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Mapping of Land Suitability for Rambutan (*Nephelium lappaceum)* in Community Agroforestry Land at Gunung Ambat Village and Simpang Kuta Buluh Village

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ABSTRACT

Rambutan (*Nephelium lappaceum*) is Sapindaceae family, commonly found in agroforestry land, owned by the community in Langkat District, North Sumatra Province as One of Multy Purpose Tree Species. This study aimed to asses and map the distribution land suitability for *N. lappaceum*. This research was conducted in Gunung Ambat Village and Simpang Kuta Buluh Village, Sei Bingai Sub District, Langkat Regency using survey method. The soil samples data was collected in the field based on the land unit. Land suitability assessment was evaluated using matching method. To map the distribution of land suitability, the Geographic Information System (GIS) was used. Global Positioning System (GPS) also was used in this study to record the coordinate points of each soil sample from the field. The results indicate that the actual land suitability classes for *N. lappaceum* were dominated by moderately suitable (S2) (97.56%) in Gunung Ambat Village and moderately suitable (S2) (52.92%) in Simpang Kuta Buluh Village. The water availability (wa) and root zone medium (rc) were the dominant limiting factor in this area.

Keywords: Agroforestry, GIS, GPS, MPTS, Rambutan

ABSTRAK

Rambutan (*Nephelium lappaceum*) adalah keluarga Sapindaceae, umumnya ditemukan di lahan agroforestri yang dimiliki oleh masyarakat di Kabupaten Langkat, Provinsi Sumatera Utara sebagai salah satu pohon serbaguna. Penelitian ini bertujuan untuk menilai dan memetakan sebaran kesesuaian lahan rambutan. Penelitian ini dilakukan di Desa Gunung Ambat dan Desa Simpang Kuta Buluh, Kecamatan Sei Bingai, Kabupaten Langkat dengan menggunakan metode survei. Data sampel tanah dikumpulkan di lapangan berdasarkan unit tanah. Penilaian kesesuaian lahan dievaluasi dengan menggunakan metode pencocokan. Untuk memetakan distribusi kesesuaian lahan digunakan Sistem Informasi Geografis (SIG). Global Positioning System (GPS) juga digunakan dalam penelitian ini untuk mengetahui titik koordinat dari setiap sampel tanah di lapangan. Hasil penelitian menunjukkan bahwa kelas kesesuaian lahan aktual untuk *N. lappaceum* didominasi oleh kelas cukup sesuai (S2) (97,56%) di Desa Gunung Ambat dan cukup sesuai (S2) (52,92%) di Desa Simpang Kuta Buluh. Ketersediaan air dan media perakaran (rc) merupakan faktor pembatas dominan di lokasi penelitian.

Kata Kunci: Agroforestri, GIS, GPS, MPTS, Rambutan

INTRODUCTION

Land suitability is used as a basis for rational land use planning. It needs consideration in land use decision making so that land can be used optimally and sustainably. Several studies about land suitability have conducted for some plants in several locations based on GIS (e.g. Rahmawaty *et al*. 2019a; Rahmawaty *et al.* 2019c; Rahmawaty *et al.* 2019d; Harahap *et al.* 2019; Parry *et al*. 2018; Tarigan *et al.* 2016; Rahmawaty *et al.* 2016; Satriawan *et al.*

2014; Rahmawaty *et al.* 2012; Chuong 2007). Several approaches have been used to analyze the suitability of land (e.g. Malczewski 2004; Chandio *et al*. 2011; He *et al.* 2011; Elsheikh et al., 2013; El Baroudy 2016; Mazahreh *et al.* 2019). There is a tool that can be applied for forestry and agriculture such as land suitability, namely: Geographical Information System (GIS). It has been widely applied in various fields. Land evaluation results can be described in the form of maps using GIS technology. According to Rahmawaty *et al*. (2019a) and Rahmawaty *et al*. (2012), one application of GIS is mapping the results of land evaluation and presenting the results in the form of maps to show the spatial distribution of geographical phenomena. The GIS is used for data collection, storage, analysis, and manipulation of geographic references (Pan and Pan 2012; Rahmawaty *et al.* 2013; Elsheikh et al., 2013; Rahmawaty *et al.* 2015; Rahmawaty *et al.* 2017a, Rahmawaty *et al.* 2017b, Rahmawaty *et al.* 2019a, Rahmawaty *et al.* 2019b). It has been widely applied in various fields, including land evaluation (Rahmawaty *et al.* 2019a; Mazahreh *et al.* 2019; Parry *et al*. 2018; Satriawan *et al.* 2015; Rahmawaty *et al.* 2012).

Indonesia has a mega-diversity of natural resources. One of the most important biodiversity is *N. lappaceum*. One place that has the potential to be found *N. lappaceum*, namely Langkat District, North Sumatra, Indonesia. In this area, *N. lappaceum* is known as the local name "rambutan binjai". It can be found in several places, including on community lands, such as in the agroforestry pattern. It is believed to be native to the Malay Archipelago. It is native to Indonesia and Southeast Asia. It is closely related to several other edible tropical fruits in Indonesian, Filipino and Malay, it literally means hairy caused by the 'hair' that covers this fruit. According to Mahmood *et al*. (2018), rambutan fruit has been proven to possess phytochemicals that demonstrate anticancer, anti-obesity, anti-allergic, antidiabetic, anti-HIV, antimicrobial, anti-hypercholesterolemia, anti-dengue and anti-hyperglycemic effects in varied in-vitro and in-vivo models. Development of *N. lappaceum* to improve the economy of rural communities specially in Sei Bingai District, Langkat District, North Sumatra Province. Many studies also have been reported about *N. lappaceum* in different places, (e.g. Rahayu et al., 2013; Chiaw *et al.* 2014; Muhtadi *et al*. 2015; Sukmandani *et al.* 2017; Mirghani 2019). Furthermore, Mohamed et al. (2019), have been studied about natural diversity of rambutan (*N. lappaceum* L.) in Kerala, India; Syarifuddin *et al.* (2018) have been reported about the impact of oil palm plantation on the ecology of rambutan insect pollinators in North Sumatra, Indonesia;

Ahmad *et al.* (2017) have been researched geraniin extracted from the rind of *N. lappaceum* binds to dengue virus type-2 in Malaysia. Research on a mapping of land suitability for *N. lappaceum* as one of agroforestry plants has never been conducted, especially in this location. There is a lack of data and information on *N. lappaceum* land suitability in Langkat District, hence, this study aimed to evaluate the actual land suitability class and map the land suitability classes for *N. lappaceum* in Gunung Ambat Village and Simpang Kuta Buluh Village, Sei Bingai Sub District, Langkat, North Sumatra, Indonesia.

MATERIALS AND METHODS

Study Area

This research was conducted in Gunung Ambat Village and Simpang Kuta Buluh Village, Sei Bingai Sub District, Langkat, North Sumatra, Indonesia (Figure 1). The total area of Gunung Ambat Village is 1990.13 ha and the total area of Simpang Kuta Buluh Village is 765.20 ha.

Data Collection

This research was conducted from February to July 2019. The survey method was conducted to collect soil samples in the field based on the land unit (Zonneveld 1989). Land units obtained from overlay results from land-use map, soil map and slope map of Gunung Ambat Village and Simpang Kuta Buluh Village, Sei Bingai Sub District, Langkat, North Sumatra, Indonesia. There were seven land units in this area. The land units have their characteristics. The land characteristics were temperature (tc), water availability (annual rainfall) (wa), oxygen availability (drainage) (oa), root zone medium (texture, soil depth) (rc), nutrients retention (cation exchange capacity, base saturation, pH, C-organic), sodicity (alkalinity) (nr), slope and soil erosion (eh), and flood hazard (fh). According to the reference and criteria were adopted from the land suitability for Agricultural Plants by the Centre for Soil and Agroclimate Research, Bogor-Indonesia (Djaenudin *et al.* 2003), Hardjowigeno and Widiatmaka (2007), highly suitable (S1) Criteria for *N. lappaceum, namely*: temperature (tc) is 22-28 °C, annual rainfall (wa) is 1000-2000 mm, oxygen availability (oa) is Well-drained, fine texture, slope less than 8% and erosion hazard is very low. Not suitable (N) Criteria for *N. lappaceum,* namely:

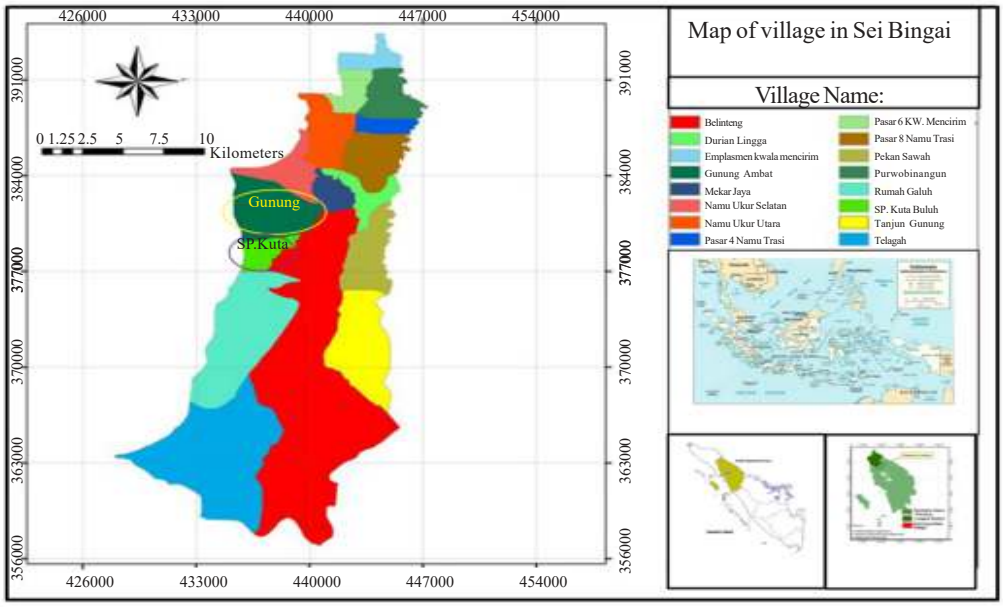

Figure 1. Map of Gunung Ambat Village and Simpang Kuta Buluh Village, Sei Bingai Sub District, Langkat, North Sumatra, Indonesia

temperature (tc) is more than 40 °C, annual rainfall (wa) is more than 4000 mm, drainage is poor, rough texture, slope more than 30% and erosion hazard is very high (Table 1).

Data analysis

The matching method was used to evaluate land suitability classification (Ritung *et al.* 2007; Ritung

Table 1. Land characteristics and land suitability criteria for rambutan (*N. lappaceum*).

Land Characteristics	land suitability criteria for rambutan (*N. lappaceum*)			
	S1	S2	S3	N
Temperature (tc)				
(°C)	22-28	28-34	34-40	> 40
Water availability (wa)				
Rainfall (mm year^{-1})	1000-2000	2000-3000	3000-4000	> 4000
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	Medium-Moderately fine, Fine	-	Moderately coarse	Coarse
Soil depth (cm)	> 100	75-100	50-75	< 50
Nutrient retention (nr)				
CEC (me 100g^{-1})	> 16	≤ 16	-	-
pH H_2O	5.0-6.0	4.5-5.0	< 4.5	-
		6.0-7.5	> 7.5	-
Organic-C (%)	>1.2	0.8-1.2	< 0.8	-
Erosion hazard (eh)				
Slope (%)	< 8	8-16	16-30	> 30
Erosion hazard	Very low	Low-medium	High	Very high
Flood hazard (fh)				
Inundation	F0	F1	F2	> F2

Source: The Centre for Soil and Agroclimate Research, Bogor (2003); Djaenudin et al. (2003), Hardjowigeno and Widiatmaka (2007). Note : S1 = highly suitable, S2 = moderately suitable, S3 = marginally suitable, N = not suitable F0 = none, F1 = low, F2 = medium, F3 = moderately high, F4 = very high.

et al. 2011). It is matching the data that has been obtained both from the field and from laboratory with land use requirements for *N. lappaceum*. The assessment and presentation of land suitability class results were based on FAO (1976) and FAO (1983), namely: Highly suitable (S1), Moderately suitable (S2), marginal suitable (S3), and not suitable (N) (Soil Research Center 2003, Arsyad 2010; Rahmawaty *et al.* 2011). The GIS was used to map the land suitability classes. The land units were used as a place to take soil samples in the field. The results of the assessment of the land suitability classes were presented in the form of tables and maps that provide a class description of the land suitability of *N. lappaceum* (Table 2 to Table 8).

To record the coordinate points of soil samples, the global positioning system (GPS) was used (Rahmawaty *et al.* 2016; Rahmawaty *et al. 2018*). The GIS was used to show the spatial distribution of land suitability classes.

Table 2. Actual land suitability classification for Rambutan (*N. lappaceum) in* Land Unit I based on the matching method.

Land characteristics	Field/laboratory data	Actual land suitability
Temperature (tc)		
(°C)	23 °C-24 °C	S1
Water availability (wa)		
Rainfall (mm year^{-1})	2010	S2
Oxygen availability (oa)		
Drainage	Well drained	S1
Root zone medium (rc)		
Texture	Fine	S1
Soil depth (cm)	60	S3
Nutrient retention (nr)		
CEC (me 100g^{-1})	22.25	S1
pH H_2O	6.66	S2
Organic-C (%)	1.47	S1
Erosion hazard (eh)		
Slope (%)	15%	S2
Erosion hazard	Very low	S1
Flood hazard (fh)		
Inundation	F0	S1
Actual land suitability evaluation		S3, rc

Table 3. Actual land suitability classification for Rambutan (*N. lappaceum)* in Land Unit II based on the matching method.

Land characteristics	Field/laboratory data	Actual land suitability
Temperature (tc)		
(°C)	23 °C-24 °C	S1
Water availability (wa)		
Rainfall (mm year^{-1})	2010	S2
Oxygen availability (oa)		
Drainage	Well drained	S1
Root zone medium (rc)		
Texture	Fine	S1
Soil depth (cm)	70	S3
Nutrient retention (nr)		
CEC (me 100g^{-1})	19.49	S1
pH H_2O	6.45	S2
Organic-C (%)	1.48	S1
Erosion hazard (eh)		
Slope (%)	30%	S3
Erosion hazard	Very low	S1
Flood hazard (fh)		
Inundation	F0	S1
Actual land suitability evaluation		S3, rc, eh

Table 4. Actual land suitability classification for Rambutan (*N. lappaceum)* in Land Unit III based on the matching method.

Land characteristics	Field/laboratory data	Actual land suitability
Temperature (tc)		
(°C)	23 °C-24 °C	S1
Water availability (wa)		
Rainfall (mm year^{-1})	2010	S2
Oxygen availability (oa)		
Drainage	Well drained	S1
Root zone medium (rc)		
Texture	Fine	S1
Soil depth (cm)	98	S2
Nutrient retention (nr)		
CEC (me 100g^{-1})	22.25	S1
pH H_2O	6.51	S2
Organic-C (%)	2.42	S1
Erosion hazard (eh)		
Slope (%)	15%	S2
Erosion hazard	Very low	S1
Flood hazard (fh)		
Inundation	F0	S1
Actual land suitability evaluation		S2 wa,rc,nr,eh

Table 5. Actual land suitability classification for Rambutan (*N. lappaceum)* in Land Unit IV based on the matching method.

Land characteristics	Field/laboratory data	Actual land suitability
Temperature (tc)		
(°C)	23 °C-24 °C	S1
Water availability (wa)		
Rainfall (mm year^{-1})	2010	S2
Oxygen availability (oa)		
Drainage	Well drained	S1
Root zone medium (rc)		
Texture	Moderately fine	S1
Soil depth (cm)	97	S2
Nutrient retention (nr)		
CEC (me 100g^{-1})	21.22	S1
pH H_2O	6.43	S2
Organic-C (%)	1.51	S1
Erosion hazard (eh)		
Slope (%)	15%	S2
Erosion hazard	Very low	S1
Flood hazard (fh)		
Inundation	F0	S1
Actual land suitability evaluation		S2 wa,rc,nr,eh

RESULTS AND DISCUSSION

The actual land suitability classes area for *N. lappaceum* in Gunung Ambat Village is presented in Figure 2.

The actual land suitability classes for *N. lappaceum* were moderately suitable (S2) (97.56%) and marginal suitable (S3) (2.44%) from the total area in Gunung Ambat Village (Figure 2). There were no suitable (S1), and not suitable (N) classes were found in this village. Class S2 means that land has a limiting factor, and this limiting factor will affect its productivity and requiring additional input and Class S3 means that lands having limitations, which are severe for sustained application of a given use and will so reduce productivity or benefits or

Table 6. Actual land suitability classification for Rambutan (*N. lappaceum)* in Land Unit V based on the matching method.

Land characteristics	Field/laboratory data	Actual land suitability
Temperature (tc)		
(^{o}C)	23 ^{o}C-24 ^{o}C	S1
Water availability (wa)		
Rainfall (mm year^{-1})	2010	S2
Oxygen availability (oa)		
Drainage	Well drained	S1
Root zone medium (rc)		
Texture	Moderately coarse	S3
Soil depth (cm)	77.5	S2
Nutrient retention (nr)		
CEC (me 100g^{-1})	19.49	S1
pH H_2O	6.58	S2
Organic-C (%)	1.82	S1
Erosion hazard (eh)		
Slope (%)	30	S3
Erosion hazard	medium	S2
Flood hazard (fh)		
Inundation	F0	S1
Actual land suitability evaluation		S3 rc,eh

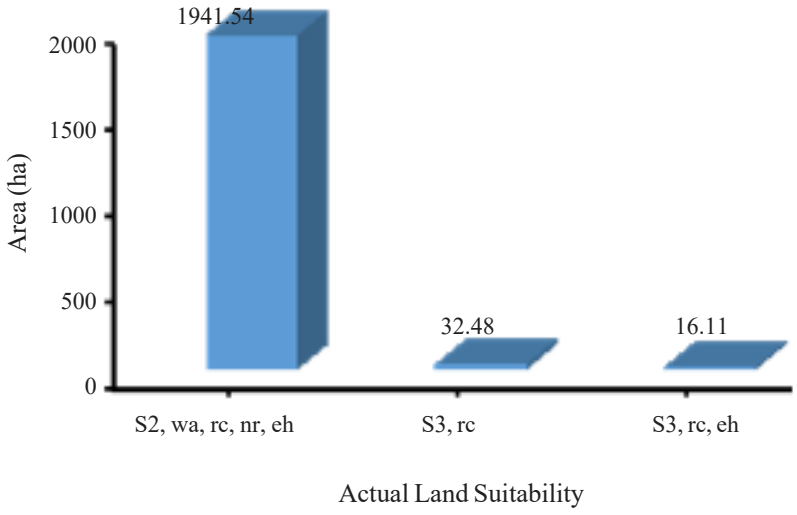

Figure 2. The area of actual land suitability classes for *N. lappaceum* in Gunung Ambat Village.

increase required inputs that this expenditure will be only marginally justified (FAO 1976).

The actual land suitability classes area of *N. lappaceum* in Simpang Kuta Buluh Village is presented in Figure 3. The actual land suitability classes for *N. lappaceum* were moderately suitable (S2) (52.92%) and marginal suitable (S3) (47.08%) from the total area in Simpang Kuta Buluh Village. The same result with actual land suitability classes for *N. lappaceum* in Gunung Ambat Village (availability of water (wa), erosion hazard (eh), root zone medium (rc), and nutrient retention (nr) were the dominant of limiting factor in this area). There were no suitable (S1), and not suitable (N) classes were found in both Gunung Ambat Village and Simpang Kuta Buluh Village.

The actual land suitability map for *N. lappaceum* in Gunung Ambat Village is presented

Table 7. Actual land suitability classification for Rambutan (*N. lappaceum*) in Land Unit VI based on the matching method.

Land characteristics	Field/laboratory data	Actual land suitability
Temperature (tc)		
(°C)	23 °C-24 °C	S1
Water availability (wa)		
Rainfall (mm year^{-1})	2010	S2
Oxygen availability (oa)		
Drainage	Well drained, medium	S1
Root zone medium (rc)		
Texture	Moderately fine	S1
Soil depth (cm)	95.33	S2
Nutrient retention (nr)		
CEC (me 100g^{-1})	17.89	S1
pH H_2O	6.62	S2
Organic-C (%)	1.66	S1
Erosion hazard (eh)		
Slope (%)	15%	S2
Erosion hazard	Very low	S1
Flood hazard (fh)		
Inundation	F0	S1
Actual land suitability evaluation		S2 wa,rc,nr,eh

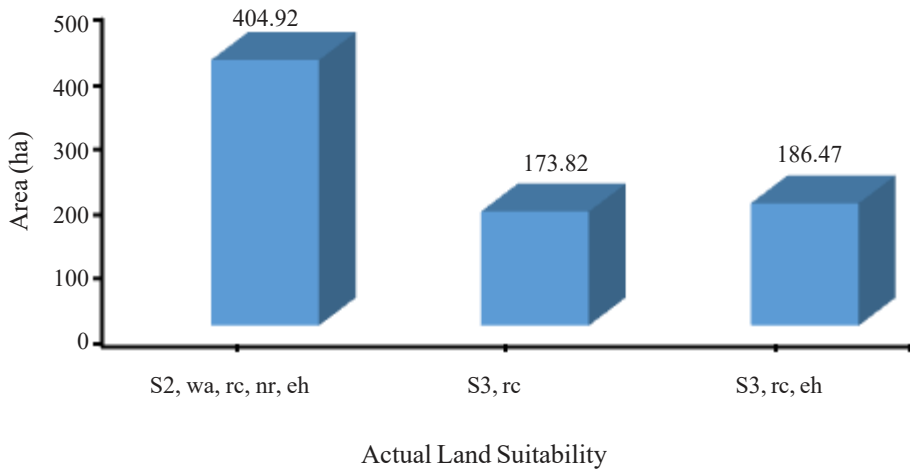

Figure 3. The area of actual land suitability classes for *N. lappaceum* in Simpang Kuta Buluh Village.

in Figure 4. and the actual land suitability map for *N. lappaceum* in Simpang Kuta Buluh Village is presented in Figure 5.

Based on Figure 4 and Figure 5, the development of *N. lappaceum* in both Simpang Kuta Buluh Village and Gunung Ambat still available based on the area of land suitability that dominated by moderately suitable (S2) especially in Land Unit 3, 4, and 6. There were several limiting factors in land suitability evaluation both in Simpang Kuta Buluh Village and Gunung Ambat, namely: availability of water (wa), erosion hazard (eh), root zone medium (rc), and nutrient retention (nr). Because of natural limitations, root zone medium (rc) and water availability (wa) were the most difficult constrain to counter in this area. Nevertheless, nutrient retention can be improved by fertilization (organic and inorganic) such as by urea and superphosphate fertilizers and the erosion hazard (slope) can be improved by terracing steep areas. For Land Unit 1, 2, 5, and 7, the actual land suitability evaluation was marginally suitable (S3). The root zone medium (rc), were the most difficult constrain to counter in this area.

Table 8. Actual land suitability classification for Rambutan (*N. lappaceum)* in Land Unit VII based on the matching method

Land characteristics	Field/laboratory data	Actual land suitability
Temperature (tc)		
(°C)	23 °C-24 °C	S1
Water availability (wa)		
Rainfall (mm year^{-1})	2010	S2
Oxygen availability (oa)		
Drainage	Well drained	S1
Root zone medium (rc)		
Texture	Moderately coarse	S3
Soil depth (cm)	58.33	S3
Nutrient retention (nr)		
CEC (me 100g^{-1})	16.90	S1
pH H_2O	6.68	S2
Organic-C (%)	1.43	S1
Erosion hazard (eh)		
Slope (%)	15%	S2
Erosion hazard	Very low	S1
Flood hazard (fh)		
Inundation	F0	S1
Actual land suitability evaluation		S3, rc

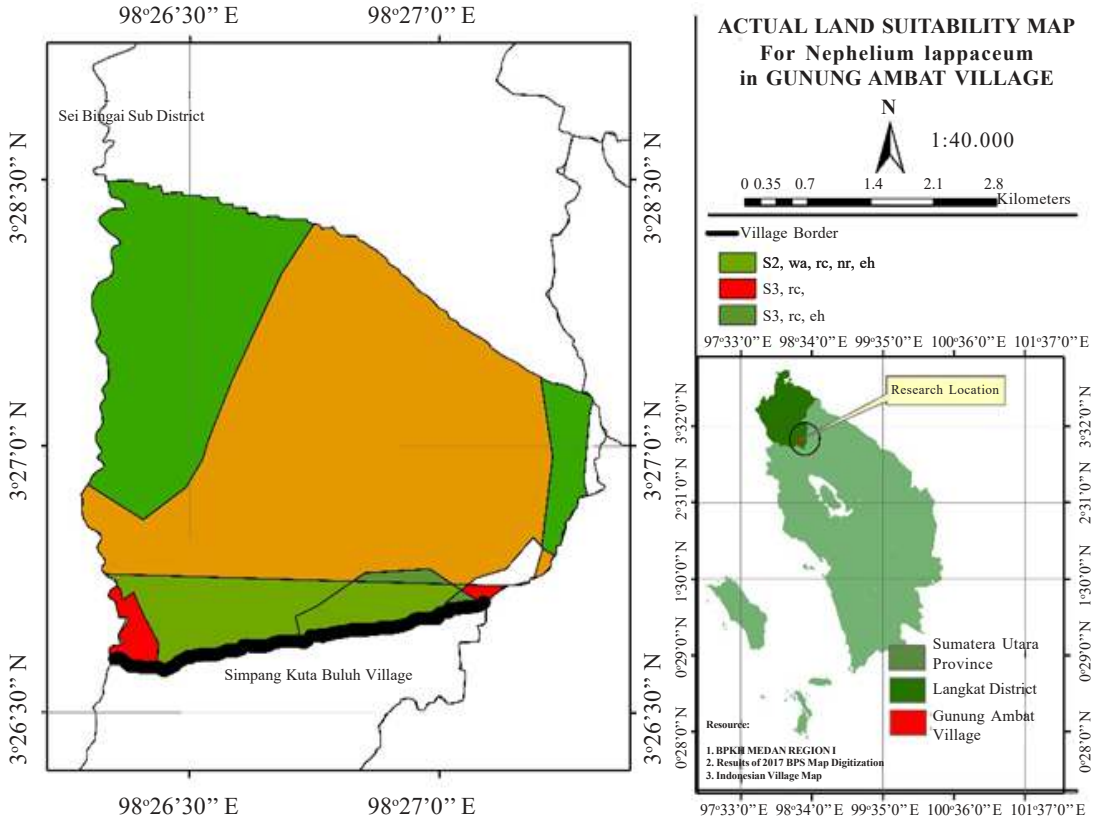

Figure 4. Distribution map of actual land suitability for *N. lappaceum* in Gunung Ambat Village.

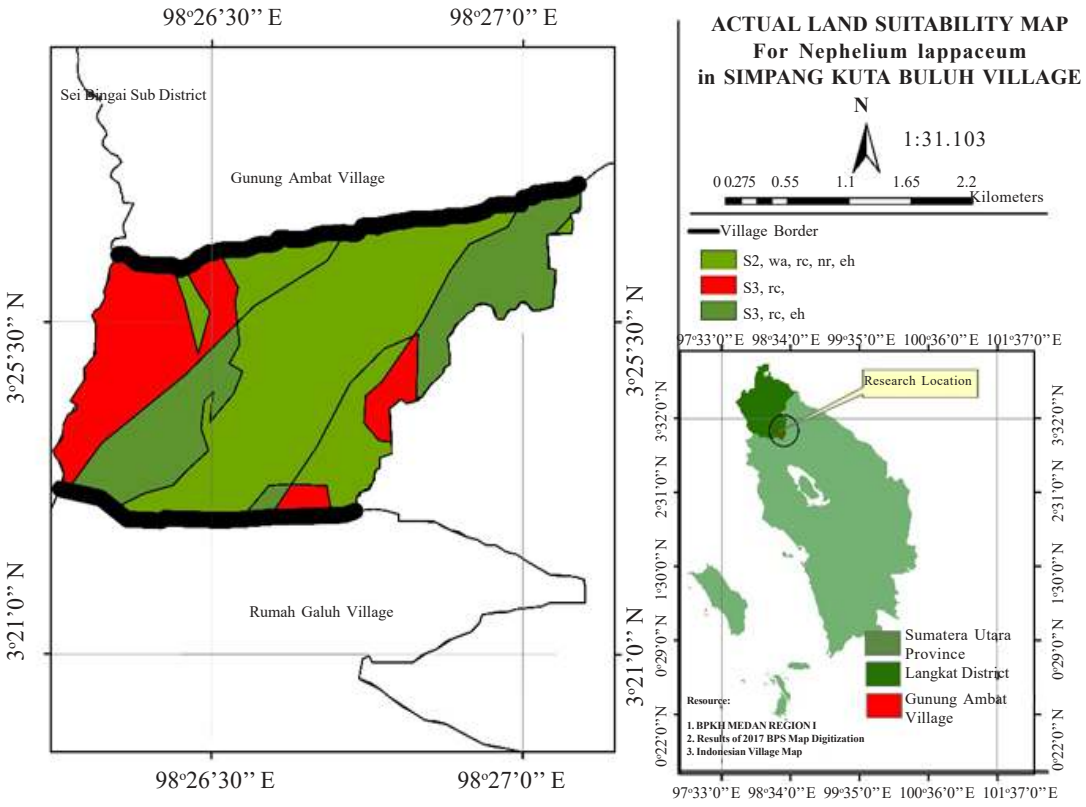

Figure 5. Distribution map of actual land suitability for *N. lappaceum* in Simpang Kuta Buluh Village.

CONCLUSIONS

Rambutan (*N. lappaceum*) is moderately suitable to be developed in Gunung Ambat Village and Simpang Kuta Buluh Village. There were dominant of limiting factor in this area which is difficult to overcome, namely: water availability (wa) inland unit 3, 4, and 6 and root zone medium (rc) in all land units.

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