Land suitability evaluation for forestry plants in Tao Lake, Padang Lawas Utara District, North Sumatra

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Abstract. Land use planning process was used to provide alternative and possible land uses as well as management activities needed to ensure land use sustainability. This study aims to evaluate the actual and potential land suitability classes for forestry plants (Mangifera indica, Syzygium aromaticum, Durio zibethinus, Acacia mangium, Nephelium lappaceum, Pometia pinnata, Paraserianthes falcatoria) and to map the actual and potential land suitability in Tao Lake, Padang Lawas Utara District, North Sumatra. The evaluation used the matching method and the spatial analysis. The land unit was determined based on spatial analysis which consists of 8 land units and 4 land unit classes. The research showed that based on the actual and potential land suitability classes, land units I to VIII are highly suitable (S1) for Pometia pinnata. Meanwhile, land units I, II, III, V, VI, VII are highly suitable (S1) for Acacia mangium and Paraserianthes falcatoria, while land units IV and VIII are moderately suitable (S2) for the same. Land units I, II, IV, V, VI, VII, VIII are highly suitable (S1) for Nephelium lappaceum, while land unit III is moderately suitable (S2) for the same. For potential land suitability classes, land units I, II, V, VI, VII are highly suitable (S1) for Durio zibethinus and land units III, IV and VIII are moderately suitable (S2) for the same. The actual and potential land suitability for Mangifera indica including non-suitable (N) class covered an area of 290,496 ha, while the actual and potential land suitability for Syzygium aromaticum including moderately suitable class (S2) covered an area of 290,496 ha.

1. Introduction

1.1. Background
Soil is one of the natural resources that has many important functions in the ecosystem including as a habitat supporting the plant growth for soil body, a medium for construction (engineering), nutrients and organic waste recycling system and as water supply and filtration system. In terms of natural resources, it is also known as land. Land is a physical environmental unit consisting of climate, topography, soil, hydrology and vegetation which in some respect affects land use capability. Each soil has its own characteristics and limitations that will determine its capability or ability so that it requires a specific, different treatment to develop each soil type.
Land use planning process could provide alternative land use and its possible limitations as well as management activities needed so that the land can be used in a sustainable manner. Land evaluation is an important component in land use planning process [1]. Land suitability evaluation is needed to provide a rationale in sustainable land use decision-making. According to [2] land suitability evaluation is very important because land has varied physical, social, economic and geographical characteristics or land is not created equal.

Tao Lake is situated in Batang Onang Baru Village, Batang Onang sub-district, Padang Lawas Utara district. Tao Lake has its natural charm with hilly contour and forest surrounding the lake area. The size of Tao Lake is about 2 Ha with a surrounding area of 450 Ha. In year 2001, Tao Lake was formally designated as nature tourism site and in year 2014 the development of tourism management of the area was begun. The development of Tao Lake nature tourism site requires land rehabilitation planning by planting tree species that are suitable for the area. For this purpose, land use planning which conforms to its function and a recommendation on forestry plants that are suitable in Tao Lake area are needed so that the land potential can be maximized and beneficial to the community living around the lake. Land suitability evaluation is needed to identify which forestry plant species are suitable and potential in developing nature eco-tourism in Tao Lake based on the available information on land suitability criteria of each plant species.

Currently, due to the lack of land use planning and land evaluation, there is not much progress in terms of land management and environmental service utilization in Tao Lake. Consequently, trees are rarely found around Tao Lake. Therefore, to maximize the utilization of land potential so that it can be beneficial to the local community that is as requirement on restoration or rehabilitation landscape forest planning [2]. To achieve more information on land suitability for several forestry plants, this research needs to be conducted. Thus, the land suitability of Tao Lake, Padang Lawas Utara district, can be determined. In this study, land suitability evaluation was only conducted on forestry plants and Multi-Purpose Tree Species (MPTS).

1.2. Objectives
The objectives of the study are:
1. To analyze the actual and potential land suitability classes for forestry plants in Tao Lake, Padang Lawas Utara District.
2. To map the actual and potential land suitability classes for forestry plants in Tao Lake, Padang Lawas Utara District.

1.3. Benefits
This study will provide a guidance on land use planning which conforms to its capacity, a guidance and direction for Tao Lake management to choose appropriate forestry plants that are suitable and beneficial to the local community, and to provide information to the relevant authorities in determining policy direction on the rehabilitation development policy of the region.

2. Methods
2.1. Time and place
This research was conducted from December 2016 until October 2017. The research was carried out in Tao Lake, Padang Lawas Utara District, North Sumatera Province (Figure 1). The analysis of physical and chemical properties of soil was performed at the Laboratory of Research and Technology, Faculty of Agriculture, University of North Sumatra. Data analysis was conducted at the Inventory Laboratory of the Forest Management Department, Faculty of Forestry, University of Sumatera Utara.
Figure 1. Research site map

2.2. Tools and Material
Tools and material used in this study were soil sample from the field, topographic map, soil map, land use map, administrative map of Padang Lawas Utara District and other maps related to this research. Tools used both in field and in the laboratory and Arc-GIS 10.3 Software, which is very useful in processing the maps of research site. Global Positioning System (GPS) to determine the position of sampling point in the field and to measure the height of the location and a series of tools used to analyze soil in the laboratory.

2.3. Research procedure
2.3.1. Research preparation. The activities conducted during this phase is literature review of secondary data collection, i.e., temperature and rain intensity, air temperature, humidity and physical properties of the area and review of necessary maps (land use map, soil map, contour map and administrative map) using tools and material used in this research [4].

2.3.2. Data collecting. The activities conducted during this phase consist of primary data collection covering physical parameters that can be measured in the field. Soil sample collection to be analysed in the laboratory consists of acidity and C-organic. Land characteristics are attributes or condition of land components that can be measured or estimated, such as soil texture, rain intensity, temperature and soil drainage. Land characteristics determine land behavior which in turn has its impact on the growth of plants [3, 5]. Land characteristics shown in Table 1.
Table 1. Land quality and characteristics used in land evaluation criteria

| Symbol | Land quality          | Land characteristics                  |
|--------|-----------------------|---------------------------------------|
| Tc     | Temperature           | Temperature                           |
| Wa     | Water availability    | Rain intensity (mm)                    |
|        |                       | Duration of drought                    |
|        |                       | Air humidity (%)                       |
| Oa     | Oxygen availability   | Drainage                              |
| Rc     | Rooting media         | Drainage                              |
|        |                       | Texture                               |
|        |                       | Coarse material (%)                   |
|        |                       | Soil depth                            |
| Nr     | Nutrient retention    | CEC of clay (me/100 g)                |
|        |                       | Base saturation (%)                   |
|        |                       | pH H2O                                |
|        |                       | C-organic (%)                         |
| Eh     | Erosion hazard        | Slope (%) Erosion hazard              |

Source: Azis et. al. (2005)

Flood hazard can be determined by conducting interviews with the community. Whereas the level of erosion hazard can be determined based on the percentage of erosion class differences [6].

2.3.3. Soil Sampling. After field observation, soil sampling conducted by collecting composite soil samples. Soil samples collected must be representative so that the analysis carried out on the soil samples is able to provide a picture of actual soil characteristics in the field. Soil sampling is done by the grid method, which is to determine soil sampling point on the map resulting from the analysis using Arc-GIS.

For sample to be representative, sample was collected using a zig-zag method where from each point 1-2 kg of sample was collected. Soil sample is collected by drilling in the land unit area. Land units are selected based on the land use unit map. Land characteristics value of soil samples was determined using a soil drill at a depth of 0-20 cm. Soil chemical properties are determined by soil analysis in the Laboratory [7].

Soil physical property that was analyzed was soil texture only. Soil texture can be defined as a comparison between soil fractions (sand, silt and clay). The soil texture relatively did not change; but the soil structure changed easily especially when there was soil processing. Soil texture and structure classification is described in Table 2.

Table 2. Soil texture and structure classification.

| Soil texture       | Code | Code | Soil structure | Code |
|-------------------|------|------|----------------|------|
| Sand              | 3    | S    | Columnar       | Col  |
| Loamy sand        | 2    | LS   | Prismatic      | Pris |
| Sandy loam        | 1    | SL   | Blocky         | Blk  |
| Loam              | 0    | L    | Nutty          | Nutt |
| Silt              | 0    | Sli  | Platty         | Plat |
| Silt              | 2    | Si   | Crumb          | Cr   |
| Sandy Clay Loam   | 1    | SCL  | Granular       | Gr   |
| Clay Loam         | 1    | Cl   |                |      |
| Silty Clay Loam   | 1    | SiCL |                |      |
| Sandy clay        | 2    | SC   |                |      |
| Clay              | 2    | C    |                |      |
| Silty Clay        | 2    | SiC  |                |      |

Source: Aziz, et.al. (2005)
2.3.4. Soil analysis. Analysis of soil samples in the laboratory includes:

- Determination of soil texture by pipette method.
- Soil C-Organic Analysis using Walkey and Black methods.
- Determination of CEC by washing method using ammonium acetate pH7.
- Determination of Soil pH by electrometric method.
- Determination of N-total by the kjeldahl method.

2.3.5. Land suitability classification. Activities in this phase include analysis of land suitability classification using matching or data matching methods that have been obtained from both primary, secondary, and laboratory results data against land use requirements.

Land suitability classification is carried out by combining the needs of plants or plant growth requirements and land characteristics [8]. Plant species to be combined are forestry plants. Therefore, this classification is also frequently called species matching. Land suitability is the suitability of a land for certain uses. For example: irrigation, ponds, annual crop farming or perennial crop farming. Land suitability class is divided into four levels i.e. Highly Suitable (S1), Moderately Suitable (S2), and Marginally Suitable (S3) and Non-Suitable. The final results of the classification are determined based on the lowest class by providing all existing constraints or obstacles. The change in classification to a better level is possible if all existing obstacles can be corrected. The sub-class in land suitability classification also reflects the inhibitor type. There are seven known types of inhibitor, namely e (erosion), w (drainage), s (soil texture), a (acidity), g (slope), sd (soil depth) and c (climate) [9, 10].

In land suitability classification, no obstacle priority is known, hence, all obstacles in a land unit will all be mentioned. However, it can be understood that from the obstacles mentioned, there are obstacles that are considered easy (such as a, w, e, g and sd) or conversely, obstacles that are difficult to handle (c and s). Then the final results of classification are determined based on the lowest class by providing all existing obstacles [9].

The change in classification to a better level is possible if all existing obstacles in the land unit can be corrected. Therefore, land units having c and s as inhibiting factors are difficult to improve. Land suitability classification was conducted by sorting data on land characteristics based on land suitability criteria for each type of plant [9]. The relationship between land suitability characteristics and the inhibiting level can be seen in Table 3.

| Inhibiting Level | Land Suitability Characteristics |
|------------------|--------------------------------|
| 0: none          | S1: highly suitable            |
| 1: slight        | S2: moderately suitable        |
| 2: moderate      | S3: marginally suitable        |
| 3: severe        | N: not suitable                |
| 4: very severe   |                                |

Source: Aziz, et.al.,(2005)

Data obtained is interpreted in the criteria of soil fertility level and interpreted into land suitability class according to [11]. Land evaluation process was conducted by matching land characteristics in each location with plant growth requirements [12]. Forestry plant species evaluated were *Syzygium aromaticum*, *Mangifera indica*, *Durio zibethinus*, *Acacia mangium*, *Nephelium lappaceum*, *Pometia pinnata*, *Paraserianthes falcataria*. The selection of recommended forestry plant species was based on plant species frequently planted by the local community [2] in the lake area. The recommended plant species are expected to be multi-purpose plants whether protective plants or those beneficial to the community in the lake area.

Data from soil analysis results were being input into the map database as attributes, such as soil physical properties, soil chemical properties, and the most suitable plants are obtained from land.
suitability map (S1, S2, S3 and N). Land suitability map was overlaid by land use map, soil map, contour map and administrative map to obtain land suitability map based on administrative region.

3. Result and discussion

3.1. Land unit of Tao lake area

Tao Lake is situated in Batang Onang sub-district, Padang Lawas Utara district. Tao Lake can be reached through Palas-Sosaspan-Batang Onang for a 2 hours-drive and via Paluta-Aek Godang-Batang Onang for a 1-hour drive. The map analysis result showed that the total area of the Research Site was 290,492 Ha. Geographically, Tao Lake is situated in the region defined by the following coordinates 1° 17' 40.29" North Latitude and 99° 26' 42.77" East Longitude. Tao Lake shares border with Nabundong Protection Forest in Padang Lawas Utara in the west part, Nabundong Conservation Forest in the north part; and community’s plantation in the east part. The research area topography of Tao Lake tends to be flat to slightly sloping with a slope of 0-30% and at an altitude of 780 meters above sea level with Alluvial (Alluvial Brown) soil type. Its climate type is type C with an average rainfall of 2 000 - 2 500 mm per year.

The result from overlaying of land use maps, slope maps, and contour maps showed that there are 8 land units and 4 land slope classes of varying sizes. The comparison of land area can be seen in Table 4. The largest land unit is land unit II with an area of 54,531 ha (6.24%) and the smallest unit area is unit IV of 25,123 ha (8.64%).

Table 4. The extent of each land unit in the research site

| No. | Land Unit | Characteristics | Area Ha | % |
|-----|-----------|----------------|---------|---|
| 1   | I         | Rolling/sloping (>8 - >15%) land cover is undeveloped land, and soil type is Alluvial | 29.372 | 10.11 |
| 2   | II        | Flat (>0 - 3%) land cover undeveloped land, and soil type is Alluvial | 54.531 | 16.24 |
| 3   | III       | Undulating/gently sloping (>3 - 8%) land cover is undeveloped land, and soil type is Alluvial | 49.072 | 14.89 |
| 4   | IV        | Hilly (>15-30%) land cover is undeveloped land, and soil type is Alluvial | 25.123 | 8.64 |
| 5   | V         | Hilly (>15-30%) land cover is undeveloped land, and soil type is Alluvial | 25.878 | 8.89 |
| 6   | VI        | Flat (>0 - 3%) land cover is Bushes, and soil type is Alluvial | 40.312 | 13.87 |
| 7   | VII       | Undulating/gently sloping (>3-8%) land cover is Bushes, and soil type is Alluvial | 49.074 | 16.89 |
| 8   | VIII      | Rolling/sloping (>8-15%) land cover is Bushes, and soil type is Alluvial | 30.421 | 10.47 |
|     | Total     |                 | 290.496 | 100.00 |

3.2. Land characteristics

The land unit characteristics of Tao Lake area shows little variations; almost all units showed similar characteristics. Air temperature in the research site was 27.5°C which was relatively the same because the region of Tao Lake is mostly situated at an altitude of 600-780 m above sea level. Rainfall in the research site was around 2303.4 mm per year. These characteristics were obtained from the secondary data (soil map of research site) as illustrated in Figure 2.
Figure 2. Soil map of research site

Based on the 2016 soil research centre of soil map, the soil type in the study area was an alluvial soil type. Alluvial soil type is a soil formed from lake mud which settled in the lowlands that is fertile and suitable for agricultural land. Alluvial is young soil originating from depositional results. Its characteristics depends on its origin carried by the river. Rooting media in the study location consisted of poor texture and drainage. Tao Lake has fine to moderately fine soil texture. Soil texture comprises of sandy-silt-loam, clay, sandy-clay-loam and sandy loam [13, 14].

The research site in Tao Lake has varied slopes from flat, sloping, moderately slope and gently sloping. Slopes are land characteristics used to assess the quality of erosion hazards [5]. The width of each slope class can be seen in Table 7. Based on Table 7 the width of slope class > 3% - 8% is the most extensive area which is around 33.786% of the total area of research site in Tao Lake. Whereas the smallest land area is the slope class > 15% - 30% or hilly which is around 17.557% of the total research site area in Tao Lake. The erosion hazard of the research site ranged from low to moderate. The flood hazard in the research site is relatively non-existent [6]. The land characteristics of the study area can be seen in Table 5 and Figure 3.

| No. | Slope Classes                        | Area | %     |
|-----|--------------------------------------|------|-------|
| 1.  | 0% - <3% (Flat)                      | 94.843 | 32.649 |
| 2.  | > 3% - 8% (Undulating/gently sloping)| 98.146 | 33.786 |
| 3.  | >8% - 15% (Rolling/sloping)         | 56.299 | 19.380 |
| 4.  | >15% - 30% (Hilly)                  | 51.001 | 17.557 |
|     | Total                                | 290.496 | 100.000 |

Source: Spatial analysis result
The results of secondary data collection, primary data and soil analysis in the laboratory, including land quality and characteristics can be seen in Table 6. Nutrient retention found at the research site has varying values. The soil pH of the research site tended to be neutral and relatively acidic. The CEC of the study location ranged from low to high.

Table 6. Land unit quality and characteristics

| Land Characteristics                  | Land Unit | Land Unit | Land Unit | Land Unit | Land Unit | Land Unit | Land Unit | Land Unit | Land Unit |
|---------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Average annual temperature (°C)       | 27.5      | 27.5      | 27.5      | 27.5      | 27.5      | 27.5      | 27.5      | 27.5      | 27.5      |
| Water availability (wa) Humidity (%)  | 78        | 78        | 78        | 78        | 78        | 78        | 78        | 78        | 78        |
| Annual Rainfall Intensity (mm)        | 2302.4    | 2302.4    | 2302.4    | 2302.4    | 2302.4    | 2302.4    | 2302.4    | 2302.4    |
| Rooting condition                     | SiCl      | CL        | CL        | CL        | SiCl      | SiC       | CL        | CL        |
| Nutrient availability (nr)            | Soil pH   | 6.7       | 6.8       | 5.7       | 6.4       | 6.5       | 6.8       | 6.1       | 6.6       |
|                                        | C-organic (%) | 2.2      | 2.7       | 0         | 1.9       | 1.4       | 1.0       | 1.5       | 2.1       |
|                                        | N - Total (%) | 0.22     | 0.28      | 0.12      | 0.21      | 0.30      | 0.34      | 0.17      | 0.11      |
|                                        | Base saturation (%) | 55.2     | 56.7      | 55.1      | 55.9      | 61.0      | 57.2      | 59.1      | 58.3      |
|                                        | CEC (me/100 g) | 17.30    | 15.10     | 18.90     | 18.00     | 15.40     | 71.00     | 1.70      | 11.60     |
| Land Preparation (lp)                 | Rocks on the surface (%) | 0         | 0         | 0         | 0         | 0         | 0         | 0         |
|                                        | Rock Outcrop (%) | 0         | 0         | 0         | 0         | 0         | 0         | 0         |
| Flood Hazard (fh)                     | Slope (%)  | 0-3%      | <3-8%     | <8-15%    | 15-30%    | 0-3%      | >3-8%     | <8-15%    | <15-30%   |
|                                        | Inundation | F0        | F0        | F0        | F0        | F0        | F0        | F0        |

Notes: SiCl : Silty Clay Loam;  L: Clay Loam;  SiC : Silty Clay
3.3. Land suitability

The analysis results of the recommended land suitability for forestry plants can be seen in Table 7. Based on the actual and potential land sustainability, Land Units I - VIII is not suitable (N) for mango plant due to the rainfall as the inhibiting factor. Rainfall is a natural factor that cannot be corrected so that land units I-VIII are not suitable based on the actual and potential land suitability classes [15]. However, mango can still be recommended to be planted in the research site provided that the seed come from superior varieties that are tolerant to rainfall conditions > 2303.4 m/year and other growing conditions [16] that are in accordance with the land characteristics and quality in Tao Lake. The comparison of land suitability for Mangifera indica can be seen in Table 8 and Figure 4.

| Table 7. Land Suitability for forestry plants |
|---|---|---|---|
| No. | Actual Land Suitability | Potential Land Suitability | Extent |
|   | | | Ha |
| 1 | N | N | 290.496 |
| Total | | | 290.496 |

| Species | Land Suitability Class | Land Unit |
|---|---|---|
| Acacia auricuiformis | Actual | S2, nr | S2, nr, eh | S2, eh | S3, eh | S2, nr, eh | S2, nr | S3, eh |
| Potential | S1 | S1 | S1 | S2, eh | S1 | S1 | S1 | S2, eh |
| Nephelium lappaceum | Actual | S1 | S2, nr, eh | S3, nr | S2, eh | S2, nr | S2, nr, eh | S2, nr, eh |
| Potential | S1 | S1 | S2, nr | S1 | S1 | S1 | S1 | S1 |
| Durio zibethinus | Actual | S1 | S2, nr, eh | S3, nr | S3, eh | S2, nr | S2, nr, eh | S2, nr, eh | S3, eh |
| Potential | S1 | S1 | S2, nr | S2, eh | S1 | S1 | S1 | S2, eh |
| Syzygium aromaticum | Actual | S2, wa | S2, wa, nr, eh | S2, wa, nr, eh | S2, wa, nr, eh | S3, eh | S2, wa | S2, wa, nr, eh | S3, eh |
| Potential | S2, wa | S2, wa | S2, wa | S2, wa, eh | S2, wa, eh | S2, wa | S2, wa | S2, wa |
| Mangifera indica | Actual | N, wa | N, wa | N, wa | N, wa | N, wa | N, wa | N, wa | N, wa |
| Potential | N, wa | N, wa | N, wa | N, wa | N, wa | N, wa | N, wa | N, wa | N, wa |
| Paraserianthes falcataria | Actual | S1 | S2, eh | S2, eh | S3, eh | S2, eh | S2, eh | S2, eh | S3, eh |
| Potential | S1 | S1 | S1 | S2, eh | S1 | S1 | S1 | S2, eh |
| Pometia pinnata | Actual | S1 | S1 | S1 | S1 | S1 | S1 | S1 | S1 |
| Potential | S1 | S1 | S1 | S1 | S1 | S1 | S1 | S1 | S1 |

Table 8. Land suitability area for Mangifera indica
Based on the actual land suitability class, *Syzygium aromaticum* plant is moderately suitable (S2) and marginally suitable (S3). Land units IV and VIII are marginally suitable (S3) for clove due to erosion hazard as an inhibiting factor. Erosion hazard can be reduced by constructing planting terrace in line with the contour and land cover planting. Thus, the potential land suitability class has improved to moderately suitable (S2). Land units II, III, VI, VII are moderately suitable (S2) with rainfall, erosion hazard, and nutrient availability as inhibiting factors. Rainfall is a natural inhibiting factor that cannot be corrected. Whereas erosion hazard and nutrient availability can be improved by constructing planting terrace in line with the contour, land cover planting, and adding organic materials.

However, based on the potential land suitability class, land units II, III, VI, VII are moderately suitable (S2) due to rainfall as a natural inhibiting factor that cannot be corrected. Hence, potentially, land units I and V are moderately suitable (S2). The area distribution of land sustainability for *Syzygium aromaticum* can be seen in Table 9 and Figure 5.

**Table 9. Distribution area of land suitability for *Syzygium aromaticum***

| No. | Actual Land Suitability | Potential Land Suitability | Extent |
|-----|-------------------------|---------------------------|--------|
| 1   | S2, wa, nr, eh          | S2, wa                    | 192.989| 61.89% |
| 2   | S2, wa, nr              | S2, wa                    | 25.878 | 8.89%  |
| 3   | S2, wa                  | S2, wa                    | 29.372 | 10.11% |
| 4   | S3, eh                  | S2, eh                    | 42.257 | 14.33% |
|     | **Total**               |                           | 290.496| 100%   |

Figure 4. Actual (a) and potential (b) land suitability map for *Mangifera indica* in Tao Lake.

Figure 5. Land suitability map of actual (a) and potential (b) land suitability for *Syzygium aromaticum* at Tao lake
Based on the actual land suitability class, *Durio zibethinus* is highly suitable (S1), moderately suitable (S2) and marginally suitable (S3). Land unit I is highly suitable (S1) since there is no inhibiting factor that requires the land to be improved. Land units II, VI, VII are moderately suitable (S2) with erosion hazard and nutrient availability as inhibiting factors. With nutrient availability as an inhibiting factor, improvement can be made by adding organic materials, while erosion hazard can be improved by constructing planting terrace in line with the contour, land cover planting. Land units II, VI, VII are potentially highly suitable (S1).

Land unit III is marginally suitable (S3) with nutrient availability as an inhibiting factor. This inhibiting factor can be improved by liming and adding organic materials. Through this improvement, land unit III has the potential to be moderately suitable (S2). Land unit V is moderately suitable (S2) with nutrient availability as an inhibiting factor. This inhibiting factor can be improved by liming and adding organic materials. Through this improvement, land unit V has the potential to be highly suitable (S1) Meanwhile, land units IV and VIII are marginally suitable (S3) with erosion hazard as an inhibiting factor. Erosion hazard can be improved by constructing planting terrace in line with the contour and land cover planting. Through this improvement, land units IV and VIII has the potential to be moderately suitable (S2). The extent of land suitability for *Durio zibethinus* can be seen in Table 10 and Figure 6.

Table 10. The area distribution of land suitability for *Durio zibethinus*

| No. | Actual Land Suitability | Potential Land Suitability | Extent Ha | Extent % |
|-----|------------------------|----------------------------|-----------|----------|
| 1   | S1                     | S1                         | 29.372    | 10.11    |
| 2   | S2, nr,eh              | S1                         | 143.917   | 53       |
| 3   | S2, nr                 | S1                         | 25.878    | 8.89     |
| 4   | S3,eh                  | S2,eh                      | 42.257    | 19.11    |
| 5   | S3,nr                  | S2,nr                      | 49.072    | 14.89    |
|     | Total                  |                            | 290.496   | 100      |

Figure 6. Actual (a) and potential (b) land suitability map for *Durio zibethinus* in Tao Lake

Based on the actual land suitability classes, acacia is moderately suitable (S1) and marginally suitable (S3). Land units I and VII are moderately suitable (S2) with nutrient availability as an inhibiting factor. Inhibiting factor such as nutrient availability can be improved by adding organic materials and liming. Thus, land units I and VII have the potential to be highly suitable (S1).

Meanwhile land units II and VI are moderately suitable (S2) with nutrient availability, slope, and erosion hazard as inhibiting factors. Nutrient availability can be improved by adding organic materials and liming, while the erosion rate can be reduced by constructing planting terrace in line with the contour and land cover planting. Land units II and VI have the potential to be highly suitable (S1). Land unit III is actually moderately suitable (S2) with slope and erosion hazard as inhibiting factors.
Erosion hazard can be improved by constructing planting terrace in line with the contour and land cover planting. Thus, land unit III has the potential to be highly suitable (S1).

Meanwhile, land units IV and VIII are actually marginally suitable (S3) with slope and erosion hazard as inhibiting factors; these factors can be improved by constructing planting terrace in line with the contour and land cover planting so that these units have the potential to be moderately suitable (S2). The extent of land sustainability for acacia can be seen in Table 11 and Figure 7.

**Table 11. The area distribution of land suitability for Acacia mangium**

| No. | Actual Land Suitability | Potential Land Suitability | Extent | % |
|-----|-------------------------|---------------------------|--------|---|
| 1   | S2, nr                  | S1                        | 104.324| 27 |
| 2   | S2, nr, eh              | S1                        | 92.843 | 39 |
| 3   | S2, eh                  | S1                        | 49.072 | 14.89 |
| 4   | S3, eh                  | S2, eh                    | 42.257 | 19.11 |
| Total|                         |                           | 290.496| 100 |

**Figure 7. Actual (a) and potential (b) land suitability map for Acacia mangium in Tao Lake**

Based on the actual land suitability class, Neppelium lapaccum is highly suitable (S1), moderately suitable (S2), and marginally suitable (S3). Land unit I is actually and potentially highly suitable (S1) since there is no inhibiting factor. Land units II, VI, VII and VIII are actually moderately suitable (S2) with nutrient availability, slope and erosion hazard as inhibiting factors. These can be improved by liming, adding organic materials, constructing planting terrace in line with the contour and land cover planting. Thus, land units II, VI, VII and VIII have the potential to be highly suitable (S1).

Land unit IV are actually moderately suitable (S2) with slope and erosion hazard as inhibiting factors. These can be improved by constructing planting terrace in line with the contour and land cover planting. Thus, land unit IV has the potential to be highly suitable (S1). Land unit V is actually moderately suitable (S2) with slope and nutrient availability as inhibiting factors. These can be improved by liming and adding organic materials. Thus, land unit V has the potential to be highly suitable (S1).

Land unit III is marginally suitable (S3) with slope and erosion hazard as inhibiting factors. This can be improved by constructing planting terrace in line with the contour and land cover planting. Thus, land unit III has the potential to be moderately suitable (S2). The extent of land suitability for Neppelium lapacceum can be seen in Table 12 and Figure 8.
| No. | Actual Land Suitability | Potential Land Suitability | Extent |
|-----|------------------------|---------------------------|--------|
| 1   | S1                     | S1                        | 29.372 | 10.11 |
| 2   | S2, nr, eh             | S1                        | 161.051| 57.47 |
| 3   | S2, nr                 | S1                        | 25.878 | 8.89 |
| 4   | S2, eh                 | S1                        | 25.123 | 8.64 |
| 5   | S3, nr                 | S2, nr                    | 49.072 | 14.89 |
|     | Total                  |                           | 290.496| 100  |

Table 12. The area distribution of land suitability for *Nephelium lappaceum*

![Image of actual and potential land suitability maps](image)

**Figure 8.** Actual and potential land suitability map for *Nephelium lappaceum* in Tao Lake

Based on the actual and potential land suitability classes, land units I-VIII are highly suitable (S1) for *Pometia pinnata* species. *Pometia pinnata* can grow in all soil types ranging from clays, sandy, rocky, coral with good and poor drainage (sometime inundated) and grow well in dry soil (not inundated) with thick soil layer. The topography of places where *Pometia pinnata* can grow varies, from flat, wavy, or slope with undulating to steep slope. Some trees grow on the banks of rivers or lakes with moist soil, and on the edge of a cliff. The climate needed for plants to grow well is a climate with high rainfall (> 1200 mm/year) and a temperature of 22° C-28° C [17].

If we compared with the temperature in the research location of 27.5° C and a rainfall of 2302.4 mm/year, matoa plant is highly suitable to be planted in Tao Lake area. *Pometia pinnata* needs light with an intensity ranging from 70 to 100%. Hence, *Pometia pinnata* is suitable to be planted in the research site. The extent of land suitability for *Pometia pinnata* can be seen in Table 13 and Figure 9.

| No. | Actual Land Suitability | Potential Land Suitability | Extent |
|-----|------------------------|---------------------------|--------|
| 1   | S1                     | S1                        | 290.496| 100  |
|     | Total                  |                           | 290.496| 100  |

Table 13. Area of land sustainability for *Pometia pinnata*
Based on the actual land suitability classes, falcata is highly suitable (S1), moderately suitable (S2), and marginally suitable (S3). Land unit I is actually and potentially highly suitable (S1) since there is no inhibiting factor. Land units II, III, V, VI, VII are moderately suitable (S2) with slope and erosion hazard as inhibiting factors. These can be improved by constructing planting terrace in line with the contour and land cover planting. Land units II, III, V, VI, VII have the potential to be highly suitable (S1).

Land units IV and VIII are marginally suitable (S3) with slope and erosion hazard as inhibiting factors. This can be improved by constructing planting terrace in line with the contour and land cover planting. Thus, land units IV and VIII have the potential to be moderately suitable (S2). The extent of land suitability for *Paraserianthes falcataria* can be seen in Table 14 and Figure 10.

| No. | Actual Land Suitability | Potential Land Suitability | Extent (Ha) | % |
|-----|-------------------------|---------------------------|-------------|---|
| 1   | S1                      | S1                        | 29.372      | 10.11 |
| 2   | S2,eh                   | S1                        | 218.865     | 70.78 |
| 3   | S3,eh                   | S2                        | 42.257      | 19.11 |
| Total |                         |                           | 290.496     | 100  |

**Table 14. The distribution area of land suitability for *Paraserianthes falcataria***
4. Conclusion
Tao lake land have actual and potential land suitability classes that are land units I to VIII are highly suitable (S1) for *Pometia pinnata*, *Acacia mangirum* and *Paraserianthes falcatoria* are potentially highly suitable (S1) for land units I, II, III, V, VI, VII and moderately suitable (S2) for land units IV and VIII. *Nephelium lappaceum* is highly suitable (S1) for land units I, II, IV, V, VI, VII, VIII and moderately suitable (S2) for land unit III. *Durio zibethinus* is highly suitable (S1) in land units I, II, V, VI, VII and is moderately suitable (S2) in land units III, IV and VIII. Meanwhile, *Mangifera indica* is not suitable (N) for an area of 290,496 ha and *Syzygium aromaticum* is not suitable (N) in an area of 290,496 ha.

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