Mapping of lamtoro field in supporting the co-firing of steam power plants program

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ABSTRACT

The policy of renewable energy in Indonesia is expressed in the government regulation no. 79 in 2014 regarding the national energy policy. In the document, renewable energy is targeted to reach 23% in 2025, and a minimum of 31% in 2050. One of the developed renewable energies is biomass which is produced by lamtoro, a plant which has been employed as a mixture in coal at Anggrek steam power plant 2×25 MW Gorontalo. As much of 1% to 5% of lamtoro is added in 1,000 ton of coal per day. The research aims to create a thematic map of the distribution of lamtoro to meet the need of co-firing at Anggrek steam power plant. The result of research shows the total area of field which has been planted with lamtoro is 69,074 ha, scattered in 14 districts. Meanwhile the largest area is Kabila Bone district (22,070 ha), and the smallest area is East Bulango district (0.228 ha). The estimated potential of lamtoro in 14 districts of Bone Bolango regency is about 916,439.86 ton/ha/year.

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1. INTRODUCTION

Energy is one of human basic needs which is continue to increase along the level of life [1]–[4]. Fuel/fossil energy is one of the non-renewable energy sources which has become a reliable source to fulfil the energy demand in all sectors [5]. Indonesia is rich of energy sources, such as hydropower, geothermal, natural gas, coal, peat, biomass, biogas, wind, ocean energy, solar, and other sources of alternative energy to diminish dependency of the depleting fuel oil [6]–[10]. The abundant quantity of renewable energy should be managed carefully and prepared as alternative energy [11], to replace and cut down the consumption of fuel oil in Indonesia [12].

The policy of renewable energy is expressed in the government's rule no. 79 in 2014 about the national energy policy [13]. It is stated that the renewable energy is targeted to reach 23% in 2025, and a minimum of 31% in 2050 [14], [15]. One of the alternative energy resources which can meet the energy demand is biomass. Biomass is a whole material from living beings, including dead or alive organic substances, both on and in the ground. The biggest waste biomass potential is the waste of forest's wood [16], followed by paddy, corn, cassava, coconuts, palm, and sugarcane. Generally raw materials of biomass can be divided into 2 kinds, namely wood trees (woody), and grasses (herbaceous) [17], [18]. One of the biomasses that can be produced by plants is lamtoro. There are already many steam power plants utilizing lamtoro wood as the mixture in coal. Among them is Anggrek steam power plant 2×25 MW in Gorontalo. They conduct co-firing with the utilization of lamtoro wood as the mixture of coal as much as 1% to 5% in 1,000 ton of coal per day [19]. Renewable energy from the woody plants grows rapidly in the climate of Indonesia which is conducive for the continuity of the plant's growth.

Growing in vast land of Indonesia *Leucaena leucochepala* (lamtoro) has been utilized by people as energy wood. It is growth is estimated to be more than 50 generations since introduced to Indonesia. The plant has been well adapted to Indonesian environment. Lamtoro is suitable in the warm tropical climate (daily temperature of 25–30 ℃). The plant can survive in dry situation and plan table everywhere, including an area with precipitation rate between 650–3000 mm (800–1500 mm optimum) and also in elevation of 1–1500 mdpl. Bone Bolango regency, the second largest regency in Gorontalo province is selected as the research location. It is area is about 1984.31 km^2 (Gorontalo Province Central Bureau of Statistics, 2019). Bone Bolango regency has about 140,182.88 ha of forest area (Gorontalo Province Central Bureau of Statistics, 2017), average temperature of 26–28 ℃, and precipitation rate 0–330 mm. Therefore, lamtoro can adapt well and developable as the energy plantation.

Geographic information system (GIS) is a computer-based system information, digitally employed to illustrate and analyse geographical characteristics. GIS produces spatial and non-spatial data aspects. Computerized geographical data plays an important role in finding changes and identifying information regarding the earth. GIS can also be used as basic information data to help energy utilization and development.

2. METHOD

Mapping is a process to create map, by taking several steps such as data collection through site survey, remote sensing survey, or satellite image and GPS survey, which then come through data process and manipulation to present the data and information in the form of maps [20]. In this research, mapping of the suitability potential area for lamtoro plantation is conducted, then applying the remote information system to analyse the land suitability. The result can be used as a computer-based media to plant lamtoro. The research used ArcGIS 10.3 software to process geographic data including data input, management, storage and recall, manipulation and analysis. The data output is processed in a short time, thus new information can be generated quickly.

This is descriptive research which can be defined by KBBI as a research method done by describing the research object as it is through some series of data analysis. The research conducted mapping by matching and overlay some necessary parameters. Primary data is obtained from ground check (field survey) of lamtoro field and secondary data such as spatial data is obtained in the official site of geographic information system. Some necessary data is also acquired from the local office. The research is started by collecting secondary data, ground check (field survey), processing primary and secondary data and the next step is to combine related geographical data into a complete data by mean of analysis.

3. RESULTS AND DISCUSSION

Mapping of existing lamtoro field in Bone Bolango regency is conducted with by the the ground check method. There are 14 districts of mapping area in Bone Bolango regency, namely regency of Kabila, Tilongkabila, Tapa, South Bulango, East Bulango, Suwawa, South Suwawa, Central Suwawa, North Bulango, Botupingge, Bone Pantai, Bulawa, Bone Raya, Bone, and Kabila Bone. Here are the results of lamtoro field mapping in 14 districts of Bone Bolango regency.

3.1. Lamtoro plant distribution map

– Kabila district

Based on the field survey and data processing using ArcGIS software, the lamtoro field distribution on Kabila district can be seen in map of Figure 1. Based on the mapping, lamtoro field is distributed along 38 spots summed up to a total area of 1.604 ha. The largest area is 0.213 ha or about 13.310% from the total area of Kabila district and the least area is about 0.001 ha or 0.065%.

– Tilongkabila district

The result of field survey and data processing of ArcGIS software are able to produce the distribution of lamtoro field in Tilongkabila district, as can be seen in Figure 2. There are 23 spots of lamtoro field distribution Tilongkabila district with a total area of 3.118 ha. The largest area takes 0.446 ha or 14.308% of the Tilongkabila district area, and the smallest area is about 0.009 ha or 0.286%.

– Kabila Bone district

Field survey of lamtoro field and its ArcGIS data processing produce distribution map in Kabila Bone district as seen in Figure 3. There are 17 spots of lamtoro field distribution with a total area of 22.070 ha.

The largest area is as large as 2.447 ha or 11.087% of the total area of Kabila Bone district and the smallest area is 0.794 ha or 3.596%.

– Bone district

Based on the field survey and data processing using ArcGIS software, the lamtoro field distribution on Bone district can be seen in map of Figure 4. Based on the mapping, lamtoro field is distributed along 8 spots summed up to a total area of 2.285 ha. The largest area is 0.7 ha or about 30.626% from the total area of Bone district and the least area is about 0.136 ha or 5.940%.

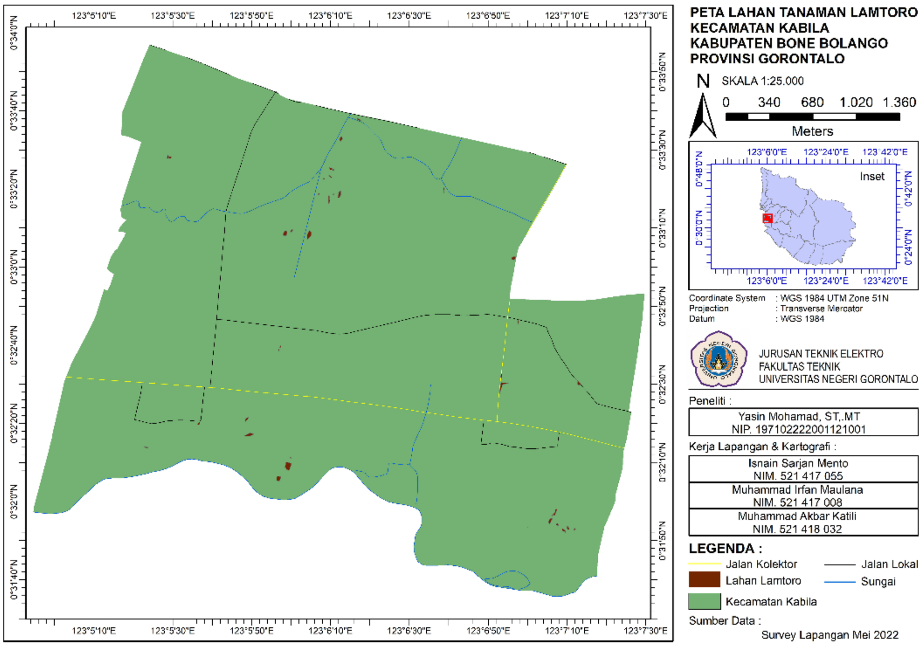

Figure 1. Lamtoro field distribution in Kabila district

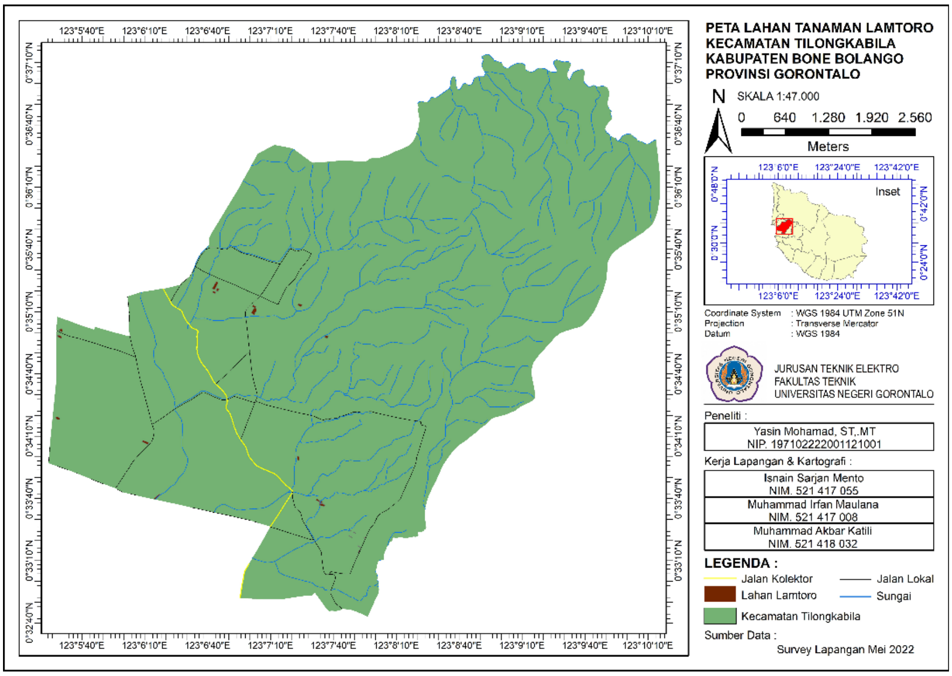

Figure 2. Lamtoro field distribution in Tilongkabila district

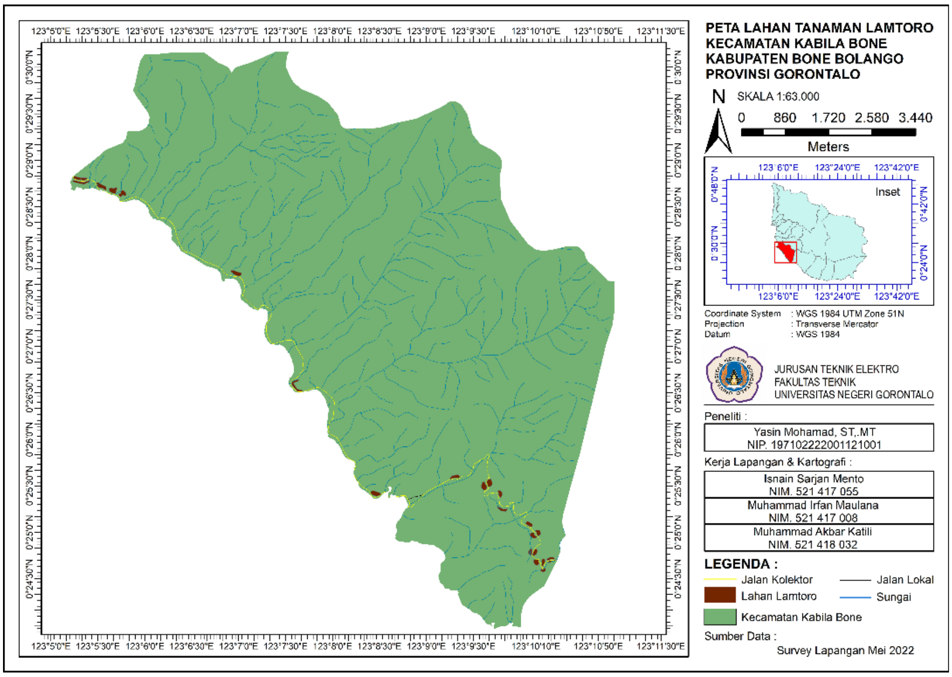

Figure 3. Lamtoro field distribution in Kabila Bone district

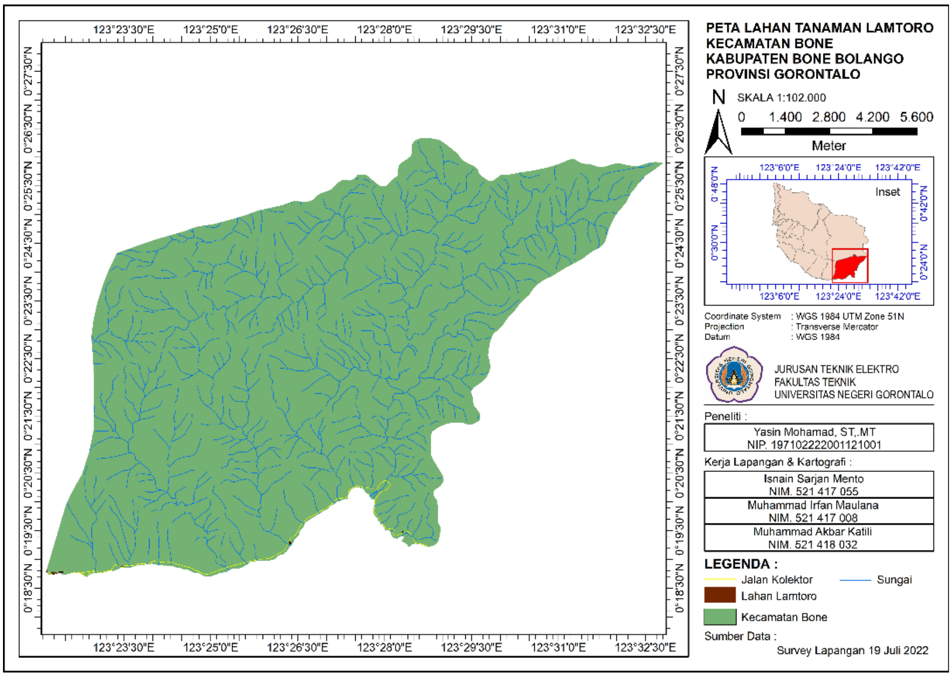

Figure 4. Lamtoro field distribution in Bone district

– Bone Raya district

The result of field survey and data processing of ArcGIS software are able to produce the distribution of lamtoro field in Bone Raya district, as can be seen in Figure 5. There are 11 spots of lamtoro field distribution in Bone Raya district with a total area of 2.752 ha. The largest area takes 0.446 ha or 16.223% of the Bone Raya district area, and the smallest area is about 0.109 ha or 3.947%.

– Bonepantai district

The result of field survey and data processing of ArcGIS software are able to produce the distribution of lamtoro field in Bonepantai district, as can be seen in Figure 6. There are 14 spots of lamtoro field distribution Bonepantai district with a total area of 8.8558 ha. The largest area takes 1.875 ha or 20.972% of the Bonepantai district area, and the smallest area is about 0.024 ha or 0.273%.

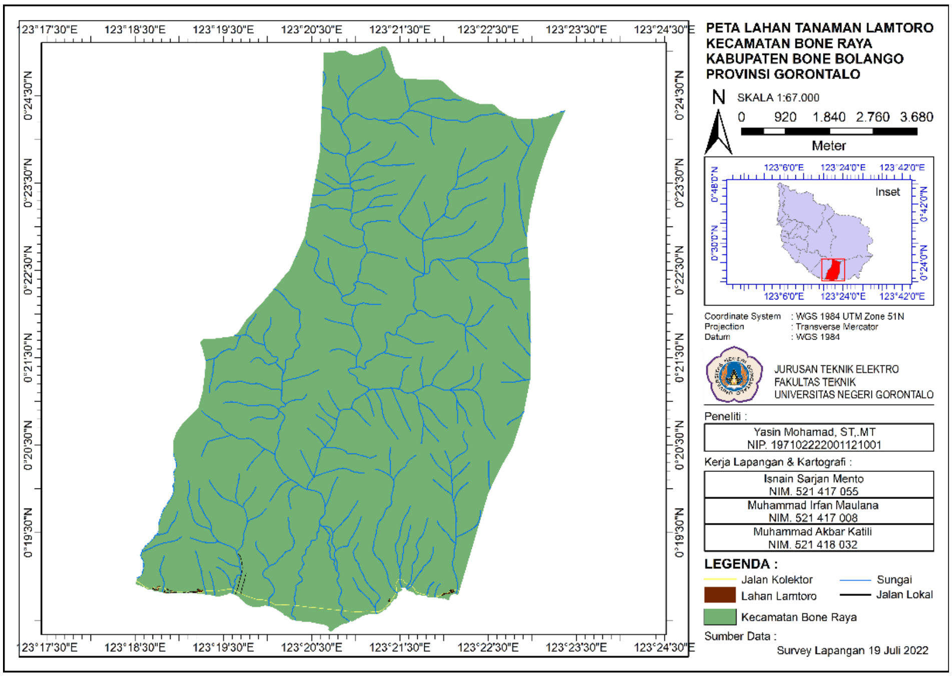

Figure 5. Lamtoro field distribution in Bone Raya district

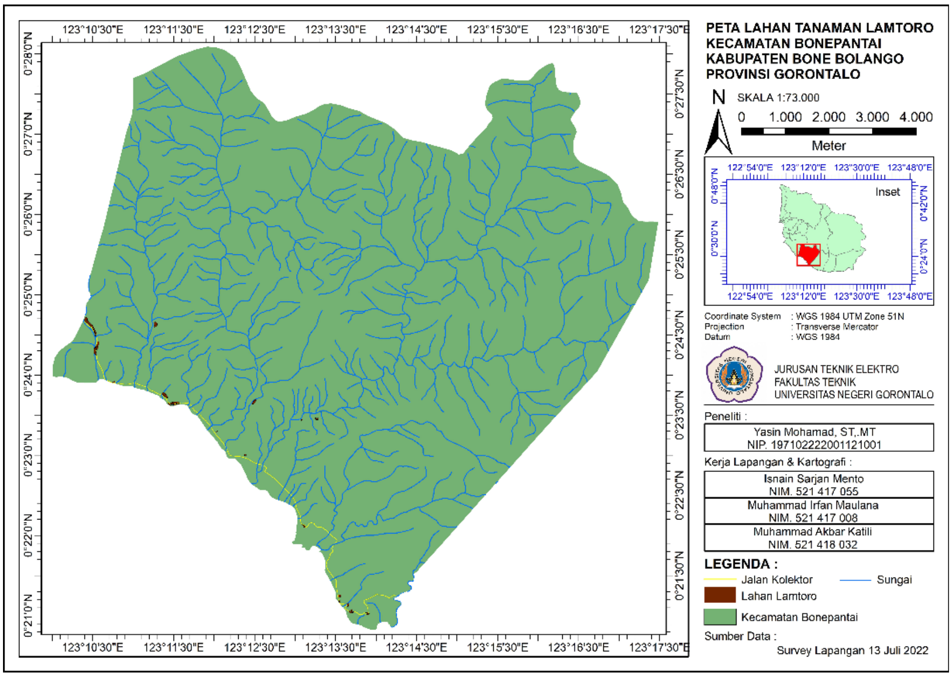

Figure 6. Lamtoro field distribution in Bonepantai district

– Botupingge district

Field survey of lamtoro field and its ArcGIS data processing produce distribution map in Botupingge district as seen in Figure 7. Based on the mapping, lamtoro field is distributed along 4 spots summed up to a total area of 6.102 ha. The largest area is 5.722 ha or about 93.777% from the total area of Botupingge district and the least area is about 0.056 ha or 0.913%.

– East Bulango district

Based on the field survey and data processing using ArcGIS software, the lamtoro field distribution on East Bulango district can be seen in map of Figure 8. There are 4 spots of lamtoro field distribution in East Bulango district with a total area of 0.228 ha. The largest area takes 0.114 ha or 50.077% of the East Bulango district area, and the smallest area is about 0.013 ha or 5.852%.

– North Bulango district

The result of field survey and data processing of ArcGIS software are able to produce the distribution of lamtoro field in North Bulango district, as can be seen in Figure 9. There are 12 spots of lamtoro field distribution in North Bulango district with a total area of 3.965 ha. The largest area takes 0.721 ha or 18.186% of the North Bulango district area, and the smallest area is about 0.032 ha or 0.811%.

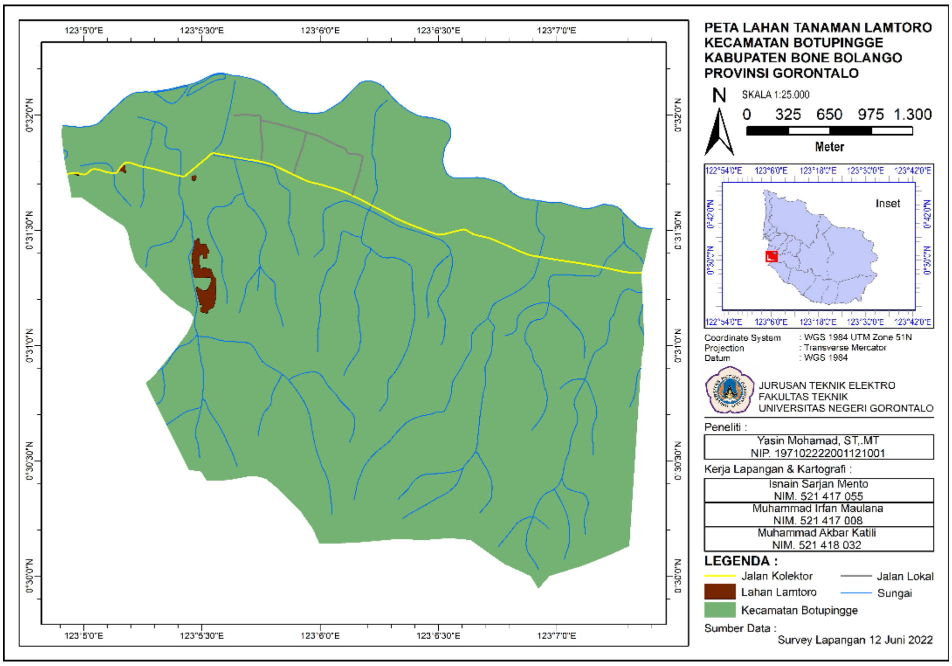

Figure 7. Lamtoro field distribution in Botupingge district

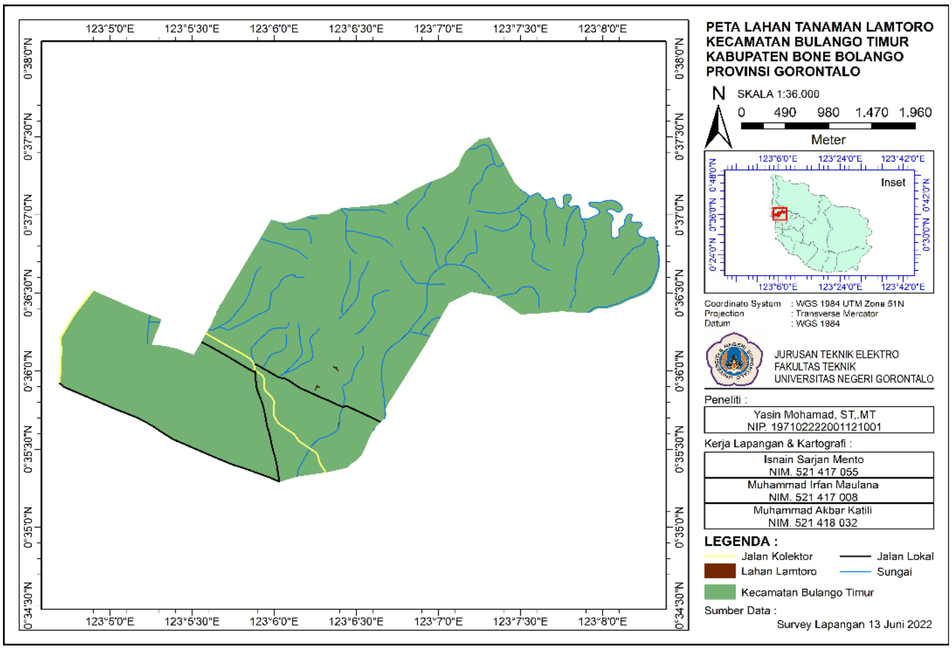

Figure 8. Lamtoro field distribution in East Bulango

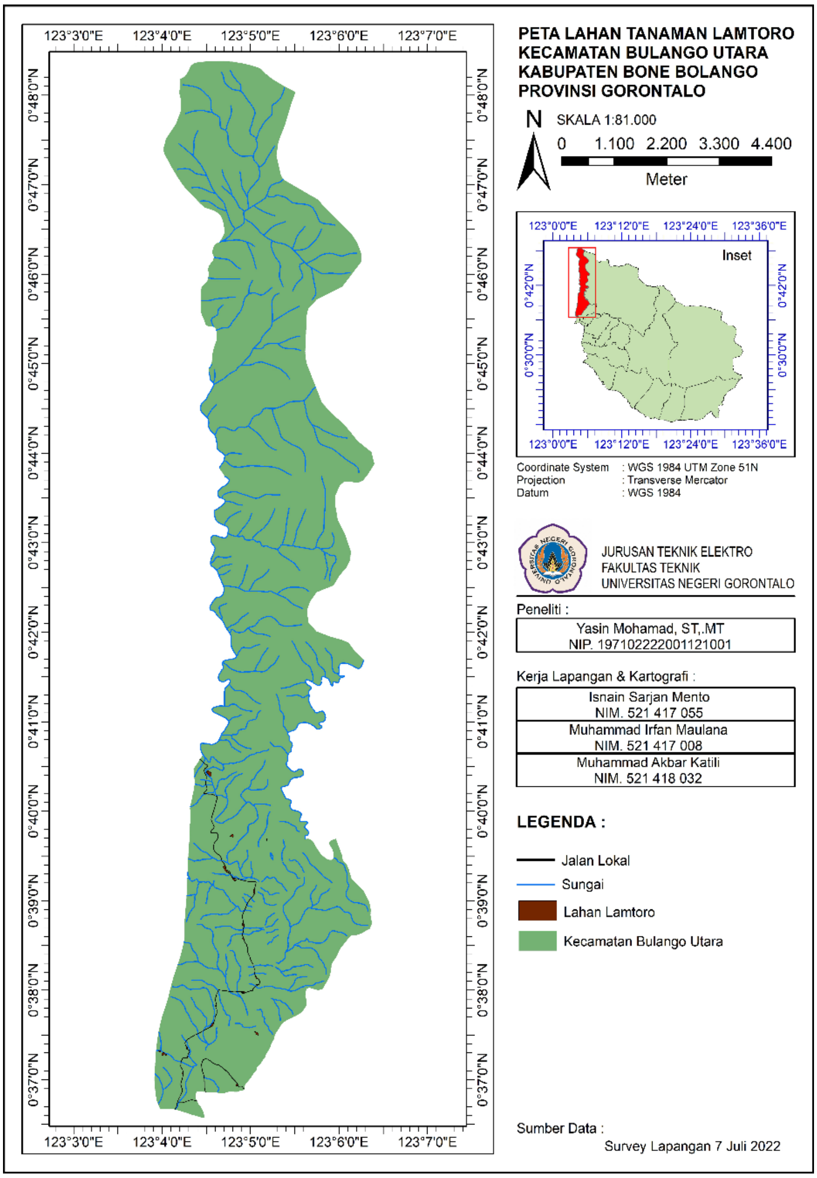

Figure 9. Lamtoro field distribution in North Bulango

– Bulawa district

Based on the field survey and data processing using ArcGIS software, the lamtoro field distribution on Bulawa district can be seen in map of Figure 10. Based on the mapping, lamtoro field is distributed along 23 spots summed up to a total area of 5.170 ha. The largest area is 0.690 ha or about 13.344% from the total area of Bulawa district and the least area is about 0.083 ha or 1.611%.

– Suwawa district

The result of field survey and data processing of ArcGIS software are able to produce the distribution of lamtoro field in Suwawa district, as can be seen in Figure 11. Based on the mapping, lamtoro field is distributed along 16 spots summed up to a total area of 2.029 ha. The largest area is 0.416 ha or about 20.479% from the total area of Suwawa district and the least area is about 0.017 ha or 0.859%.

– South Suwawa district

Based on the field survey and data processing using ArcGIS software, the lamtoro field distribution on South Suwawa district can be seen in map of Figure 12. There are 12 spots of lamtoro field distribution in South Suwawa district with a total area of 3.770 ha. The largest area takes 1.037 ha or 27.508% of the South Suwawa district area, and the smallest area is about 0.051 ha or 1.346%.

– Central Suwawa district

The result of field survey and data processing of ArcGIS software are able to produce the distribution of lamtoro field in Central Suwawa district, as can be seen in Figure 13. There are 16 spots of lamtoro field distribution in Central Suwawa district with a total area of 3.857 ha. The largest area takes 0.770 ha or 19.956% of the Central Suwawa district area, and the smallest area is about 0.053 ha or 1.361%.

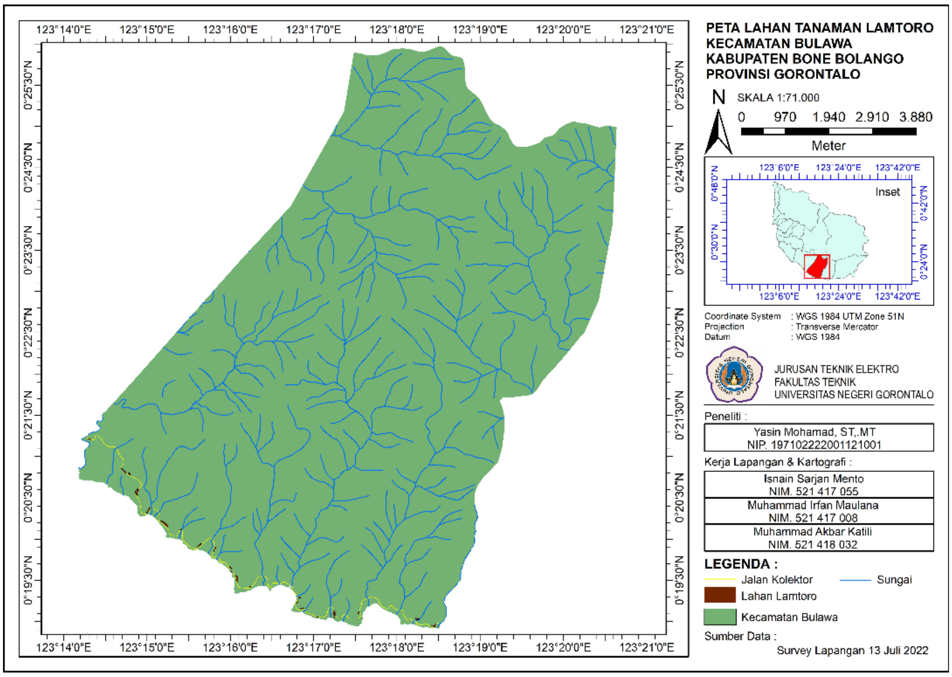

Figure 10. Lamtoro field distribution in Bulawa district

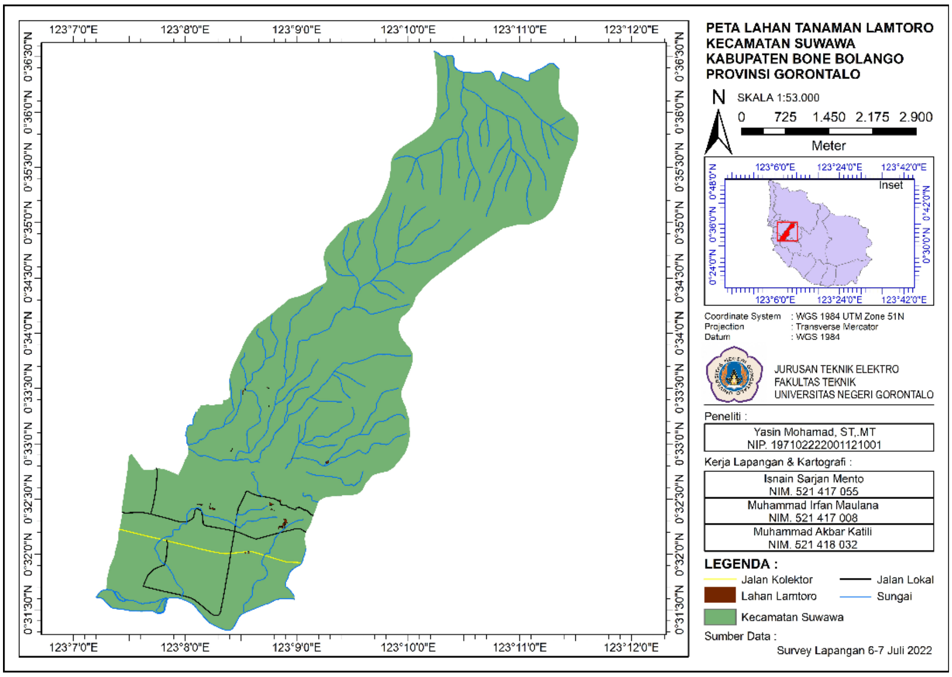

Figure 11. Lamtoro field distribution in Suwawa district

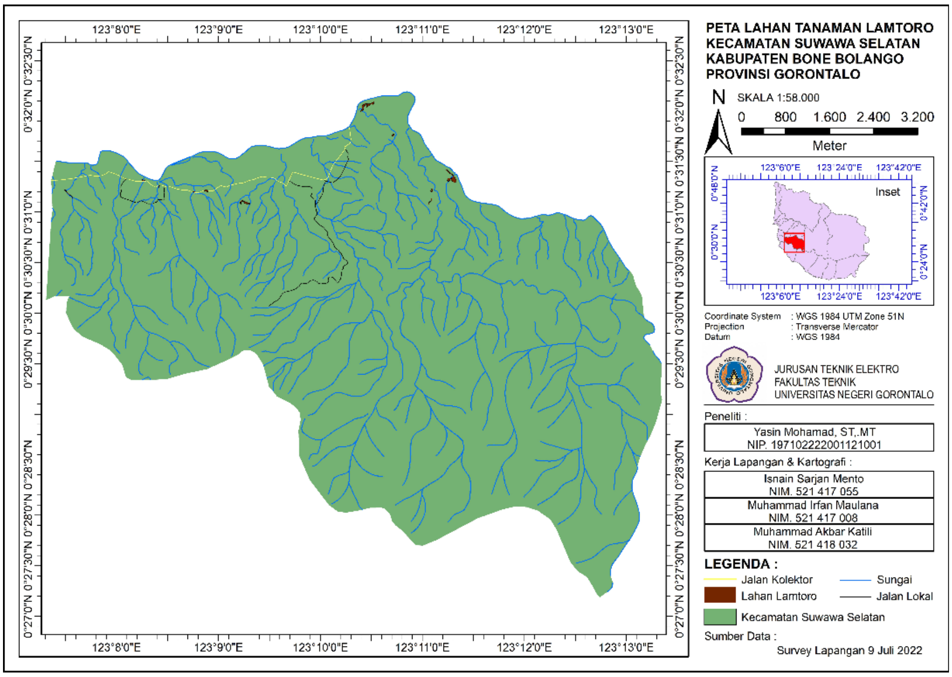

Figure 12. Lamtoro field distribution in South Suwawa district

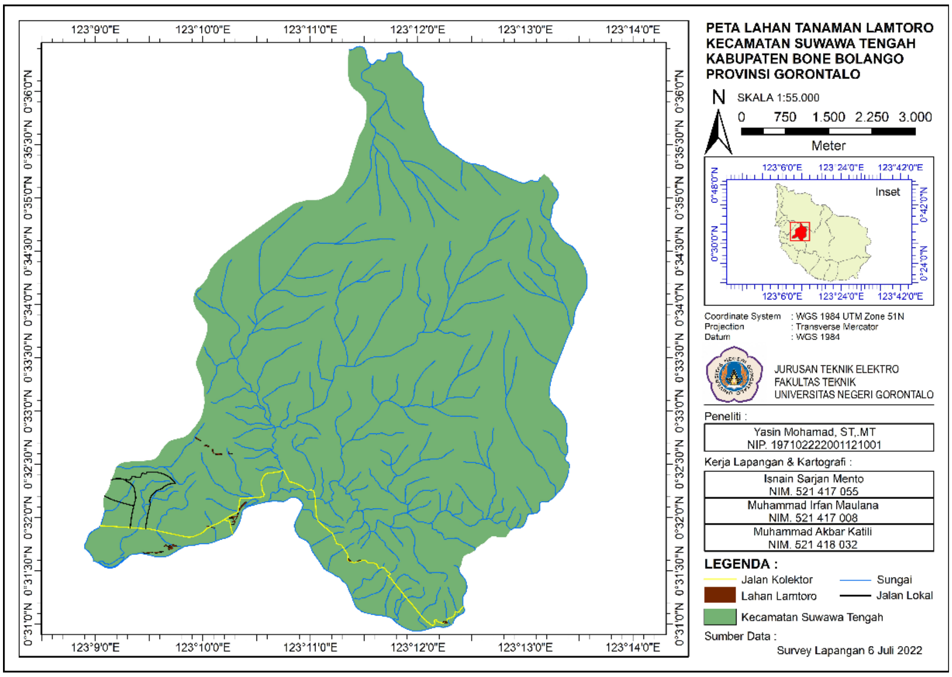

Figure 13. Lamtoro field distribution in Central Suwawa district

– Tapa district

The result of field survey and data processing of ArcGIS software are able to produce the distribution of lamtoro field in Tapa district, as can be seen in Figure 14. There are 6 spots of lamtoro field distribution in Tapa district with a total area of 1.296 ha. The largest area takes 0.332 ha or 26.149% of the Tapa district area, and the smallest area is about 0.13 ha or 10.233%.

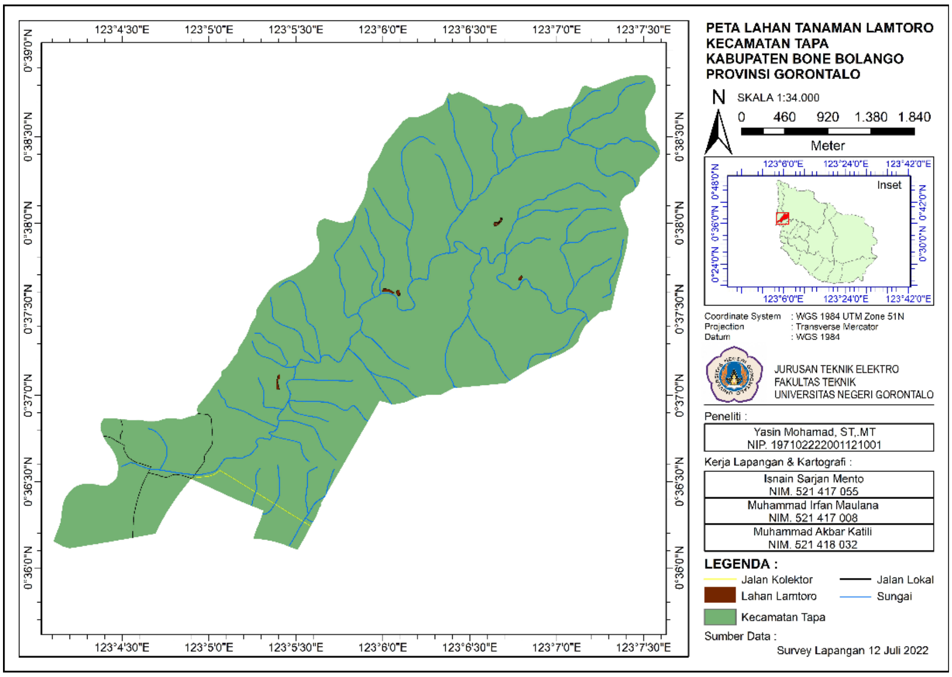

Figure 14. Lamtoro field distribution in Tapa district

3.2. Estimation analysis of lamtoro wood potential

To calculate the potential per hectare, the research assumed 3×6 m plant spacing on non-critical land. Therefore, there are 555 trees/ha (Minister of Forestry Number: P.65/Menhut-II/2014).

$$V = L_{bds} \times T \quad (1)$$

Where L_{bds} = base area and T = average height of ready to cut trees. L_{bds} of lamtoro woods could be substitute to lamtoro's growth rate which is about 20 m^3/ha/year, therefore the equation would be:

$$V = 20 \times U \times T \quad (2)$$

$$V/ha = V \times JB/ha \quad (3)$$

where 20 = lamtoro's growth rate; U = tree's age (1 year); T = average height (2 meter); JB/ha = amount of woods per hectare; V/ha = volume per hectare; hence, the potential would be:

$$V = 20 \times 1 \times 2 = 40\ m^3$$

$$V/ha = 40 \times 555 = 22{,}200\ m^3/ha$$

due to above calculation, the obtained potential is 22,200 m^3/ha. It is then multiplied by the area of lamtoro field be 69.074 ha. Finally, the potential of lamtoro field is 1,533,442.8 m^3/ha.

3.3. Total potential calculation

The value of lamtoro field potential would be used to calculate the total potential of lamtoro wood. Utilizing the total field area, the equation would be:

$$V_p = V_t \times FE \quad (4)$$

where, V_p = wood volume potential; V_t = total area; FE = forest exploitation factor as much as 70%; then, the total wood potential:

$$\begin{aligned} V_p &= 1{,}533{,}442.8 \times 70\% \\ &= 1{,}073{,}409.96\ m^3/ha \end{aligned}$$

3.4. Estimation analysis of energy production

Energy production potential is affected by the water content in lamtoro wood with an estimated value of 10.13%. Equation of the final wood volume is:

$$V_b = V_p - \left(V_p \times KA\right) \tag{5}$$

where V_b = final wood's volume; V_p = wood's potential volume; KA = water content in lamtoro (10.13%); then, the final wood volume would be:

$$\begin{aligned} V_b &= 1{,}073{,}409.96 - (1{,}073{,}409.96 \times 10.13\%) \\ &= 964{,}673.54\ m^3/ha \end{aligned}$$

the raw material supply is determined by the calculation in ton and conversion from m3 to ton is necessary. The formula applied for the calculation is as (6).

$$V_e = V_b - AK \tag{6}$$

Where, V_e = converted wood volume (ton/ha/year); V_b = final wood's volume; AK = conversion factor (0.95) as in the circular letter 484/BIKPHH-1/2012; therefore, the conversion would be:

$$\begin{aligned} V_e &= 964{,}673.54 \times 0.95 \\ &= 916{,}439.86\ ton/ha/year \end{aligned}$$

it is estimated that the lamtoro potential from Bone Bolango regency is about 916,439.54 ton/ha/year.

4. CONCLUSION

The lamtoro field have been distributed in 14 districts or 204 spots with a total area of 69.074 ha. Meanwhile the largest lamtoro field is in Kabila Bone district with an area of 22.070 ha and the smallest field is in East Bulango with an area of 0.228 ha. Lamtoro field cannot be found in 3 districts since they have long been cultivated as rice field area and also parts of the protected forest. The estimated potential of lamtoro in the 14 districts of Bone Bolango regency is about 916,439.86 ton/ha/year.

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