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Habitat characteristics of Andaliman (*Zanthoxylumacanthopodium* DC) in North Sumatra using a GIS (Geographical Information System) approach

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Abstract. Andaliman (*Zanthoxylum acanthopodium* DC) is a member of the Rutaceae family which is spread in the regions of East Asia, Southeast Asia, and South Asia. In the territory of Indonesia, andaliman is spread in the highlands of North Sumatra and parts of Aceh. Andaliman is a spice plant that is usually used as a spice for the Batak tribe in North Sumatra. This study aims to analyze the characteristics of andaliman habitat in North Sumatra. A total of 169 samples from 8 regencies in North Sumatra analyzed habitat characteristics using the ArcGis 10.3 program using various ecological data. The results showed that andaliman was widely distributed in the highlands in North Sumatra. Andaliman inhabits 4 soil types, namely Humic Acrisols (36.09%), Orthic Acrisols (34.31%), Humic Cambisols (18.34%), and Orthic Ferralsols (11.24%), 7 Types of land cover namely dry land agriculture (81.06%), open soil (0.59%), rice fields (6.5%), settlements (2.9%), secondary dryland forests (4.73%), shrubs (3.55%), and industrial plantations (0.59%). Andaliman inhabits a limited elevation between 854-2676 m above sea level. The highest number in elevation 1161-1526 (76.92%), 854-1160 (14.20%), 1527-1968 (7.69%), 1969-2676 (0.59%). In rainfall ecology variables, Andaliman occupies an area with rainfall between 1500-4000 mm/year. The highest number occupies rainfall between 1500-2000 (8.87%), 2000-2500 (83.43%), 2500-3000 (5.91%), 3000-3500 (0.59%), and 3500-4000 (0.59%) mm/annual. Most of Andaliman grew in areas with Critical land types (69.23%), rather critical (25.44%), critical potential (3.55%) and very critical (1.18%). Andaliman occupies a limited habitat character so that the right steps are needed in his conservation efforts. This research is expected to become important information in the conservation and cultivation efforts of andaliman in North Sumatra.

1. Introduction

Andaliman (*Zanthoxylum acanthopodium*DC) is a member of the genus *Zanthoxylum*, Rutaceae family [1]. This family contains essential oils and therefore is widely used in culinary and medicine[2] [3]. Fruits from this plant are used as spices in ethnic Batak cuisine of North Sumatra[4]. The genus *Zanthoxylum* is found throughout the regions of Central and North America[5] with characteristics of thorned bushes, small trees, spiny leaves and branches and fruits with a very strong aroma[6].

According to Wijaya [7], *Z. acanthopodium* has a very high essential oil content and serves as antioxidant and natural antimicrobial. *Zanthoxylum acanthopodium* also contains terpenoid substances with antioxidant, anti microbe and immune-stimulant properties [8]. Due to its wide-ranging benefits,



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Z. acanthopodium in North Sumatra is widely exported at premium prices. However, to this day it has yet to have an extensive agricultural sector in Indonesia.

At present, the Andaliman population in Indonesia is very limited, ranging from 1000-2000 trees, because the seeds are difficult to germinate despite optimum growth environment [9]. Andaliman conservation efforts are just as difficult because it can only grow properly in its natural habitat [10]. Andaliman is an endemic plant in the Lake Toba region and a protected plant species in the Lake Toba geopark conservation effort [11]. According to Simatupang [12], the Batak people of North Sumatra has indirectly carried out in situ conservation because of its benefits in the tribe's cuisine.

Forest area in North Sumatra continues to experience a reduction from 2001 to 2017 of 1.21 Mha or 21% due to illegal logging, conversion of forests into oil palm plantations and into industrial forests [13]. The reduced forest area in North Sumatra has consequently threatened the existence of *Z. acanthopodium*, and made worse by the fact that *Z. acanthopodium* is difficult to germinate outside of its natural habitat.

One hindrance to the conservation of *Z. acanthopodium* is a lack of information regarding habitat characteristics and the distribution of Andaliman in North Sumatra. This study aims to analyze habitat characteristics of *Z. acanthopodium* in North Sumatra using GIS (Geographical Information System) approach to identify the characteristics of *Z. acanthopodium* habitat in North Sumatra. This research is expected to be important information in *Z. acanthopodium* conservation efforts in North Sumatra.

2. Materials and Methods

2.1. Collecting Coordinate Points

Coordinate data was obtained from 169 points from 8 districts in North Sumatra, as a result of field exploration. The coordinate data during field exploration in North Sumatra was obtained using GPS (Global Position System) Garmin Etrex 30 type. Field exploration included the Dairi district, Karo, Humbang Hasudutan, Samosir, North Tapanuli, Toba Samosir, Simalungun, and South Tapanuli (Table 1).

Table 1. Wilayah pengambilan koordinat *Z. acanthopodium* di Sumatera Utara

No	Regency	Total
1	Dairi	36
2	HumbangHasudutan	39
3	Samosir	5
4	Simalungun	60
5	Karo	9
6	Tapanuli Selatan	4
7	Tapanuli Utara	2
8	Toba Samosir	14

2.2. Environmental Variabel

We consider five types of environmental variables as potential predictors of *Z. acanthopodium* habitat character in North Sumatra (Table 2). The five types of environmental variables are obtained from various relevant sources. The five types of variables are rainfall, elevation, critical land, soil type, and land cover.

Table 2. Data variabel lingkungan yang digunakan dalam analisis

No	Variable	Source
1	Soil Type	Land Soil type data, FAO UNESCO soil map of Southeast Asia ver. 3.0 (2003)
2	Rainfall	Sumatra Island rainfall data, ESRI shape rain observation station source files (BMKG, PU, Private) 1970-2004 with a 0,01 degree resolution or 1.11 km
3	Critical Land	Sumatran Island critical land data, Directorate General of Forestry Planning, Ministry of Forestry Indonesian Republic of Indonesia, KML format

4	Elevation	Sumatera island elevation data, DIVA-GIS shapefile source SRTM30 data set, CGIAR-SRTM data with resolution of 30 arc sec
5	Land Cover	Land Cover map data, Directorate General of Forestry Planning, Ministry of Forestry Indonesian Republic of Indonesia, KML format

2.3. Data Analysis

The coordinate data that has been obtained will be analyzed using the ArcGIS 10.3 application by combining coordinate data obtained from the field with environment variable data. The analysis is carried out with integrated steps, beginning with coordinate data input, data merging, overlaying, scoring, and output. By combining field data with secondary data, several different data layers will be obtained according to the results of the coordinate analysis with environment variable data.

The ArcGIS application has a set of structured mathematical calculations to create a raster data analysis which is data from different parameters for the same region. ArcGIS can explore interactions and relationships between different layers of data sets. The ArcGIS application can be used to analyze the relationship between environmental variables in specific regions with the presence of *Z. acanthopodium* in North Sumatra.

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3. Result and Discussion

3.1. Result

Based on data obtained from field explorations in North Sumatra, *Z. acanthopodium* is widely distributed in the Lake Toba region. Field studies also show that *Z. acanthopodium* is distributed around the Lake Toba Regency such as in Simalungun, Dairi, HumbangHasudutan, Samosir, Toba Samosir, Karo, North Tapanuli, and South Tapanuli. The data obtained from field explorations shows 169 points of distribution across 8 districts.

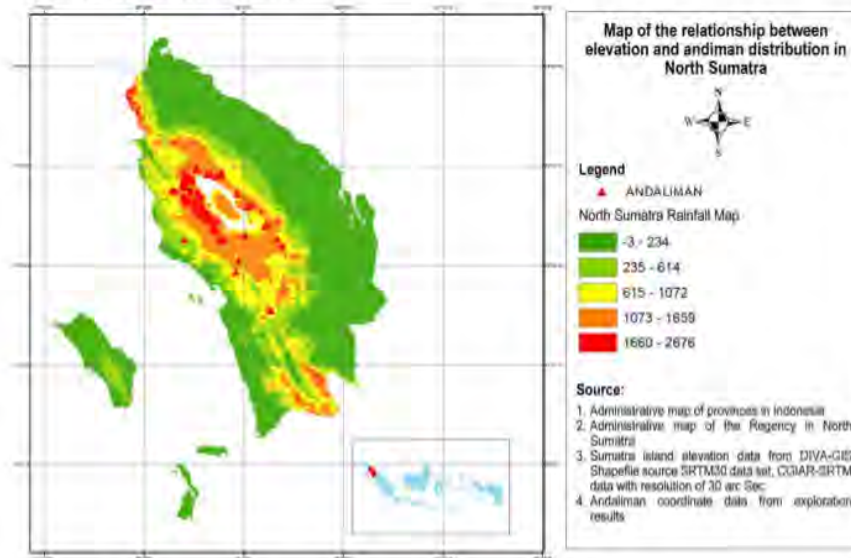


Figure 1. Map of the relationship between elevation and andaliman distribution in North Sumatera

Zanthoxylumacanthopodium found at limited elevation of 854-2676 meters above sea level. *Z. acanthopodium* more is at an altitude of 1161-1526 m (76,92%), followed by an elevation of 854-1160 m (14.20%), 1527-1968 m (7.69%), and 1969-2676 m (0.59%). *Z. acanthopodium* distribution is

based on elevation, as presented in Figure 1. This shows that distribution of *Z. acanthopodiumis* very limited and tends to accumulate at certain heights. Regarding rainfall environment variables, *Z. acanthopodiumis* found in areas with rainfall of 1500-4000 mm/annum. The largest number of *Z. acanthopodiumis* are found in areas with rainfall of 2000-2500 mm/annum (83.43%), followed by areas with rainfall of 1500-2000 mm/annum (8.87%), 2500-3000 mm/annum (5.91%), 3000-3500 mm/annum (0.59%), and 3500-4000 mm/annum (0.59%). *Z. acanthopodiumis* distribution based on rainfall is found in Figure 2.

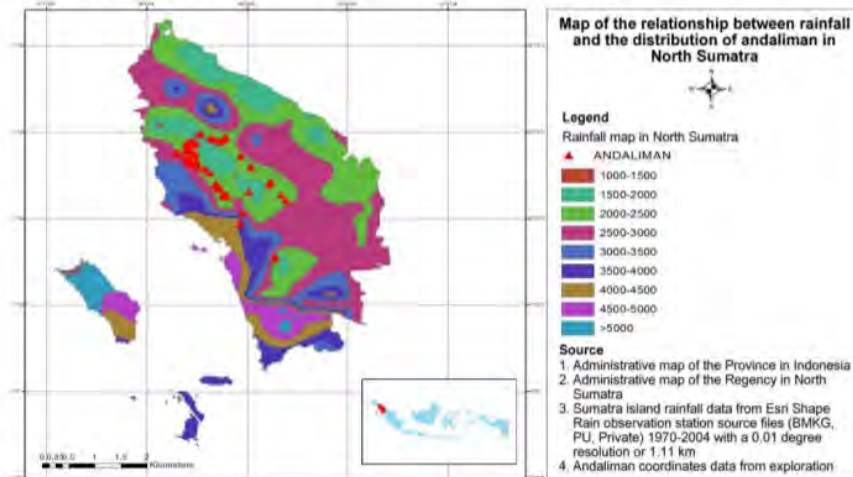


Figure 2. Map of the relationship between rainfall and the distribution of andaliman in North Sumatera

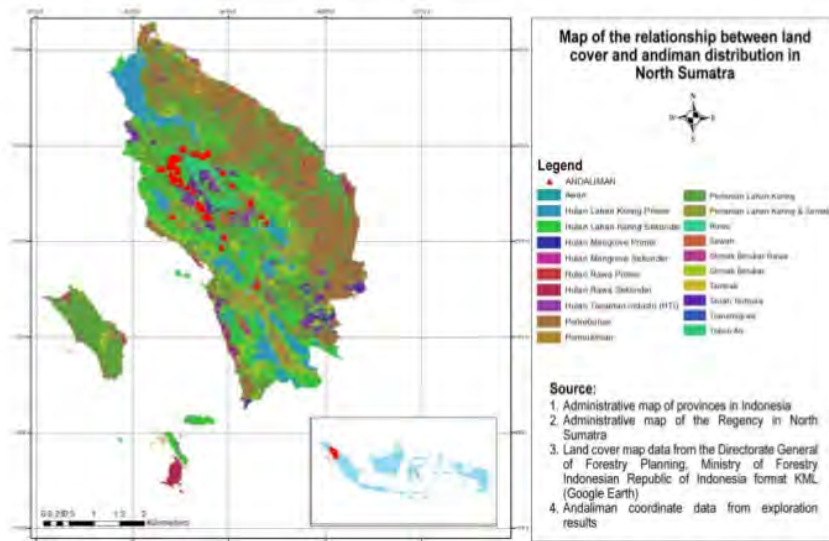
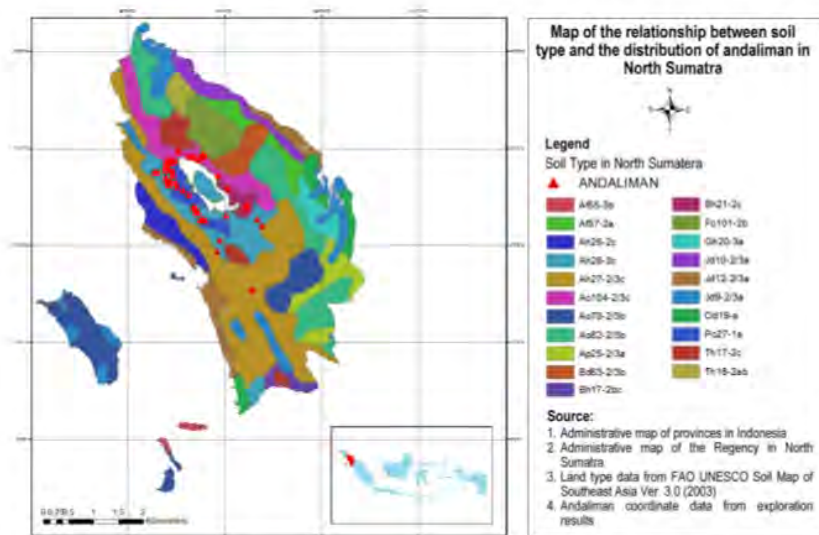
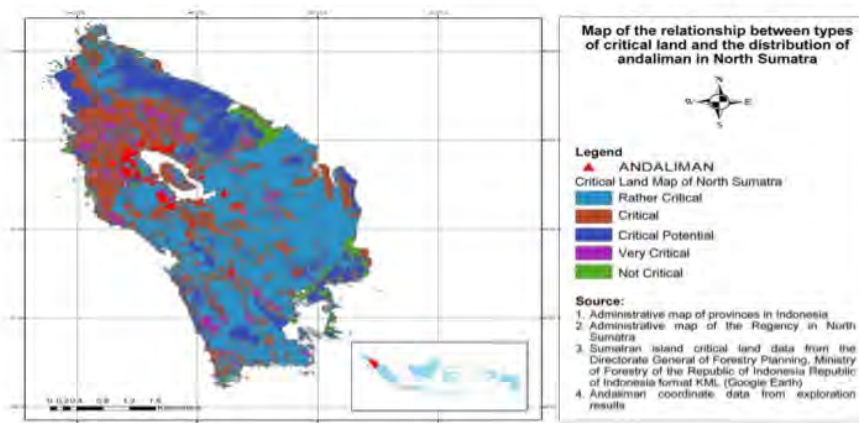


Figure 3. Map of the relationship between land cover and andaliman distribution in North Sumatera

Based on environmental variants in the form of land cover, *Z. acanthopodium* found in 7 types of land cover. The largest number of *Z. acanthopodium* are found on dryland agriculture (81.06%), paddy fields (6.5%), dryland forest (4.74%), bushes (3.55%), industrial plantations (0.59%), and settlements (0.59%). Distribution of *Z. acanthopodium* based on land cover is shown in Figure 3. When it comes to soil type environmental variety, *Z. acanthopodium* distributed across 4 types of soil: Its largest population is found on Humic Acrisols (36.09%), Orthic Acrisols (34.31%), Humic Cambisols (18.34%), and Orthic Ferralsols (11.24%) soil types. Distribution of *Z. acanthopodium* based on soil type is found in Figure 4. Based on critical land environmental variety, the largest number of *Z. acanthopodium* are found on critical (69.23%), rather critical (25.44%), potentially critical (3.55%), and very critical (1.18%) lands. Distribution of *Z. acanthopodium* based on critical land types is found in Figure 5.



5 **Figure 4.** Map of the relationship between soil type and andaliman distribution in North Sumatera



5 **Figure 5.** Map of the relationship between of critical land and andaliman distribution in North Sumatera

3.2. Discussion

In its original habitat, *Z. acanthopodium* grows on limestone rocks in warm, humid subtropical climates, with rainfall ranging from 1500 to 2000 mm per year with an average temperature of 25°C [14]. This plant blooms every year at the end of March to early May to produce a group of greenish yellow flowers, while its reddish fruit ripens between September and October [15]. *Zanthoxylum acanthopodium* grows on loam soil at an altitude of 900 meters above sea level where rainfall reaches 2500 mm per year with as much as 170-180 days of rain a year [16].

Character habitat research in the form of soil type for *Z. acanthopodium* has never been carried out before. According to the research results, *Z. acanthopodium* grows on humic Acrisols and orthic Acrisols soil types. Humic Acrisols has moderate level of natural fertility, especially due to the high content of organic substances and its acidic property. This type of soil is found on mountain slopes and valleys of Kalimantan, Sumatra, and Sulawesi with natural vegetation of tropical rain forests. Orthic Acrisols are spread throughout the Southeast Asia region with natural vegetation of tropical forests in Indonesia, the Philippines, Malaysia, and Thailand. This soil type is different from humic Acrisol, in which it contains very minimum traces of chemicals, is naturally acidic and lacking in minerals [17].

Based on research results, *Z. acanthopodium* mostly grows on dry agricultural lands (81.06%). Dry agriculture land can utilize forests with high nutritional content for farming purposes [18]. Based on exploration experience, researchers found that most *Z. acanthopodium* grow on tropical rainforest mountain slopes at a specific inclination. This indicates that *Z. acanthopodium* grows well in dryland farming areas but still require adequate nutrients to flourish.

The majority of *Z. acanthopodium* grow in areas with critical land conditions. This indicates that *Z. acanthopodium* can survive on land with critical conditions. Uncontrolled land changes and those not followed by soil conservation from water have caused the creation of critical land [19]. When left unchecked, it can result in a more severe damage, thereby disrupting the existence of *Z. acanthopodium* in nature.

The results of this study can be used as initial information in *Z. acanthopodium* conservation efforts in North Sumatra. The conservation of *Z. acanthopodium* becomes important due to being highly associated with the culture of Batak tribes of North Sumatra. The difficulties of growing *Z. acanthopodium* outside its natural habitat has made the habitat characteristics data of *Z. acanthopodium* the key to maintaining its natural existence and its extensive association with the traditional cultures of North Sumatran tribes.

4. Conclusion

Based on the results of the study, the *Z. acanthopodium* habitat characteristics include growing at an elevation of 854-2676 meter above the sea level with rainfall of 1500-4000 mm/annual, 7 types of land cover (dryland agriculture, rice fields, secondary dryland forests, shrubs, industrial plantations, and settlements), 4 soil types (Humic Acrisols, Orthic Acrisols, Humic Cambisols, and Orthic Ferralsols), and 4 types of critical lands (critical, rather critical, critical potential, and very critical). The results of the study are expected to serve as an important information in the cultivation and conservation of *Z. acanthopodium* in North Sumatra.

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