Application of geographic information system for mapping of *Hevea brasiliensis* and *Aquilaria malaccensis* land suitability at Simpang Kuta Buluh

Rahmawaty\(^1\)*, A Rauf\(^2\), R Batubara\(^1\) and S Frastika \(^1\)
\(^1\)Faculty of Forestry, Universitas Sumatera Utara, Jl. Tridharma Ujung No.1, Kampus USU Medan, Sumatera Utara, Indonesia
\(^2\)Faculty of Agriculture, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia

*E-mail: rahmawaty@usu.ac.id*

**Abstract.** *Hevea brasiliensis* and *Aquilaria malaccensis* were planted by the community because of its high economic value. The suitability land of *Hevea brasiliensis* and *Aquilaria malaccensis* in North Sumatra Province are important, especially in the agroforestry land that are often planted by the community. This study aimed to map the suitability of the land for *Hevea brasiliensis* and *Aquilaria malaccensis* in Simpang Kuta Buluh village, Sei Bingai Sub District, Langkat District, North Sumatra, Indonesia. The survey method was conducted to collect soil samples in the field. Land suitability classification (LSC) for *Hevea brasiliensis* and *Aquilaria malaccensis* was evaluated based on the matching method. The Geographic Information System (GIS) was used to map the land suitability. The results showed that the actual land suitability classes for *Hevea brasiliensis* in Simpang Kuta Buluh Village were moderately suitable (S2) (52.91%) and marginal suitable (S3) (47.09 %). The actual land suitability classes for *Aquilaria malaccensis* in Simpang Kuta Buluh Village also the same with *Hevea brasiliensis*, namely: S2 and S3. The limiting factors for *Hevea brasiliensis* namely: temperature (tc) and root zone medium (rc). The limiting factors for *Aquilaria malaccensis* namely: root zone medium (rc).

1. Introduction
Currently, the use of geographic information system (GIS) technology has been widely used and applied in various fields. Some of the most widely used GIS applications are for land mapping, watersheds, landslide hazard predictions, flood predictions, forest and land fires. GIS has also been used in various scientific fields, such as agriculture, biology, environment, and forestry [1-8]. This technology is widely used because of its ability to store data, analyze data and display data in the form of tables, graphs and maps. The map serves to display the spatial distribution of geographical phenomena including characteristics that exist on the surface of the earth [9].

*Aquilaria malaccensis* in Langkat District, was planted by community on the sidelines of old rubber and oil palm plants [10]. One of the agarwood-producing trees is *A. malaccensis*. Agarwood is one of the non-timber forest products which is a potential natural resource in Indonesia [11]. In Indonesia, agarwood-producing trees spread on various islands, such as: Sumatra, Kalimantan, Maluku, Sulawesi, Papua, and Southeast Nusa Tenggara. One of the factors that causes limited agarwood yield from plantations, because planting can only be done in the shade [12]. Furthermore, it was stated that its nature was semitolary, causing people to not be able to plant *A. malaccensis* in open land including former cultivation, ex-fires and other non-productive areas that were open.
The main problems facing plantations community is low in rubber and agarwood productivity. Consider the magnitude of the potential for *Hevea brasiliensis* and *A. malaccensis* development in Langkat District and in an effort handling rubber development problems, it is necessary planning so people are not harmed by planting crops rubber in locations that do not meet the growing criteria plants (biophysics), spatial aspects (spatial) and aspects economy. Therefore, direction for the community is needed in choosing the right location for crop cultivation that is. Selection of the right location will produce maximum productivity and will correlate with the benefits.

Land evaluation can be defined as a process of assessing the potential of a land for certain uses [13-16]. The results of land suitability analysis are needed as consideration for decision makers regarding land use [17]. The land evaluation process is carried out by comparing the growing requirements of a plant with the characteristics of the land used. There are two types of land suitability, namely: actual land suitability (before the improvement effort is made) and potential (after the improvement effort is carried out) [14,18-20]. The usefulness of land evaluation data is used as a basis for rational land use planning [19]. The results of the land evaluation study can be displayed in the form of a map with the help of GIS technology. This technology is very helpful in various research activities including activities related to vegetation and land. Several researches have proved that GIS can be an impressive instrument for cataloguing vegetation data obtained from ground surveys into mapping and analysis. For example, some of the results of studies that have used GIS are: the use of GIS for estimating potential rubber production in different harvesting systems [21]; use of GIS techniques for mapping potential areas for rubber plantations in India [22]; use of GIS for analysis of medicinal plants and herbs with spatial distribution in arid and semi arid zones in North West of Jordan [23]; use of GIS to evaluate the suitability of the region for medicinal species of Astragalus [24] and use of GIS on locating *Astragalus hypsogeton bunge* appropriate site [25].

Actual land suitability or current land suitability where the land is in natural condition. The existing limiting factors are not undertaken improvement efforts. Limiting factors are divided into two, namely: permanent (impossible to repair or not economical to repair) and limiting factors that can be improved because they are still economically profitable, such as by applying appropriate technology.

*H. brasiliensis* and *A. malaccensis* in North Sumatra Province are favourite plants and very popular with people in North Sumatra, especially on agroforestry land which is often managed by the community. This is due to the economic value of rubber and agarwood. Indonesia is one of the biggest rubber exporting countries in the world after Thailand. As for agarwood, it is one of the products of non-timber forest products [12]. Agarwood is a resin obtained from microbial infections in trees from the Thymeleaceae family, Leguminaceae family and Euforbiaceae family. Among several agarwood types of there are 3 (three) types of good quality, namely: *Aquilaria malaccensis*, *Aquilaria filarial* and *Aetoxylon sympethallum* [11, 26].

One place that has potential to be develop *H. brasiliensis* and *A. malaccensis* in North Sumatra Province is Sei Bingai Sub-district, Langkat Regency. Research about mapping of land suitability for *H. brasiliensis* and *A. malaccensis* in this area has never been conducted, Hence, evaluation of actual and potential land suitability is needed. There is a lack of research related distribution of *H. brasiliensis* and *A. malaccensis* land suitability in North Sumatra Province, there is a lack of data and information on the actual and potential land suitability in Langkat District. There is a lack of data and information related distribution of *H. brasiliensis* and *A. malaccensis* land suitability in this area, therefore, the objective of this study was to evaluate the actual and potential land suitability for *H. brasiliensis* and *A. malaccensis* in Simpang Kuta Buluh Village, Sei Bingai Sub-district, Langkat Regency. The result of this study were expected to the local government in policy formulation as well as smallholder *H. brasiliensis* and *A. malaccensis* plantations in North Sumatra Province.

### 2. Materials and Methods

This research was conducted from January to April 2019 in Simpang Kuta Buluh Village, Sei Bingai Sub-district, Langkat Regency, North Sumatra Province as presented in Figure 1.
In this study, survey methods were used to collect soil samples in the field. Classification of land suitability classes uses the matching method [27]. The reference and land suitability criteria were adopted from the library of land and agro-climate research centers, Bogor [16,28]. Soil characteristics consist of temperature (tc), water availability (wa), oxygen availability (oa), texture and soil depth (rc), nutrient retention (nr), cation exchange capacity, base saturation, pH, C-organic, slope, soil erosion, and flood hazard. To make a map of the suitability of actual and potential land use GIS technology with Arc GIS Software. Determination of land suitability classes consisting of S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), and N (not suitable [1.15-20].

Primary data obtained from the results of field surveys and results of analysis of soil samples in the laboratory. Whereas secondary data was obtained from several institutions. Land suitability analysis was done by comparing the characteristics of the land obtained from the field with the growing requirements of *H. brasiliensis* and *A. malaccensis* [20].

### 3. Results and Discussion

Comparison area of the actual and potential land suitability of *H. brasiliensis* and *A. malaccensis* in Simpang Kuta Buluh Village is presented in Table 1 and Table 2.

**Table 1.** Comparison of actual and potential land suitability classes of *H. brasiliensis* in Simpang Kuta Buluh Village

| Actual land suitability classes | Potential land suitability classes | Area | % |
|-------------------------------|-----------------------------------|------|---|
| S2 (tc,rc,eh)                 | S2 (tc,rc)                        | 404.92 | 52.91 |
| S3 (rc)                       | S3 (rc)                           | 360.28 | 47.09 |
| Total                         |                                   | 765.20 | 100.00 |
Table 2. Comparison of the actual and potential land suitability classes of *A. malaccensis* in Simpang Kuta Buluh Village

| Actual land suitability classes | Potential land suitability classes | Area | %  |
|--------------------------------|-----------------------------------|------|----|
| S2 (rc,nr,eh)                  | S2 (rc)                           | 404.92 | 52.91 |
| S3 (rc,eh)                     | S3 (rc)                           | 186.47 | 24.37 |
| S3 (rc)                        | S3 (rc)                           | 173.82 | 22.72 |
| Total                          |                                   | 765.20 | 100.00 |

Based on Table 1, actual land suitability classes for *H. brasiliensis* in Simpang Kuta Buluh Village was moderately suitable (S2), with area of 404.92 ha (52.91%) from the total area and limiting factor were temperature (tc), root zone medium (rc), and slope (eh) and marginal suitable (S3) with area of 360.28 ha (47.09%) from the total area with limiting factor was rc. Based on Table 2, actual land suitability classes for *A. malaccensis* in Simpang Kuta Buluh Village was moderately suitable (S2), with area of 404.92 ha (52.91%) from the total area and limiting factor were nutrients retention (nr), root zone medium (rc), and and slope (eh), marginal suitable (S3) with area of 186.47 ha (24.37%) and marginal suitable (S3) with area of 173.82 ha (22.72%) from the total area with limiting factor was rc. Class S3 (marginally suitable) means that the land has a limiting factor that is very difficult to overcome and requires sophisticated technology and requires a large cost and intervention from the government or company to overcome it. [14,18]. The slope (eh) can be improved by terracing steep areas. The most difficult constrain to counter were root zone medium (rc) and temperature (tc), because they were natural limitations. Hence, potential LSC for *H. brasiliensis* in the area could become S2tc,rc (52.91) and S3rc (47.09) and potential LSC for *A. malaccensis* in the area could become S2rc (52.91) and S3rc (47.09). There were no highly suitable (S1) and N (not suitable) classes were found in the area in accordance with the study in Besitang Watershed [14].

A comparison map between the actual land suitability class of the *H. brasiliensis* and *A. malaccensis* plants in Simpang Kuta Buluh Village is presented in Figure 2,3,4,5.

![Figure 2](image_url). Map of actual land suitability distribution for *H. brasiliensis* in Simpang Kuta Buluh Village.
Figure 3. Map of potential land suitability distribution for *H. brasiliensis* in Buluh Simpang Kuta Village

Figure 4. Distribution map of actual land suitability for *A. malaccensis* in Simpang Kuta Buluh Village
4. Conclusion
There are two actual land suitability classes for *H. brasiliensis* and *A. Malaccensis* at Simpang Kuta Buluh Village, namely: S2 and S3. The area of *H. brasiliensis* and *A. malaccensis*, land suitability class S2 is 52.91% of the total area and land suitability class S3 is 47.09%. There are no S1 and N classes were found at this location. The limiting factors for *H. brasiliensis* are temperature and root zone medium (texture), whereas *A. malaccensis* is only root zone medium (texture).

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