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

C Suriani*, E Prasetya, T Harsono, D Handayani
Department Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, North Sumatera, Indonesia

* cicik.suriani@unimed.ac.id

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,
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).

| No | Regency         | Total |
|----|-----------------|-------|
| 1  | Dairi           | 36    |
| 2  | Humbang Hasudutan | 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 Variables

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.

| 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 |
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.

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, Humbang Hasudutan, 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](image)

*Zanthoxylum acanthopodium* is 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. acanthopodium* is very limited and tends to accumulate at certain heights. Regarding rainfall environment variables, *Z. acanthopodium* is found in areas with rainfall of 1500-4000 mm/annum. The largest number of *Z. acanthopodium* 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. acanthopodium* 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* is 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* is 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.

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

**Figure 5.** Map of the relationship between types 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 humicacrisols and orthicacrisols soil types. Humicacrisol 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. Orthicacrisol are spread throughout Southeast Asia region with natural vegetation of tropical forests in Indonesia, the Philippines, Malaysia, and Thailand. This soil type is different from humicacrisol, 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 forest 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 nutrition 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 (HumicAcrisols, OrthicAcrisols, HumicCambisols, and OrthicFerralsols), 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.

Acknowledgments
The authors gratefully acknowledge that the present research is supported by Ministry of Research and Technology and Higher Education Republic of Indonesia. The support is under the research grant “superior university basic research” of year 2018.

References
[1] Siregar, B.L. (2003) Andaliman (*Zanthoxylum acanthopodium* DC.) in North Sumatra: Description and Germination. *Hayati* 10(1): 38-40
[2] Kumar, V., Kumar, S., Singh, B., & Kumar, N. (2014). Quantitative and structural analysis of amides and lignans in *Zanthoxylum armatum* by UPLC-DAD-ESI-QTOF–MS/MS.
[3] Zhang, Y., Wang, D., Yang, L., Zhou, D., & Zhang, J. (2014). Purification and characterization of flavonoids from the leaves of *Zanthoxylum bungeanum* and correlation between their structure and antioxidant activity. *PLoS One*, 9(8): e105725.

[4] Kristanty, R. E., & Junie, S. (2015). The Indonesian *Zanthoxylum aechmatopodium* DC.: Chemical And Biological Values. *International Journal of PharmTech Research*, 8(6): 313-321.

[5] Hartley, T. G. (1966). A revision of the Malesian species of *Zanthoxylum* (Rutaceae). *Journal Arnold Arboretum*, 47:171-221.

[6] Chyau, C. C., Mau, J. L., and C. M. Wu (1996). Characteristics of the steam-distilled oil and carbon dioxide extract of *Zanthoxylum simulans* fruits. *Journal Agriculture Food Chemistry*, 44: 1096-1099.

[7] Wijaya CH. 1999. Andaliman, rempah tradisional Sumatera Utara dengan aktivitas antioksidan dan antimikroba. *Bul Teknol Industri Pangan* 10:59-61.

[8] Tarigan, A. 1999. *Studi aktivitas senyawa antimikroba dari berbagai rempah-rempah*. Skripsi. Unika St. Thomas.

[9] Napitupulu, B., Sortha, S., dan Mery, S., 2004. Potensi andaliman sebagai Food Additive tradisional etnis batak Sumatera Utara. BPTP Sumatera Utara. Medan, hlm. 53-56.

[10] Khoiriah, N. 2009. *Kultur Jaringan Daun Andaliman (Zanthoxylum aechmatopodium DC.) dengan Perlakuan EMS (Ethyl Methana Sulphonate)*. Skripsi. Departemen Biologi, FMIPA, Universitas Sumatera Utara.

[11] Peraturan Presiden Republik Indonesia Nomor 81 Tahun 2014 Tentang Rencana Tata Ruang Kawasan Danau Toba dan Sekitarnya.

[12] Simatupang, S. 2013. Pangan Tradisional Sumatera Utara Berbasis Budaya dan Pelestarian In Situ. *Warta Plasma Nutfah Indonesia*, Nomor 25: 5-16.

[13] Global Forest Watch (2017) Tree cover loss in Sumatera Utara. https://www.globalforestwatch.org/dashboards/country/IDN/32?treeLossTsc=eyJoaWlobGlnaHRlZCI6ZmFsc2UsImZvcmVzdFR5cGUiOiIiLCJsYW5kQ2F0ZWdvcnkiOiIiLCJsYWNrZ29kcyI6IiLCJ0ZXN0IjoxfQ%3D%3D Accessed 10 August 2017

[14] Walter, H., Harnickell, E., & Mueller-Dombois, D. (1975). *Klimadiagramm-Karten der einzellen Kontinente und die okologische Klimagliederung der Erde*. Fischer Verlag, Stuttgart.

[15] Rakić, T., Šinžar-Sekulić, J., Filipović, B., Tadić, V., Stevanović, B., & Tan, K. (2009). Ecophysiological and anatomical characteristics of the subtropical shrub *Zanthoxylum aechmatopodium* (Rutaceae) in conditions of a temperate continental climate (Serbia). *Archives of Biological Sciences*, 61(2), 249-260.

[16] Napitupulu, B.; Simatupang, S.; Sinaga, M. Potency of Andaliman as Traditional Food Additive of Batak Ethnic North Sumatera. In Presented at *Seminar Nasional Peningkatan Daya Saing Pangan Tradisional*.; BB Pascapanen., Ed.; 2004; Bogor, Indonesia.

[17] FAO, 1979. *Soil Map of the World, 1 : 5,000,000*. Vol. 1, legend. Unesco-Paris.

[18] Notohadiiprawiro, T. (2006). Pertanian lahan kering Di Indonesia: Potensi, prospek, kendala, dan pengembangannya. Yogyakarta, Indonesia: Ilmu Tanah Universitas Gadjah Mada.

[19] Nugroho, S. & Prayogo, T. (2011). Penerapan SIG untuk penyusunan dan analisis lahan kritis pada satuan wilayah pengelolaan Das Agam Kuantan, Provinsi Sumatera Barat. *Jurnal Teknologi Lingkungan*, 9(2).