Mapping of Parkia speciosa (petai) land suitability distribution as one of multipurpose tree species (MPTS) at community agroforestry land

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Abstract. In Indonesia, Parkia speciosa (petai) is one of multy purpose tree species (MPTS). It belongs to the Fabaceae family and commonly found in agroforestry land in North Sumatera. This study aimed to map the distribution of land suitability for P. speciosa in Peria-ria Village and Sari Laba Jahe Village, Biru-biru Sub-district, Deli Serdang District, North Sumtera Province, Indonesia. This research was conducted by a survey method to collect soil samples based on the land unit that was obtained from overlay soil map, land use map, and slope map. Land suitability was evaluated based on the matching method. The Geographic Information System (GIS) was used to map the distribution of land suitability class. The results showed that the actual land suitability class for P. speciosa were moderately suitable (S2) (8.25%), marginally suitable (S3) (14.26%) and not suitable (N) (77.5%) in this area. Erosion hazard (eh), root zone medium (rc), availability of water (wa), and nutrient retention (nr) were the dominant of limiting factor in this area. The most difficult constrain to counter were root zone medium and water availability.

1. Introduction
In land-use planning, the use of computer-based technology is needed to support the planning. Geographic Information System (GIS) is a computer-based technology that has been widely used in land use planning, which can analyze, manipulate, and present information in tabular and spatial form. GIS is able to provide a description, explanation, and estimation of a factual condition [1-7].

Several studies related to land evaluation using GIS have been conducted by several researchers [8-15]. In order to obtain data, on information and spatial description of MPTS plants (such as P. speciosa Hassk./petai), which is suitable to be planted in North Sumatra quickly and accurately, evaluation of land suitability is carried out. One of them is P. speciosa. MPTS plants such as P. speciosa are preferred by the community because of their high nutritional value as well as the high economy. However, because of the
scent that arises after consuming, some people do not like *P. speciosa*. Some of the results related to *P. speciosa*, include: Review: *P. peciosa* as valuable, miracle of nature, total phenolic content, antioxidant and antimicrobial activities of stink bean (*P. speciosa* Hassk.) pod extracts, Evaluation of antiangiogenic and antioxidant properties of *P. speciosa* Hassk extracts. Antioxidant *P. speciosa* pod powder as potential functional flour in food applications: Physicochemical properties' characterization, Potential of *petai* skin extract (*P. speciosa*) as a source of antioxidants, and analysis of land quality for *petai* gardens [16-26]. The *P. speciosa* skin fruit has a higher antioxidant activity than the seeds and leaves of the *petai* [17,20,22]. *P. speciosa* seeds contain a good source for minerals and also have many nutritional values, namely: protein, fat, and carbohydrate [21].

The purpose of this study was to identify the suitability of *petai* plantations in Peria-ria and Sari Laba Jahe Villages, Biru-biru Sub-district, Deli Serdang Regency, North Sumatra Province through spatial data analysis. Thus, it can present data that is more accurate, objective and complete as the basis for consideration in decision making and policy in terms of forest and land planning.

2. Material and Methods
2.1. Research location
Peria-ria and Sari Laba Jahe Villages, Biru-biru Sub-district were chosen as research locations because this location was found in many MPTS plants, one of which was *P. speciosa*. In addition, the livelihoods of the people in the two villages are farmers whose lives depend heavily on agricultural products. Existing agricultural land determines people's income. Apart from being a farmer, many people have livelihoods in the tourism sector, one of which is in the field of tourist attractions. One of the most famous tours in the Biru-biru Sub-district is the Biru-biru natural bath. Biru-biru Sub-district is located in Deli Serdang Regency, North Sumatra Province, Indonesia.

2.2. Data collection
The data used in this study was divided into two, namely: primary data and secondary data. Primary data obtained from survey in the field then analyzed in the laboratory and secondary data obtained from several agencies, including rainfall and spatial data (maps). Spatial data includes land use maps, soil types maps, and topographic maps. Spatial data can be presented in two models, namely: the raster model (grid), and the vector model. But this study uses vector data only. In the vector model, objects are presented as points or line segments. This type of data has more involvement with the form (format) of an object stored [27].

The land characteristics used in this study represented land quality, such as: temperature (*tc*), water availability (*wa*), oxygen availability (*oa*), nutrient retention (*nr*), erosion hazard (*er*), flood hazard (*fh*) and land preparation (*lp*). Determination of characteristic land values related to soil depth such as texture, cation exchange capacity (CEC), soil reaction or acidity (pH), C-organic, and base saturation (KB) adjusted to the depth of the root zone of the plant being evaluated. Usually, up to a depth of 60 to 100 cm [28-34]. Based on this, soil samples taken in this study are soils that were located between 60 to 100 cm deep since *petai* are annual plants.

2.3. Data processing and classification
The study were divided into three stages: data input, classification of each parameter, and presentation of results in maps. Data input includes inputting attribute data on a map, aiming that each parameter of land characteristics is displayed. The level of land suitability for *petai* in the Biru-biru Sub-district can be known after a comparison (matching) is made between the characteristics of the land in the Biru-biru Sub-district with the conditions for growing the *petai*. The land characteristics in the Biru-biru Sub-district were obtained through observations and measurements in the field, laboratory tests, and documentation.

The matching method for land suitability values is to compare land suitability classes based on the lowest (heaviest) value as a limiting factor in land suitability evaluation. It is matching data that was
obtained both from laboratory result analysis and data from the field with land uses requirements for petai [30]. The next stage is the classification of data, which aims to classify data based on the level of land suitability for petai. Classification is divided into 4 classes: S1 (highly suitable), S2 (moderately suitable) and S3 (marginally suitable) and N (not suitable) [35-38]. The highly suitable criteria for petai, namely: tc is 18-25 °C, wa is 1000-2000 mm, oa is well drained, slope less than 8% and erosion hazard is very low. The moderately suitable S2 criteria for petai, namely: tc are 25 - 30 °C and 15 – 18 °C, wa are 500 - 1.000 and 2.000 - 3.000 mm, rc is moderate, oa is moderate, slope more than 8 - 15 % and eh is low to moderate. Marginally suitable criteria for petai, namely: tc are 30 - 35 °C and 10 - 15 °C, wa are 250 - 500 and 3.000 - 4.000 mm, rc is rather rough, oa is rather bad drained, slope is 15 - 40 % and eh is high. Not suitable criteria for petai, namely: tc is more than 35 °C and less than 10 °C, wa is less than 250 and more than 4.000 mm, rc is rough, oa is bad drained/very fast, slope more than 40% and erosion hazard is very high. The final stage is the presentation of land suitability class maps for each parameter based on the level of suitability of the values of each parameter to the growth of petai. The analytical method used was spatial analysis, the results of the accumulation of the values for all parameters will be overlaid with an administrative map. The Arc GIS Software was used to map the classes of land suitability [12-15]. Thus, that information on the location or area with the suitability of land cover by petai was obtained.

3. Results and Discussion

The results of the comparison show that the actual land suitability class for petai in Sari Laba Jahe and Peria-ria Villages, Biru-biru Sub-district is N, S3, and S2. The land suitability class N dominates approximately 1234.83 ha (77.5%) of the total area with erosion limiting factors (eh), but this can be overcome with terrace builders to reduce erosion. The S3 land suitability class is 227.2 ha (14.26%) with rc limiting factor. Class S3 can be interpreted that the land has a severely limiting factor (rc) that is difficult to overcome. The land suitability class S2 is 131.37 ha (8.25%) with limiting factors wa, rc, and nr. The nr can be improved by fertilization (organic and inorganic), such as by urea and superphosphate fertilizers. The results of evaluating the actual land suitability for petai in Sari Laba Jahe and Peria-ria Villages, Biru-biru Sub-district are presented in Table 1.

Table 1. The area of actual land suitability for petai (P. speciosa)

| Land Unit | Actual land suitability | Area |
|-----------|-------------------------|------|
|           |                         | Ha   | (%)  |
| 1         | S3 rc                   | 143,92 | 9.03 |
| 2         | N eh                    | 1,203.74 | 75.54 |
| 3         | N eh                    | 4,75 | 0.3  |
| 4         | N eh                    | 0,28 | 0.02 |
| 5         | N eh                    | 26,06 | 1.64 |
| 6         | S3 rc                   | 3,26 | 0.2  |
| 7         | S2 wa,rc,nr             | 11,28 | 0.71 |
| 8         | S3 rc                   | 19,50 | 1.22 |
| 9         | S2 wa,rc,nr             | 118,34 | 7.43 |
| 10        | S2 wa,rc,nr             | 1,75 | 0.11 |
| 11        | S3 rc                   | 60,52 | 3.8  |
| Total     |                         | 1,593.40 | 100   |

Note: Water availability (wa), erosion hazard (eh), root zone medium (rc), and nutrient retention (nr)
Based on the results of improvements to the limiting factors, it is known that the potential land suitability class for *petai* in Sari Laba Jahe and Peria-ria Villages, Biru-biru Sub-district is S3 and S2. The S2 land suitability class is approximately 1361.45 ha (85.45%) of the total area with a limiting factor *wa*, *rc*, *eh*. The S3 land suitability class is 231.95 ha (14.55%) with the limiting factor of *rc* and *eh*. The results of evaluating the potential land suitability for *petai* in Sari Laba Jahe and Peria-ria Villages, Biru-biru Sub-district are presented in Table 2.

| Land Unit | Potential land suitability | Area (Ha) | (%) |
|-----------|---------------------------|-----------|-----|
| 1         | S3 rc                     | 143.92    | 9.03|
| 2         | S2 *wa,rc,eh*            | 1203.74   | 75.54|
| 3         | S3 *rc,eh*               | 4.75      | 0.3 |
| 4         | S2 *wa,rc,eh*            | 0.28      | 0.02|
| 5         | S2 *wa,rc,eh*            | 26.06     | 1.64|
| 6         | S3 *rc*                  | 3.26      | 0.2 |
| 7         | S2 *wa,rc*               | 11.28     | 0.71|
| 8         | S3 *rc*                  | 19.50     | 1.22|
| 9         | S2 *wa,rc*               | 118.34    | 7.43|
| 10        | S2 *wa,rc*               | 1.75      | 0.11|
| 11        | S3 *rc*                  | 60.52     | 3.8 |
| **Total** |                          | 1593.40   | 100 |

*Note: Water availability (wa), erosion hazard (eh), root zone medium (rc), and nutrient retention (nr)*

The results of the land suitability analysis using the spatial analysis method get results for the *petai* in each village (Figure 1 and Figure 2). Each land turned out to have different characteristics for each horizon in the soil profile and one land characteristic can affect several land qualities [34].

**Figure 1.** Map of the actual land suitability for *petai* (*P. speciosa*)
Based on land suitability assessment of *petai* in Peria-ria Village, there are two land suitability classes, namely N and S3. Almost all Peria-ria Village are not suitable with the limiting factor erosion hazard (*eh*), but this can be overcome so that the potential land suitability class becomes S2. Only a small portion of the area in the Peria-ria Village with land suitability class S3. Different from the Sari Laba Jahe Village, based on the land suitability assessment of *petai*, there are three land suitability classes, namely: N, S3 and S2. The not suitable (N) with limiting factor *eh*, S3 with limiting factor *rc*, and S2 with limiting factors *wa*, *rc*, *nr*. Soil texture affects soil physical and chemical properties, especially soil structure, water holding capacity and nutrient availability. Clay is a soil fraction that has a great ability to hold water [34-38].

The results of the study show that *petai* can be developed in these two villages. The development of *petai* plantation in this area will provide benefits to the village community, including health benefits. Because *petai* has many benefits, such as: *petai* with a high content of *amino acids* (protein), especially the *essential amino acid tryptophan* can play a role in relaxing nerves and relieving depression [17-26]. Feeling bad in the mood is a sign of malnutrition. The mood is controlled by the brain's working system. The ability of the brain to work is influenced by the input of nutrients needed. These nutrients must be supplied in a balanced way from the food and drinks consumed daily. One of the nutrients that plays a role in improving mood is *tryptophan* (an *essential amino acid*) which is widely contained in *petai* [20-25]. Consuming *petai* as part of daily diet will reduce the risk of death from stroke by 40% [39,40]. *Petai* with high potassium content can help normalize the heartbeat, send oxygen to the brain and regulate body fluid balance. When stressed, metabolic rate will increase, so it will reduce potassium levels in the body. This can be balanced with the help of eating *petai* [17-26].

Likewise, with several other multipurpose tree species (MPTS) studies, such as: *durian* and *avocado* which have been conducted, showing that *rc* is a limiting factor in several land units in Karo District [8]. In contrast to forestry plants, such as: *Pinus merkusii* carried out in Telagah Village, Sei Bingai Sub-district, shows that the *tc* and *eh* factors are limiting factors [12]. Neither the plantation crops, such as: oil palm which is done in several areas in North Sumatra Province [14]. One of the studies that have been done shows that the limiting factor is *wa* [15]. These differences indicate that each plant has different growth requirements. Between one region and another even though the plants are the same, the results of

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**Figure 2. Map of the potential land suitability for *petai* (*P. speciosa*)**
the land suitability evaluation are not necessarily the same because of differences in land characteristics. Land evaluation requires physical environmental characteristics that are broken down into land quality, where each land quality can consist of one or more land characteristics [37]. Some land characteristics generally have a relationship with each other. Land quality will affect the type of land-based use and / or growth of plants and other commodities. Thus, the results of this land evaluation study are very necessary for land use planning in an area.

4. Conclusion

The development of petai in both Sari Laba Jahe Village and the Peria-ria Village were possible. The area of two villages in Biru-biru Sub-district after the improvement effort was made, the potential land suitability class for the growth of petai was S2, with the area is approximately 1361.45 ha (85.45%) of the total area with a limiting factor $wa, rc, eh$.

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