove is classified as spice plants where In Indonesia, its flower buds are used to add flavor to food even tobacco and also as medicine. Clove plantation in Indonesia distributes in Java Island, South Sulawesi, and the Moluccas. However, Moluccas is the first area where clove was developed and contributes 12.48% of the second largest national production after South Sulawesi (13,51%) [2] and mostly cultivated by family farms [3].

One of the clove producing areas in the Maluku islands in the southern Halmahera district (including the Bacan Islands). Even though the area of clove plantations has increased from 3,170 ha in 2013 to 4,055 ha in 2017 but the production of cloves in this district has decreased 32% where production in 2013 was as much as 657 tons and decreased to 724 tons in 2017 [4,5]. The decreasing of clove production influenced by the age of old plants [2] and the declining quality of land [3]. Therefore, in increasing the production of cloves in South Halmahera, efforts were made to rehabilitate plants in 600 ha of clove plantations where 397 ha (66.16%) were located on Bacan Island and land expansion of 100 ha [5].

To grow and produce optimally an agricultural commodity it requires land with a certain quality, characteristics, and management [6–8]. It often happens that a commodity that is cultivated in an area can be grown in a fertile manner, but is unable to produce optimally because the requirements for generative growth are not fulfilled by the land concerned. This means that agricultural development programs must be based on land suitability, potential, and availability.



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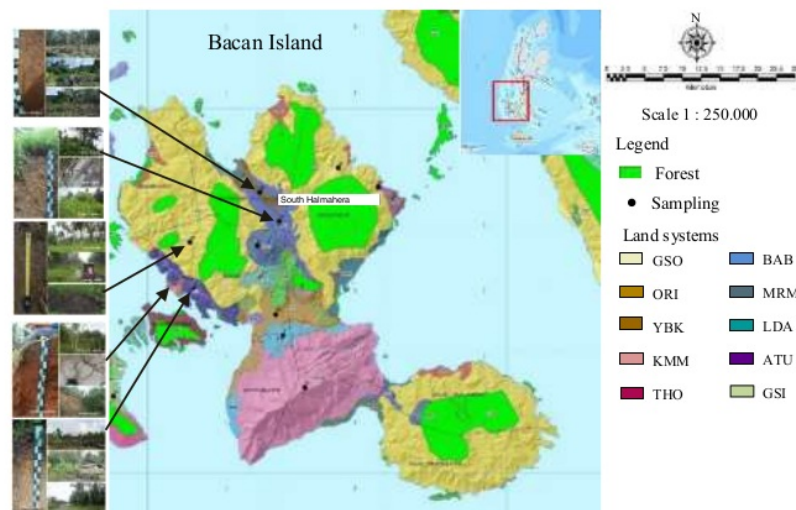
Land suitability evaluation can be done at the level of orders, classes, sub-classes, and land suitability units. Based on the FAO-Frame Work for Land Evaluation [9], the classification of land suitability at the level of the order is divided into two main groups namely land suitability at the level of the "S" Order and the "N" Order. Order "S" is a suitable for certain uses land and can provide profitable production. The "N" order land means not suitable for planting because the results cannot overcome the problem of the characteristics of land resources and the large number of inputs needed.

The purposes of this study are to identify the potential of land resources for the development and management of clove plants, and to analyzing various constraints of clove plant development and management related to the land characteristics resources in Bacan Island, South Halmahera Regency.

## 2. Methodology

### 2.1. Study site

The land evaluation for the clove commodity on Bacan island was conducted from July to December 2017. Geographically, Bacan island located in  $0^{\circ} 40' 0''$  S,  $127^{\circ} 30' 0''$  E. Administratively, Bacan Island is included in area of South Halmahera Regency, North Maluku province, Indonesia and covers 7 districts are Bacan Barat, Bacan Barat Utara, Bacan, Bacan Timur, Bacan Selatan, Bacan Timur Tengah, and Bacan Timur Selatan. Based on the classification of Schmidt-Ferguson, the climate in Bacan island is classified into type B climate (tropical rain forest). The soil types in the Bacan Islands are classified into Typic Hapludalfs, Typic Kanhanplohums, Typic Hapludolls, Lithic Haprendolls, Typic Dystrudepts, Typic Udivitrands, Typic Sulfaquents, and Typic Udipsamments. the land observation point and the location of soil sampling can be seen in figure 1.



**Figure 1.** Map of Study site and sampling location in Bacan Island, South Halmahera Regency

### 2.2. Data

The technique to get the data was a land survey, observation, identification, direct measurement, and sampling in the field. Climate data obtained from the Climatology station of Meteorology Station Class III of Labuha. Land unit map overlaid by using a land system and land use maps. Land unit in Bacan Island was divided into 30 land units where each land unit has a different land characteristic. Topography, land use, main material, and drainage was observed in the fields. Soil profiles were made for observing soil layer thickness, soil color, texture, structure, consistency, rooting, porosity, un-

permeable layer, sand layer, water layer, etc. In addition, soil sampling in the field was carried out based on field observation guidelines by the Bogor Soil Research Center and the Guidelines for Soil Profile Description by FAO. Field sampling and laboratory analysis follow standardized methods or procedures follow the Indonesian National Standard (SNI).

### 2.3. Data analysis

2.3.1. *Soil properties.* Soil samples were analyzed at the Soil Fertility and Chemistry Laboratory, Department of Soil Science, Faculty of Agriculture, Universitas Hasanuddin. Soil parameters to be analyzed in detail can be seen in table 1.

**Table 1.** Soil analysis parameters and analysis methods used.

Soil Parameters	Analysis Method
Soil texture (3 fractions)	Hydrometer
pH (H <sub>2</sub> O)	pH meter
C-organic	Walkey-Black
Total of Nitrogen	Kjehldahl
Cation Exchange Capacity (CEC)	NH <sub>4</sub> -Ac pH 7
Aluminium content (Al)	NH <sub>4</sub> -Ac pH 7
P <sub>2</sub> O <sub>5</sub>	Olsen
K <sub>2</sub> O	NH <sub>4</sub> OAC pH 7
Exchange bases (Ca, Mg, K, and Na)	NH <sub>4</sub> OAC pH 7

2.3.2. *Land suitability evaluation.* The land suitability evaluation method is carried out according to the limiting approach developed by [10]. Limiting approach method is a qualitative and traditional method in land evaluation [11]. However, currently the method is still widely used by land evaluation researchers [12]. Limiting approach in land evaluation with the following steps:

1. Determination of climate characteristics.
2. Determination of climate characteristics based on crop requirements [10]
3. Determination of limiting levels for each climate characteristic.
4. Link the limiting level with the climate suitability class
5. Determination of the Limiting Level and land suitability class for clove commodities as listed in table 2.

**Table 2.** Criteria for limiting levels and land suitability class [9]

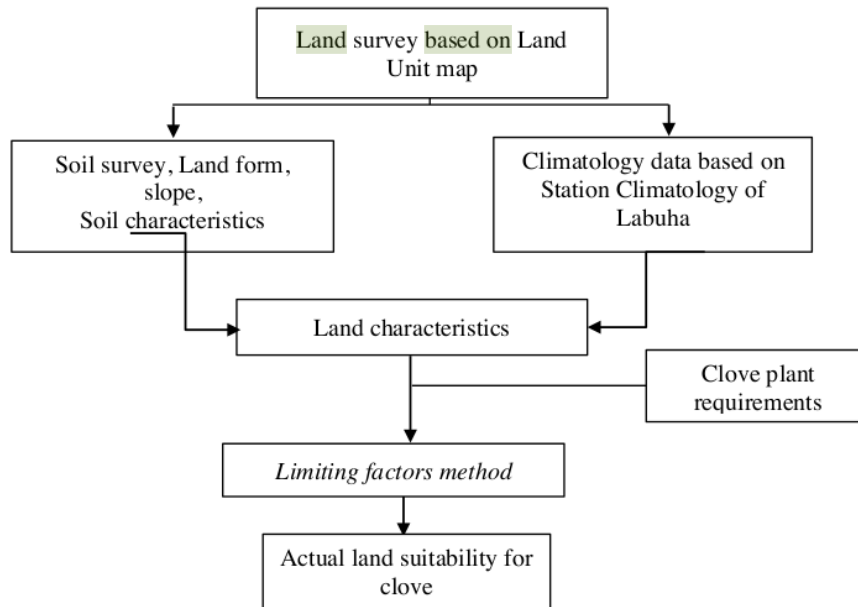
Limitation Levels	Land Suitability Class
0, without limitation	S1, very suitable
1, slight limitation	S1, very suitable
2, moderate limitation	S2, sufficiently suitable
3, severe limitation	S3, marginal suitable
4, very severe limitation	N1 dan N2, Unsuitable

The stages of research on land suitability evaluation for the development of clove plants in Bacan Islands, South Halmahera Regency can be seen in detail in figure 2.

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### 3. Results and discussion

#### 3.1. Climate



**Figure 2.** The stages of research on land suitability evaluation for clove plants in Bacan island, South Halmahera Regency, Indonesia.

Environmental factors that affect clove plants include climate, height and type of soil. Optimal rainfall for the development of clove plants is 1,500 - 2,500 mm a year or 2,500 - 3,500 mm a year with a dry month of less than two months. The intensity of radiation 61 - 60% and the air temperature 22 - 28 °C and no strong winds throughout the year. Climate parameter in Bacan island shows that rainfall, temperaruter is very suitable (S1) for clove cultivation and humidity is suitable (S2). Amount of rainfall in Bacan island is 1,834.1 mm/year, average temperature and humidity are 26.5 °C and 80%, respectively. The climate condition of rainfall, temperature, and relative humidity in Bacan island can be seen in figure 3.

#### 3.2. Topography

The morphological shape of the Bacan island is influenced by past tectonic processes that form fold structures in the form of anticline and syncline. The last tectonic process occurred during the Holocene era which was marked by the removal of coral reefs to the mainland that can be found around South Bacan. This causes the existence of very steep mountains with slope class  $\geq 30\%$ . However, there are also alluvial plain (0-3% slope class) which are spread in the coastal and alluvial part of Bacan island river.

#### 3.3. Soil properties

Clove plants to be able to grow and produce require specific growing environmental requirements. Suitable soil for clove is loose soil, a minimum of 1.5 m if the layer and a depth of ground water more than 3 m from the surface of the soil and no impermeable soil layer. Suitable soil types include Andosol, Latosol, Regosol and Red Podsolik. Based on the results of soil analysis in the laboratory, it is known that the soil texture in Bacan island varies from clay, clay loam, sandy clay loam, dusty clay,

and clay. In addition, the color of the soil is dominated by dark yellowish brown. Soil acidity (pH) also plays a role in stimulating plant growth. Optimum soil acidity ranges from 5.5 - 6.5. If the soil pH is lower or higher then the growth of clove plants will be disrupted because the absorption of nutrients by the roots becomes inhibited. To reduce the risk of failure and high costs in clove cultivation, it is recommended that clove plants only be developed in highly suitable and suitable areas. The soil properties in Bacan island can be seen in table 3.

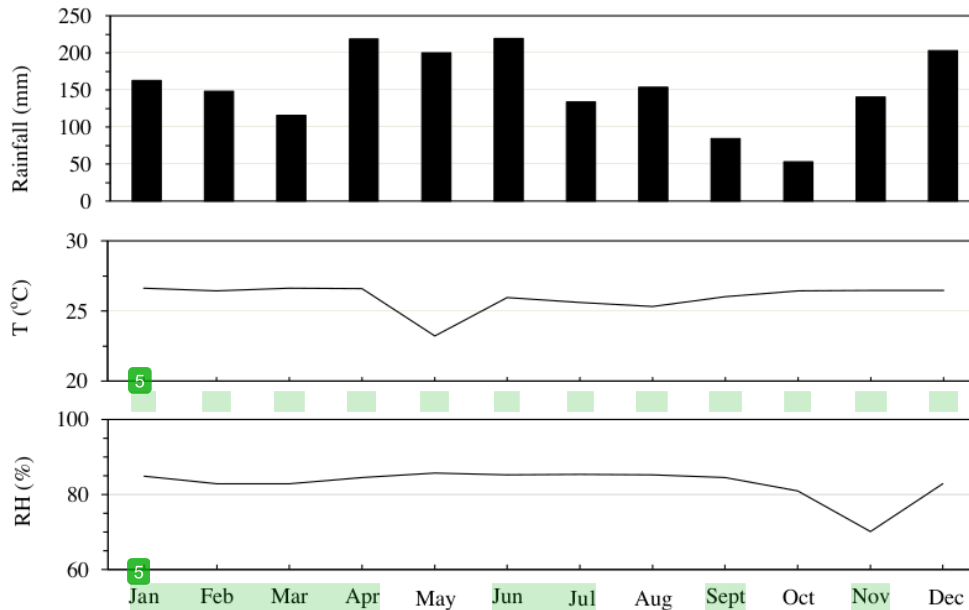


Figure 3. Climate condition in Bacan island from 2010 to 2015

Table 3. Soil Properties in Bacan island, South Halmahera regency, Indonesia

Parameters	Value	Criteria
pH	6.1	Rather acid
C-organic	2.0	Moderate
N-total	0.2	Low
P2O5	13.3	Moderate
KTK	22.3	Moderate
KB (%)	57.9	Moderate

Note: the soil analysis criteria based on the Bogor Soil Research Institute, 2004.

4. Land suitability for Clove

The results of the land suitability analysis at the subclass level and their distribution in several sub-districts in the Bacan Islands, South Halmahera Regency for clove plants are shown in Table 4 and its distributin can be seen in figure 4. The results of the land analysis of 30 land units in Bacan Island show that there is land that is classified as very suitable (S1) and without any significant growth limiting factors for clove plant development. The land is located in the land units 13 and 27. On the other hand, some land units are classified as inappropriate (N) for the development of clove plants. Land classified as inappropriate is found in land units 8, 11, 15, 21, 22, 23, and 30. The most imiting

factors for clove development in Bacan island are erosion hazard (eh) and root zone medium (rc). The results of the land suitability analysis for clove plants at the sub-class level and their distribution in the Bacan Island are shown in table 4 and figure 4.

**Table 4.** Results of Actual Land Suitability Analysis for Clove Plants in Bacan island, South Halmahera Regency, Indonesia

District	Land unit	Actual land suitability class	Limiting Factor
Bacan Barat Utara	1	S3-eh,	erosion hazard
	12, 14	S3-eh,rc	erosion hazard, root zone medium
	21	N-eh,rc	erosion hazard, root zone medium
	23	N-rc	root zone medium
	27	S1	None
	29	S2-rc	root zone medium
Bacan	2, 14, 20, 24	S3-eh,rc	erosion hazard, root zone medium
	3, 29	S2-rc	root zone medium
	4, 26, 28	S2-eh	erosion hazard
	5	S3-eh	erosion hazard
	8, 11	N-eh	erosion hazard
	27	S1	None
Bacan Selatan	3, 17, 25	S2-rc	root zone medium
	15	N-eh	erosion hazard
	16, 18	S3-eh,rc	erosion hazard, root zone medium
	19	S2-rc,eh	erosion hazard, root zone medium
Bacan Timur	3, 25, 29	S2-rc	root zone medium
	4, 7, 26	S2-eh	erosion hazard
	10	S3-rc	erosion hazard, root zone medium
	12, 14, 16, 18, 24	S3-eh,rc	erosion hazard, root zone medium
	13, 27	S1	None
	15, 30	N-eh	erosion hazard
	21	N-eh,rc	erosion hazard, root zone medium
	22, 23	N-rc	root zone medium
Bacan Timur Selatan	6, 9	S2-eh	erosion hazard
	12, 14, 16, 18	S3-eh,rc	erosion hazard, root zone medium
	13, 27	S1	None
	15	N-eh	erosion hazard
	19	S2-rc,eh	erosion hazard, root zone medium
Bacan Timur Tengah	9	S2-eh	erosion hazard
	11, 15	N-eh	erosion hazard
	12, 14, 16, 18	S3-eh,rc	erosion hazard, root zone medium
	17	S2-rc	root zone medium
	27	S1	None
	29	S2-rc	root zone medium
Bacan Barat	12, 14	S3-eh,rc	erosion hazard, root zone medium
	13	S1	None
	29	S2-rc	root zone medium

*Note: S1 is very suitable, S2 is sufficiently suitable, S3 is moderately suitable, N is non suitable, eh is erosion hazard, rc is root zone medium*



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