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Land suitability assessment for *Lansium domesticum* cultivation on agroforestry land using matching method and geographic information system

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Abstract. *Rahmawaty, Frastika S, Rauf A, Batubara R, Harahap FS. 2020. Land suitability assessment for* Lansium domesticum *cultivation on agroforestry land using matching method and geographic information system. Biodiversitas 21: 3683-3690. Lansium domesticum* is one of the multipurpose tree species (MPTS) and is commonly found on agroforestry lands in Sumatra. This study aimed to evaluate the actual land suitability classes for *L. domesticum* and to map the potential land suitability for the species using matching method and geographic information system (GIS). The study was conducted in Sei Bingai Sub-district, Langkat District, North Sumatra, Indonesia. A survey was conducted to collect soil samples based on land units. Land unit information was obtained by overlaying soil map, land-use map, and slope map. Land suitability was evaluated based on the matching method and GIS was used to map the distribution of land suitability. The results showed that both the actual and potential land suitability classes based on matching approach for *L. domesticum* were moderately suitable (S2) which accounted for 88.95% of total land and marginally suitable (S3) which accounted for 11.05%. Availability of water (*wa*), erosion hazard (*eh*), root-zone medium (*rc*), oxygen availability (*oa*), and nutrient retention (*nr*) were the dominant limiting factors in this area. The most difficult constraints to manage were root-zone medium and water availability. The results of this study suggest that the development of *L. domesticum* in Sei Bingai is possible although it requires some land improvements to deal with the limiting factors.

Keywords: Agroforestry, GIS, land suitability, *Lansium domesticum*, multipurpose

INTRODUCTION

Land is a physical environment that comprises soil, climate, relief, hydrology, and vegetation, where these factors affect its potential uses. Land has characteristic, which is defined as environmental factor that can be measured or estimated in particular units such as slopes, rainfall, soil texture, and available water. There can be more than one effect of land characteristic on land quality, for example, soil texture could affect water availability, whether or not land is easily cultivated and erosion sensitivity (Ritung et al. 2011).

Land evaluation is a process of assessing the potential of land quality based on the measurement of land characteristics for particular use, mainly for agricultural and cultivation purposes. The basic framework of the evaluation of land suitability is by comparing land characteristics required for particular land use (e.g. planting a crop) with the existing characteristics or quality of the land in question. The main purpose of land evaluation is to select an optimal land use for each specific land unit by considering physical, social and economic factors as well as the conservation of environmental resources for sustainable use (Arsyad 2010; Li et al. 2011; Bagdanavičiūtė and Valiūnas 2012; Budiharta et al. 2016; Ennaji et al. 2018).

Land use suitability is used as a basis for rational land use planning and decision-making. In doing this, Geographical Information System (GIS) has been commonly used to analyze the suitability of land in several studies (Rahmawaty et al. 2011, 2019a; Khormi and Kumar 2013; Satriawan et al. 2015; Wali et al. 2016; Nuarsa et al. 2018). One of the key advantages of using GIS is the process of evaluation and the presentation of results can be conducted in spatially explicit manner in the form of maps to show the spatial distribution of geographic features (Nie et al. 2016; Barakat et al. 2017). GIS is used for data collection, data storage, data analysis, and data manipulation of geographic references (Rahmawaty et al. 2015).

While there are various studies of the assessment of land suitability on popular agriculture, plantation, and forestry crop species, limited works are available for lesser-known species commonly cultivated on agroforestry land, including *Lansium domesticum* Corrêa, locally known as *duku* or *langsat*. *L. domesticum* is native to Indonesia, Malaysia and Thailand and commonly found in South-East Asia. It has many varieties and grows particularly well in tropical climates with high humidity and shady environment. The fruit of *L. domesticum* is rich in vitamin B and phosphorus, carbohydrates, and protein (Munir et al. 2018). There are many studies on *L. domesticum* focused on various aspects, including agroecological aspect (Apuy et al. 2017; Hanum et al. 2013; Isfaeni et al. 2012; Mayanti et al. 2011), genetic variations (Yulita 2011), chemical contents and efficacy of the parts of the plant (Marfori et al. 2015; Yapp and Yap 2003; Wahyuni et al. 2014; Tilaar et al. 2008; Song et al. 2000; Saewan et al. 2006; Klungsupya et al. 2015; Matsumoto et al. 2018) and morphological characterization (Salim et al. 2016).

Study of mapping land suitability of *L. domesticum* as an agroforestry plant has not been conducted, especially in Sumatra, a region where agroforestry is common land use. One area potential to be cultivated with *L. domesticum* is Langkat District, North Sumatra, Indonesia. This study aimed to evaluate the actual land suitability classes for *L. domesticum* and to map the potential land suitability for the species using matching method and geographic information system. We expected the results of this study can be used as reference when developing the cultivation of *L. domesticum* in the region.

MATERIALS AND METHODS

Study period and area

This study was conducted from October 2018 to May 2019 in Sei Bingai Sub-district, Langkat District, North Sumatra Province. The Sub-district has an area of 333.17 km^2 and serves as a buffer zone of Gunung Leuser National Park. Geographically, Sei Bingai Sub-district is located between N 03^{0}19'10'' to N 03^{0}34'30'' and E 98^{0}21'14'' to E 98^{0}31'30'' at an altitude of 106 meters above sea level. Sei Bingai Sub-district consists of 16 villages and the research location was conducted in four villages: Telaga (53.38 km^2), Gunung Ambat (19.07 km^2), Simpang Kuta Buluh (5.79 km^2) and Rumah Galuh (36.15 km^2) (Figure 1).

Data collection

A survey was conducted to collect soil samples using a global positioning system in the field based on land unit. Land units were obtained by overlaying land use maps, soil maps, and slope map of this location. There were 10 land units in the studied area, each having its own characteristics in terms of temperature (*tc*), water availability (annual rainfall) (*wa*), oxygen availability (drainage) (*oa*), root-zone medium (texture, soil depth) (*rc*), nutrient retention (cation-exchange capacity, base saturation, pH, C-organic) (*nr*), slope and soil erosion (*eh*) and flood hazard (*fh*). Data for these variables were collected and evaluated according to the Land Suitability for Agricultural Plants published by the Centre for Soil and Agro-Climate Research, Bogor, Indonesia (Ritung et al. 2011). The highly suitable (S1) criteria for *L. domesticum* are as follows: *tc* is 25-28 ºC, *wa* is 2,000-3,000 mm, *oa* (drainage) is well-drained, slope is less than 8% and erosion hazard is very low (Table 1).

Data analysis

The matching method was used to evaluate land suitability classification for *L. domesticum.* In principle, land suitability assessment is carried out by matching the existing characteristics of the land with the requirements of the plant. This study was used Leibig's low law to determine the limiting factor affecting the land suitability class and subclass (Ritung et al. 2011). This method matches the data that have been obtained both from the field and the laboratory with land use requirements. The assessment and presentation of land suitability class results were classified as highly suitable (S1), moderately suitable (S2), marginally suitable (S3), and not suitable (N) (FAO 1976; Arsyad 2010; Rahmawaty et al. 2011). The analytical method used to explain the distribution of land suitability classes in this region was spatial analysis with the results of the accumulation of values for all parameters that will be overlaid with an administrative map. ArcGIS software was used to map land suitability classes (Rahmawaty et al. 2011).

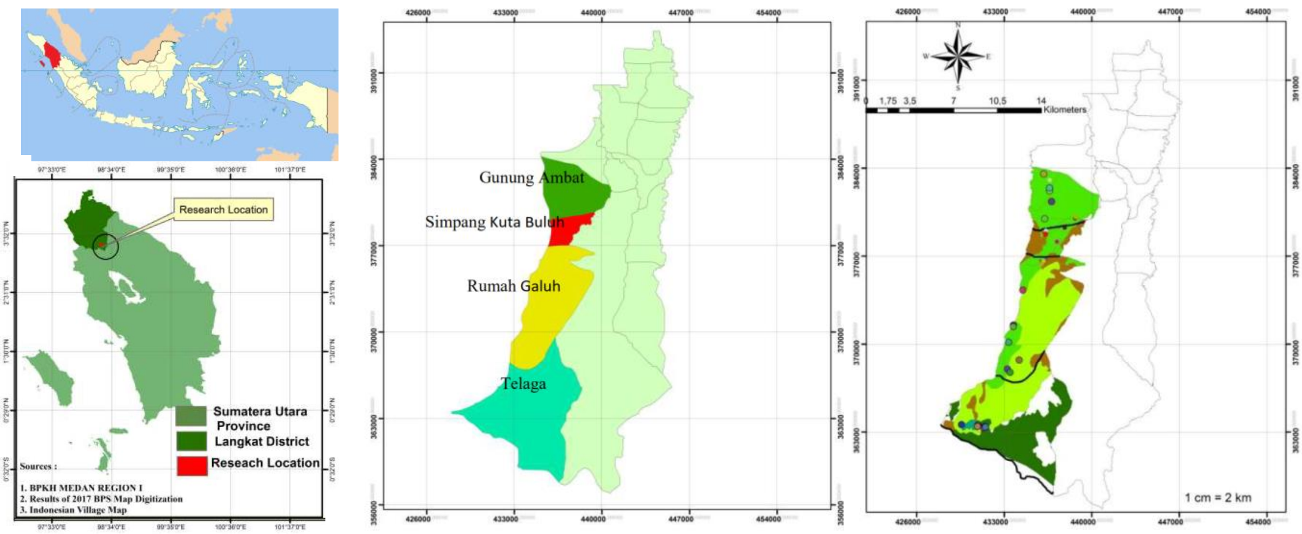

Figure 1. Map of research location and sampling points in Telaga, Gunung Ambat, Simpang Kuta Buluh and Rumah Galuh Villages in Sei Bingai Sub-district, Langkat District, North Sumatra Province, Indonesia

Table 1. Land characteristics and land suitability criteria for *Lansium domesticum*

Land characteristics	Land suitability criteria for *L. domesticum*			
	S1	**S2**	**S3**	**N**
Temperature (*tc*)				
(ºC)	25-28	28-32 22-25	32-35 20-22	> 35 < 20
Water availability (*wa*)				
Rainfall (mm year^{-1})	2,000-3,000	1,750-2,000 3,000-3,500	1,250-1,750 3,000-4,000	< 1,250 > 4,000
Oxygen availability (*oa*)				
Drainage	Well drained, medium	Moderately poorly drained	Poorly drained, moderately excessively drained	Very poorly drained, excessively drained
Root zone medium (*rc*)				
Texture	Fine, moderately fine	Medium	Moderately coarse	Coarse
Soil depth (cm)	> 100	75-100	50-75	< 50
Nutrient retention (*nr*)				
CEC (me 100g^{-1})	> 16	5-16	<5	-
pH H_2O	5.0-6.0	4.5-5.0 6.0-7.5	< 4.5 > 7.5	- -
C-organik (%)	>1.2	0.8-1.2	< 0.8	-
Erosion hazard (*eh*)				
Slope (%)	< 8	8-15	>15-40	> 40
Erosion hazard	Very low	Low-medium	High	Very high
Flood hazard (*fh*)				
High (cm)	-	25	25-50	>50
Duration of waterlogged (day)	-	<7	7-14	>14

Note: S1: highly suitable, S2: moderately suitable, S3: marginally suitable, N: not suitable (Ritung et al. 2011)

Thus, information about suitable locations for *L. domesticum* was obtained. GIS was used to map the distribution of land suitability classes and to show the spatial distribution of land suitability classes. The ArcGIS software by ESRI was used in this study. Geoprocessing was used when doing the analysis of land suitability assessment. Geoprocessing is one of the ArcGIS extensions that has several functions in spatial analysis such as: dissolve, merge, clip, union, intersect, and spatial joint. In addition, in ArcGIS software, there were also facilities to layout and display the land suitability maps.

RESULTS AND DISCUSSION

The results of actual land suitability of *L. domesticum* in the area by matching data of land characteristics collected from the field and laboratory and the criteria/requirements of *L. domesticum* as stated by Ritung et al. (2011) are presented in Table 2.

The result of matching (Table 2) shows that Land Unit I has the actual land suitability of moderately suitable (S2) with the limiting factors being water availability, nutrient retention, and erosion hazard (Table 1). Since nutrient retention and erosion hazard can be improved, the potential land suitability for Land Unit I could become S2 *wa*. As stated by Rahmawaty et al. (2020a), improvement efforts cannot be made for rainfall (wa). Land Unit II has the actual land suitability of marginally suitable (S3) with the limiting factor being root-zone medium (soil depth). This cannot be improved because it is a natural factor, so the potential land suitability for Land Unit II is still the same as actual land suitability (S3). This condition is similar to the research conducted by Rahmawaty et al. (2011) for oil palm (*Elaeis guineensis*) land suitability in the Besitang Watershed. Land Unit III has the actual land suitability of marginally suitable (S3) with the limiting factors being root-zone medium (soil depth) and erosion hazard. The root-zone medium cannot be improved because it is a natural factor, but the erosion hazard can be improved. Therefore, the potential land suitability for Land Unit III is still S3 with a limiting factor being the root-zone medium. This aligns with previous findings (Harahap et al. 2019) for oil palm (*E. guineensis*) in Pakpak Bharat District, North Sumatera Province. Land Unit IV has the actual land suitability of moderately suitable (S2) with the limiting factors being water availability, root-zone medium, nutrient retention, and erosion hazard.

Table 2. Actual land suitability evaluation using matching approach between the criteria of land characteristics required by *Lansium domesticum* and field/laboratory data in Land Unit I to X.

Land characteristics	**Field/Laboratory data and land suitability class**									
	LU I	**LU II**	**LU III**	**LU IV**	**LU V**	**LU VI**	**LU VII**	**LU VIII**	**LU IX**	**LU X**
Temperature (tc) (°C)	25-26 (S1)	22-24 (S2)	23-24 (S2)	25-26 (S1)	25-26 (S1)	25-26 (S1)	25-26 (S1)	23-24 (S1)	25-26 (S1)	22-24 (S2)
Water availability (*wa*)										
Rainfall (mm.year^{-1})	2,000 (S2)	2,010 (S1)	2,010 (S1)	2,000 (S2)	2,000 (S2)	2,000 (S2)	2,000 (S2)	2,010 (S1)	2,000 (S2)	2,010 (S1)
Oxygen availability (*oa*) Drainage	well-drained (S1)	well-drained (S1)	well-drained (S1)	well-drained (S1)	well-drained (S1)	well-drained (S1)	moderately well-drained (S2)	well-drained (S1)	well-drained (S1)	well-drained (S1)
Root-zone medium (*rc*)										
Texture	MF (S1)	F (S1)	MC (S3)	MF (S1)	MF (S1)	MF (S1)	MF (S1)	MC (S3)	MF (S1)	MC (S3)
Soil depth (cm)	113 (S1)	60 (S3)	70 (S3)	98 (S2)	97 (S2)	105 (S1)	91.5 (S2)	77.5 (S2)	95.5 (S2)	58.5 (S3)
Nutrient retention (*nr*)										
CEC (me 100g^{-1})	9.29 (S2)	22.25 (S1)	19.49 (S1)	16.97 (S1)	21.22 (S1)	19.78 (S1)	19.12 (S1)	19.49 (S1)	17.89 (S1)	16.90 (S1)
pH H_2O	6.51 (S2)	6.66 (S2)	6.45 (S2)	6.51 (S2)	6.43 (S2)	6.75 (S2)	6.86 (S2)	6.48 (S2)	6.62 (S2)	6.68 (S2)
Organic-C (%)	1.68 (S1)	1.47 (S1)	1.48 (S1)	2.42 (S1)	1.51 (S1)	1.39 (S1)	2.01 (S1)	1.82 (S1)	1.66 (S1)	1.43 (S1)
Erosion hazard (*eh*)										
Slope (%)	15 (S2)	15 (S2)	30 (S3)	15 (S2)	15 (S2)	<8 (S1)	15 (S2)	30 (S3)	15 (S2)	15 (S2)
Erosion hazard	Very low (S1)	Very low (S1)	Very low (S1)	Very low (S1)	Very low (S1)	Very low (S1)	Very low (S1)	Very low (S1)	very low (S1)	very low (S1)
Flood hazard (*fh*)										
High (cm)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)
Duration of waterlogged (day)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)	- (S1)
Actual land suitability evaluation	S2 wa, nr, eh	S3, rc	S3, rc, eh	S2 wa, rc, nr, eh	S2 wa, rc, nr, eh	S2 wa, nr	S2 wa, oa, rc, nr, eh	S3, rc, eh	S2 wa, rc, nr, eh	S3, rc

Note: LU: land unit, S1: highly suitable, S2: moderately suitable, S3: marginally suitable, N: not suitable, MF: moderately fine, F: fine, MC: moderately coarse

Water availability and root-zone medium cannot be improved, but nutrient retention and erosion hazard can be. Therefore, the potential land suitability for Land Unit IV could become S2 *wa rc,* which is similar to previous works (Rahmawaty et al. 2011; 2019b; Harahap et al. 2019). Improvement efforts cannot be made for wa as stated by Rahmawaty et al. 2020a. Land Unit V has the actual land suitability of moderately suitable (S2) with the limiting factors being water availability, root-zone medium, nutrient retention, and erosion hazard. While water availability and root-zone medium cannot be improved, nutrient retention and erosion hazard can be. Thus, the potential land suitability for Land Unit V could become S2 *wa rc*.

Land Unit VI has the actual land suitability of moderately suitable (S2) with the limiting factors being water availability and nutrient retention. Water availability cannot be improved, but nutrient retention can be improved. Therefore, the potential land suitability for Land Unit VI could become S2 *wa*. Land Unit VII has the actual land suitability of moderately suitable (S2) with the limiting factors being water availability, oxygen availability, erosion hazard, root-zone medium, and nutrient retention. Several limiting factors can be improved, namely *oa, nr,* and *eh.* Therefore, the potential land suitability for Land Unit VII could become S2 *wa rc*.

Land Unit VIII has the actual land suitability of marginally suitable (S3) with the limiting factors being the root-zone medium (soil depth) and erosion hazard. Root-zone medium cannot be improved because it is a naturally occurring feature. Thus, the potential land suitability for Land Unit VIII is S3 *rc*. Land Unit IX has the actual land suitability of moderately suitable (S2) with the limiting factors being water availability, root-zone medium, nutrient retention, and erosion hazard. Water availability and root-zone medium cannot be improved, but nutrient retention and erosion hazard can be. Thus, the potential land suitability for Land Unit IX could become S2 *wa rc*. Land Unit X has the actual land suitability of marginally suitable (S3) with the limiting factor being root-zone medium (soil depth). This cannot be improved as it is a naturally occurring factor. Thus, the potential land suitability for Land Unit X is the same as the actual land suitability (S3).

If summed up based on limiting factor, the actual suitability classes for *L. domesticum*, become six classes, namely: S2 *wa nr eh* (2,422.70 Ha or 21.51%), S2 *wa rc nr eh* (5,872.98 Ha or 52.13%), S2 *wa oa rc nr eh* (1,152.67 Ha or 10.23%), S2 *wa nr* (571.88 Ha or 5.08%), S3 *rc eh* (319.04 Ha or 2.83%), and S3 *rc* (925.98 Ha or 8.22%). S2 *wa rc nr eh* has the largest area of the actual land suitability in this area (52.13% from total area). If summed up based on limiting factor, the potential suitability classes for *L. domesticum*, become three classes, namely: S2 *wa rc* (7,025.65 Ha or 62.37%), S2 *wa* (2,994.58 Ha or 26.58%), and S3 *rc* (1,245.02 Ha or 11.05%). S2 *wa rc* has the largest area of the potential land suitability in this area (62.37% from total area). If summed up based on the actual suitability classes for *L. domesticum*, total lands in Sei Bingai that moderately suitable (S2) were 10,020.23 Ha (88.95%) and marginally suitable (S3) were 1,245.02 (11.05%). In addition, if summed up based on the potential land suitability classes, the total lands that moderately suitable (S2) were 10,020.23 Ha (88.95%) and marginally suitable (S3) were 1,245.02 (11.05%).

The map of actual land suitability for *L. domesticum* in the Sei Bingai Sub-district is presented in Figure 2, and the map of potential land suitability is presented in Figure 3. The summaries of both actual and potential land suitability classes for *L. domesticum* in the Sei Bingai Sub-district based on land unit are presented in Table 3. Based on Figure 3, the development of *L. domesticum* in Sei Bingai is still possible based on the area of land suitability classified as predominantly moderately suitable (S2), which is 88.95% of the total land area. The distribution of actual and potential land suitability classes based on village is presented in Table 4.

There were only moderately and marginally suitable classes in the four villages studied and no land under the classes of highly suitable and not suitable (Table 4). The moderately suitable land (S2) means that the land has a limiting factor that will affect its productivity and requires additional input. The marginally suitable land (S3) means that the land has several limiting factors that severely affecting plant growth, requiring sustained particular agricultural treatments which often increase the expenditures which are difficult to justify, or otherwise will reduce productivity (FAO 1976).

Table 3. The actual and potential land suitability classes for *Lansium domesticum* in the Sei Bingai Sub-district, Langkat, North Sumatra, Indonesia based on land unit

Land unit	Actual land suitability	Potential land suitability	Area	
			Ha	%
I	S2, *wa, nr, eh*	S2, *wa*	2,422.70	21.51
II	S3, *rc*	S3, *rc*	836.65	7.43
III	S3, *rc, eh*	S3, *rc*	307.84	2.73
IV	S2, *wa, rc, nr, eh*	S2, *wa, rc*	986.62	8.76
V	S2, *wa, rc, nr, eh*	S2, *wa, rc*	514.01	4.56
VI	S2, *wa, nr*	S2, *wa*	571.88	5.07
VII	S2, *wa, oa, rc, nr, eh*	S2, *wa, rc*	1,152.67	10.23
VIII	S3, *rc, eh*	S3, *rc*	11.20	0.10
IX	S2, *wa, rc, nr, eh*	S2, *wa, rc*	4,372.35	38.82
X	S3, *rc*	S3, rc	89.33	0.80
Total			11,265.25	100.00

Note: S2: moderately suitable, S3: marginally suitable, *wa*: water availability, *nr*: nutrient retention, *eh*: erosion hazard, *rc*: root-zone medium, *oa*: oxygen availability

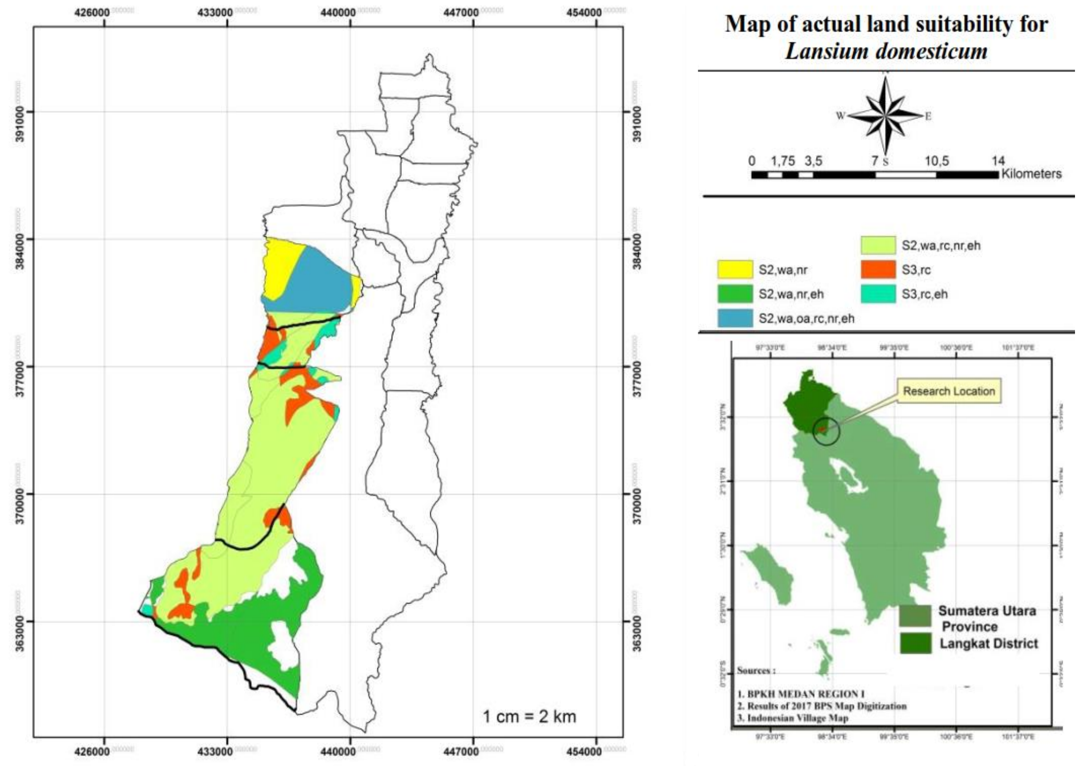

Figure 2. Map of actual land suitability for *Lansium domesticum* in four villages in Sei Bingai Sub-district, Langkat, North Sumatra, Indonesia

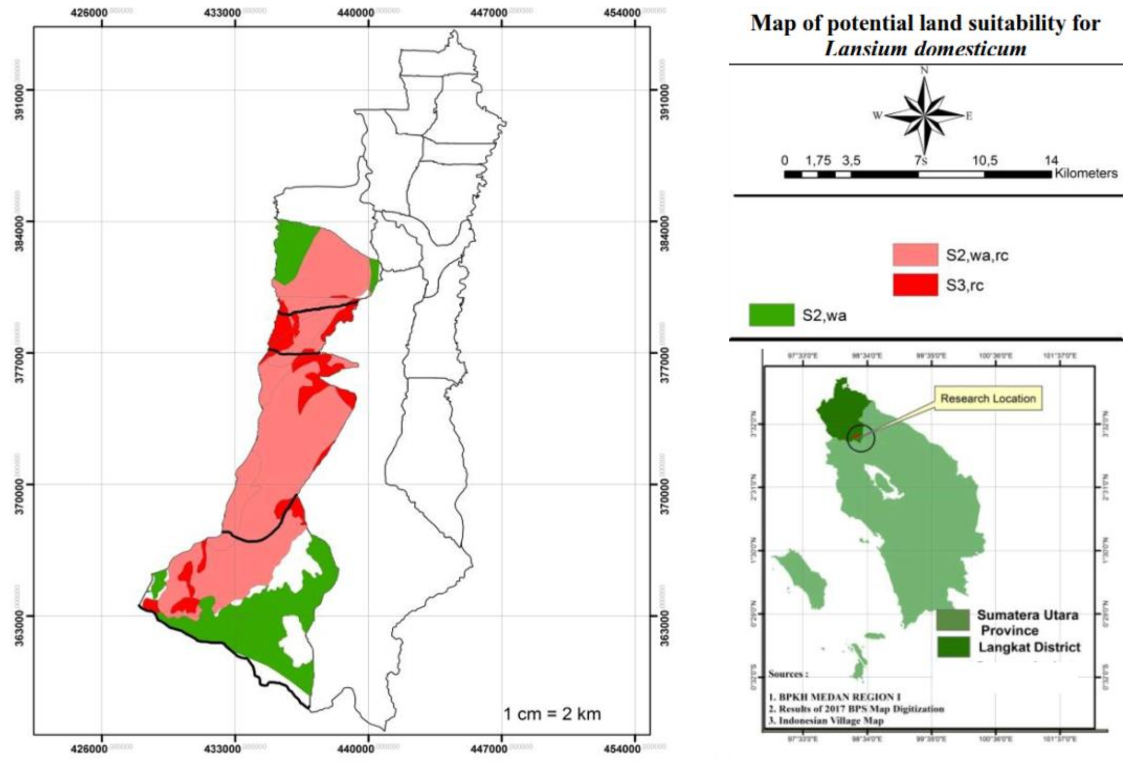

Figure 3. Map of potential land suitability for *Lansium domesticum* in four villages in Sei Bingai Sub-district, Langkat, North Sumatra, Indonesia

Table 4. The distribution of actual and potential land suitability classes based on village in Sei Bingai Sub-district, Langkat, North Sumatra, Indonesia

Village	Actual and potential land suitability class							
	S1		S2		S3		N	
	ALS	PLS	ALS	PLS	ALS	PLS	ALS	PLS
Rumah Galuh	No	No	Yes	Yes	Yes	Yes	No	No
Simpang Kuta Buluh	No	No	Yes	Yes	Yes	Yes	No	No
Gunung Ambat	No	No	Yes	Yes	Yes	Yes	No	No
Telaga	No	No	Yes	Yes	Yes	Yes	No	No

Note: S1: highly suitable, S2: moderately suitable, S3: marginally suitable, N: not suitable, ALS: actual land suitability, PLS: potential land suitability

There were several limiting factors in land suitability evaluation in the area including availability of water (*wa*), erosion hazard (*eh*), root-zone medium (*rc*), oxygen availability (*oa*) and nutrient retention (*nr*). Nutrient retention can be improved by fertilization (organic and inorganic), for example, with urea and superphosphate fertilizer, and the erosion hazard (slope) can be improved by terracing steep areas.

Similar to previous studies of land suitability for multipurpose tree species, such as durian (*Durio zibethinus*) and avocado (*Persea americana*) (Rahmawaty et al. 2020a,b), the present work shows that root-zone medium (*rc*) is the limiting factor in North Sumatra Province. These results are also similar to land suitability study by Rahmawaty et al. (2020c) for *Hevea brasiliensis* and *Aquilaria malaccensis* in North Sumatra. However, these differ with a study of land suitability for *Pinus merkusii* which shows that temperature (*tc)* and erosion hazard (*eh)* are the limiting factors (Rahmawaty et al. 2019c) and while for oil palm (*E. guineensis*) the limiting factor was *wa* (Rahmawaty et al. 2011, 2019b; Harahap et al. 2019). These differences indicate that each plant has different criteria for growth requirements. According to Ritung et al. (2011), land evaluation requires physical environmental characteristics that are broken down into land quality, where each quality can consist of one or more land characteristics.

The development of *L. domesticum* in this area will provide benefits to rural communities, including economic and health benefits (Mayanti et al. 2011; Marfori et al. 2015; Munir et al. 2018). Some land characteristics generally have relationships with others. Land quality will affect the most suitable land use and the growth of plants and other commodities cultivated in such land. Thus, the results of this land evaluation study fulfill a highly significant need for land use planning for the studied area.

Even though the plants are the same, the results of land suitability evaluation are not necessarily the same between one region to another because of the differences in land characteristics. With technology, land that naturally has a low land suitability class (on actual land suitability) can be improved to higher land suitability class (on potential land suitability). However, not all the quality or characteristics of land can be improved with existing technology, but requires a high level of management to be able to improve it. Based on these results, it appears that *L. domesticum* can be developed in the studied area.

This research concludes that the actual and potential land suitability classes for *L. domesticum* in the Sei Bingai Sub-district of Langkat, North Sumatra, Indonesia were moderately suitable (S2) and marginally suitable (S3). The predominant land suitability was moderately suitable (S2), amounting to 88.95 %. The results of this study suggest that the development of *L. domesticum* in Sei Bingai is possible although it requires some land improvements to deal with the limiting factors.

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REFERENCES

Apuy M, Lahjie AM, Simarangkir BDAS, Ruslim Y, Kristiningrum R. 2017. Traditional plants in forest gardens of West Kutai, Indonesia: Production and financial sustainability. Biodiversitas 18 (3): 1207-1217.

Arsyad S. 2010. Soil and Water Conservation. 2nd ed. IPB Press, Bogor. [Indonesian]

Bagdanavičiūtė I, Valiūnas J. 2012. GIS-based land suitability analysis integrating multi-criteria evaluation for the allocation of potential pollution sources. Environ Earth Sci 68 (6): 1797-1812. DOI: 10.1007/s12665-012-1869-7.

Barakat A, Ennaji W, El Jazouli A, Amediaz R, Touhami F. 2017. Multivariate analysis and GIS-based soil suitability diagnosis for sustainable intensive agriculture in Beni-Moussa irrigated subperimeter (Tadla plain, Morocco) model. Earth Syst Environ 3 (1): 1-8.

Budiharta S, Meijaard E, Wells JA, Abram NK, Wilson KA. 2016. Enhancing feasibility: Incorporating a socio-ecological systems framework into restoration planning. Environ Sci Pol 64: 83-92.

Ennaji W, Barakat A, El Baghdadi M. 2018. GIS-based multi-criteria land suitability analysis for sustainable agriculture in the northeast area of Tadla plain (Morocco). J Earth Syst Sci 127: 79. DOI: 10.1007/s12040-018-0980-x.

FAO [Food and Agriculture Organization]. 1976. A Framework for Land Evaluation. FAO Soil Bulletin 32. FAO, Rome. Italy.

Hanum L, Kasiamdari RS, Santosa, Rugayah. 2013. The phylogenetic relationship among varieties of *Lansium domesticum* Correa based on its rDNA sequences. Indonesian J Biotechnol 18 (2): 123-132.

Harahap FS, Sitompul R, Rauf A. Rahmawaty. Harahap DE and Walida H. 2019. Land suitability evaluation for oil palm plantations (*Elaeis gu*ineensis Jacq.) on Sitellu Tali Urang Julu, Pakpak Bharat District. IOP Conf Ser: Earth Environ Sci 260: 012116. DOI: 10.1088/1755-1315/260/1/012116.

Isfaeni H, Filani R, Pertiwi A. 2012. Repellency of *Lansium domesticum* peels extracts to Nilaparvata lugens (Homoptera) on *Oryza sativa* IR 42. Proc Soc Indon Biodiv-Intl Conf 1: 55-58.

Khormi HM, Kumar L. 2013. Using geographic information system and remote sensing to study common mosquito-borne diseases in Saudi Arabia: A review. J Food Agric Environ 11 (2): 14-17.

Klungsupya P, Suthepakul N, Muangman T, Rerk-Am U, Thongdon-A 2015. Determination of free radical scavenging, antioxidative DNA damage activities and phytochemical components of active fractions from *Lansium domesticum* Corr. fruit. J Nutrients 7 (8): 6852-6873. DOI: 10.3390/nu7085312.

Li L, Zhao J, Yuan T. 2011. Study on approaches of land suitability evaluation for crop production using GIS. In: Li D., Liu Y., Chen Y. (eds) Computer and Computing Technologies in Agriculture IV. CCTA 2010. IFIP Advances in Information and Communication Technology 345. Springer, Berlin.

Marfori EC, Kajiyama SI, Fukusaki EI, Kobayashi A. 2015. Lansioside D, a new triterpenoid glycoside antibiotic from the fruit peel of *Lansium domesticum* Correa. J Pharmacogn Phytochem 3 (5): 140-143.

Matsumoto T, Kitagawa T, Teo S, Anai Y, Ikeda R, Imahori D, Ahmad HSB, Watanabe T. 2018. Structures and antimutagenic effects of on oceranoid-type triterpenoids from the leaves of *Lansium domesticum*. J Nat Prod 81 (10): 2187-2194. DOI: 10.1021/acs.jnatprod.8b00341.

Mayanti T, Tjokronegoro R, Supratman U, Mukhtar MR, Awang K, Hadi AH. 2011. Antifeedant triterpenoids from the seeds and bark of *Lansium domesticum* cv. Kokossan (Meliaceae). Molecules 6 (4): 2785-2795.

Munir T, Munawar KS, Mohyuddin A. 2018. An overview of the antibacterial implications of *Lansium domesticum.* J Basic Appl Sci 14: 206-209.

Nie Y, Yu J, Peng Y, Wu Y, Yu L, Jiang Y, Zhou Y, 2016. A comprehensive evaluation of soil fertility of cultivated land: A GIS-based soil basic niche-fitness model. Commun Soil Sci Plant Anal 47 (5): 670-678.

Nuarsa IW, Dibia IN, Wikantika K, Suwardhi D, Rai IN. 2018. GIS-based analysis of agro climate land suitability for banana plants in Bali Province, Indonesia. Hayati J Biosci 25 (1): 11-17.

Rahmawaty, Frastika S, Marpaung RME, Batubara R, Rauf A. 2019a. Short Communication: Use of Geographic Information System for mapping of *Aquilaria malaccensis* land suitability in North Sumatra, Indonesia. Biodiversitas 20 (9): 2561-68.

Rahmawaty, Marpaung, RME, Rauf A, Batubara R. 2020a. Integrated GIS and GPS for mapping of land suitability for multi-purpose tree species (*Persea americana*) at community agroforestry land in Peria-ria Village. IOP Conf Ser Earth Environ Sci 454: 012146. DOI: 10.1088/1755-1315/454/1/012146.

Rahmawaty, Rauf A, Batubara R, Frastika S. 2020c. Application of geographic information system for mapping of *Hevea brasiliensis* and *Aquilaria malaccensis* land suitability at Simpang Kuta Buluh. IOP Conf Ser: Earth Environ Sci 458: 012030. DOI: 10.1088/1755-1315/458/1/012030.

Rahmawaty, Rauf A, Frastika S. 2019b. Mapping of actual and potential land suitability for oil palm in several land unit using geographic information system. IOP Conf Ser Earth Environ Sci 260: 012073. DOI: 10.1088/1755-1315/260/1/012073.

Rahmawaty, Rauf A, Frastika S. 2019c. Spatial analysis for *Pinus merkusii* land suitability at agroforestry land in Telagah Village Sumatera Utara Indonesia. IOP Conf Ser Mater Sci Eng 593: 012017. DOI: 10.1088/1757-899X/593/1/012017.

Rahmawaty, Sari EK, Syofyan A, Rauf A. 2015. Integrated geographic information system and global positioning system for mapping of forest plants in supporting natural resources protection. Procedia Chem 14 (2015): 334-342.

Rahmawaty, Situmorang LKN, Rauf A, Batubara R. 2020b. GIS based: mapping of multy purpose tree species (*Durio zibethinus*) in Perkebunan Tambunan Village, Langkat District, North Sumatra Province, Indonesia. IOP Conf Ser: Earth Environ Sci 454: 012147. DOI: 10.1088/1755-1315/454/1/012147.

Rahmawaty, Villanueva TR, Carandang MG. 2011. Participatory land-use allocation, case study in Besitang Watershed, Langkat, North Sumatera, Indonesia. Lambert Academic Publishing, Germany.

Ritung S, Nugroho K, Mulyani A, Suryani E. 2011. Technical Guidelines for Evaluating Land for Agricultural Commodities (Revised Edition). Agricultural Research and Development Agency, Bogor. [Indonesian]

Saewan N, Sutherland JD, Chantrapromma K. 2006. Antimalarial tetranortriterpenoids from the seeds of *Lansium domesticum* Corr. Phytochemistry 67: 2288-2293. DOI: 10.1016/j.phytochem.2006.07.005.

Salim M, Sulistyaningrum N, Isnawati A, Sitorus H, Yahya Y, Ni'mah T. 2016. Characterization of simplicia and the peel extract of duku (*Lansium domesticum* Corr.) from South Sumatra and Jambi Province. Jurnal Kefarmasian Indonesia 6 (2): 117-128.

Satriawan H, Harahap EM, Rahmawaty, Karim A. 2015. Effectiveness of soil conservation to erosion control on several land-use types. Agriculture (Ponohospodárstvo) 61 (2): 61-68.

Song BK, Clyde MM, Wickneswari R, Normah MN. 2000. Genetic relatedness among *Lansium domesticum* accessions using RAPD markers. Ann Bot 86: 299-307.

Tilaar M, Wih WL, Ranti AS, Wasitaatmadja SM, Suryaningsih, Junardy, FD. 2008. Review of *Lansium domesticum* Corrêa and its use in cosmetics. Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 7 (4): 183-189.

Wahyuni D, Furqani F, Astuti AW, Khoiriah, Indrawati, Zein R. 2014. Removal of Cadmium (II) and Copper (II) from aqueous solution by using langsat fruit (*Lansium domesticum* Corr) seed. Res J Pharmaceut Biol Chem Sci 5 (5): 1320-1328.

Wali E, Datta A, Shrestha RP, Shrestha S. 2016. Development of a land suitability model for saffron (*Crocus sativus* L.) cultivation in Khost Province of Afghanistan using GIS and AHP techniques. Arch Agron Soil Sci 62: 921-934.

Yapp DTT, Yap SY. 2003. *Lansium domesticum*: skin and leaf extracts of this fruit tree interrupt the lifecycle of *Plasmodium falciparum*, and are active towards a chloroquine-resistant strain of the parasite (T9) in vitro. J Ethnopharmacol 85: 145-150. DOI: 1016/S0378-8741(02)00375-6.

Yulita KS. 2011. Genetic variations of *Lansium domesticum* Corr. accessions from Java, Bengkulu and Ceram based on Random Amplified Polymorphic DNA fingerprints. Biodiversitas 12 (3): 125-130.