Biomass and carbon stock potential of *Gliricidia Sepium* as an alternative energy at Timor Tengah Utara Regency, East Nusa Tenggara Province, Indonesia

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Abstract. The utilization of biomass from plants is one efforts for the fulfillment an availability of alternative energy in indonesia. *Gliricidia sepium* is a tolerant species that can grow in dry land. However its utilization as renewable energy source is non-optimized. This study aims to analyze the potential carbon stocks and biomass from *Gliricidia sepium* as a raw material for alternative energy in East Nusa Tenggara. This study was conducted in November 2015 and located in Humusu Sainiup, Timor Tengah Utara Regency, East Nusa Tenggara Province. The method used in collecting data was applied in three different land-use, namely monoculture *Gliricidia sepium*, polyculture between *Gliricidia sepium* and *Leucaena leucocephala*, and polyculture between *Gliricidia sepium* and *Zea mays*. We used the allometric equation from Ketterings namely $B = 0.11\rho D^{2+0,62}$ and $C = 0.5 \times B$. The results showed that the different land-use will give different value of carbon stocks which is in this study the biggest value of carbon stocks was found in monoculture of Gliricidia sp (35.35 tC ha^{-1}) compared with Gliricidia sp + Leucaena sp (18.83 tC ha^{-1}), and Gliricidia sp + Zea mays (13.79 tC ha^{-1}). The value of biomass and carbon stocks was influenced by wood density, trees density, and diameter at breast height (dbh).

Keywords: *biomass, carbon stocks, renewable energy, Gliricidia sepium*

1. Introduction

Population growth encourage increased energy needs for the improvement of human well-being from year to year. Increased energy consumption caused by two factors: population growth, which reached more than 20% and the improvement of living standards that drive energy consumption per capita increased by almost 40%.

The need for energy is a crucial issue for national development requires the availability of sufficient energy, safe, quality, and diverse and spread evenly throughout Indonesia affordable. The high growth of industry and population resulted in a gap between demand and supply of energy. This can lead to an energy crisis. Indonesia has energy resources which consist of non-renewable energy sources and renewable energy sources. The energy source has an important role in development as a crucial factor for other sectors such as industry, transport, households, commercial, and others [1].

Law No. 30 of 2007 on Energy [2] and Government Regulation No. 78 of 2014 on National Energy Policy [3] has been set up management and utilization of energy resources. National energy policy mandates a target of achieving an optimal mix of primary energy in 2025 that the role of renewable energy at least 23% and by 2050 at least 31%. Utilization of Indonesia's energy consumption has increased with an average growth of 1.9% per year which is still dominated by fossil fuels, the increase was due to higher activity in the transportation, industrial, and household [4]. The energy problem faced by Indonesia, which are: energy subsidies increased to Rp 255.6 trillion in 2011, the number of people who do not have access to electricity was 87.69 million population, limitations of domestic infrastructure challenges and problems in meeting domestic energy needs. Dependence on oil is still dominant reached 49.7%, while the utilization of renewable energy was approximately 6% [5]. Indonesia has the landscape and geographical location on the equator have some type of alternative energy sources that can be developed such as solar energy, wind energy, geothermal energy, ocean thermal energy and biomass energy. Among the sources of alternative energy, biomass energy is an alternative energy source that needs to be given priority in development compared with other energy sources.

Efforts to comply with the availability of alternative energy is the utilization of biomass plants. Biomass-based energy sources have the advantage in ensuring the availability of alternative energy sources as energy needs. Gliricidia plants is one of the renewable energy sources available in Indonesia, particularly in the province of East Nusa Tenggara. *Gliricidia* have a place to grow tolerant characteristics in upland and utilization of renewable energy sources is not optimal. This study aims to analyze the potential of carbon stocks and biomass in *G. sepium*.

2. Materials and Methods

The study was conducted in October 2015 in the secondary forest in Humusu Sainiup, Timor Tengah Utara Regency, East Nusa Tenggara Province. Location of the study there are three types of land cover, namely on *G. sepium* monoculture, polyculture between *G. sepium* and *L. leucochepala*, and polyculture between *G. sepium* and *Z. mays*.

The materials used for the observation and measurement of the vegetation is in a location that includes seedlings, saplings, poles, trees. The equipment used for to conduct of research include GPS, Compass, Roll-meter, Meter Sewing, Hagameters, Tally Sheet,, Cameras, and Stationery.

The type of experimental plot is square with 20x20 cm, then made 3 subplot each sized 10x10 cm, 5x5 cm, and 2x2 cm. Plot with sized 20x20 cm be destined for tree, 10x10 cm for poles, 5x5 cm for stakes, and 2x2 cm for seedlings. Each type of land cover has made 5 experimental plots. After determining and make the plot as the sample plot, then do inventary to obtain data and information carefully according to circumstances on the ground in each plot were made, the variety of data and information is the location plots, plant species, and the diameter breast height (1.3 m). Biomass data analysis done using the allometric equation $B = 0.11\ \rho\ D^{2+0.62}$ [6] and $C = 0.5 \times B$ [7].

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3. Results and Discussions

3.1 Inventory of biomass and carbon storage on monoculture G. sepium

Inventory of biomass and carbon storage on monoculture *G. sepium* is located at coordinates S 09^0 29' 16" E 124^0 56' 05" and at an altitude of 333 meters above sea level. Inventory made on 5 experimental plots, inventory data for biomass and carbon storage of data obtained by the above ground biomass that include categories stakes, poles, and trees. Table will present the results of the inventory of biomass and carbon storage contained in monoculture *G. Sepium*.

Table 1. Inventory of Biomass and Carbon Storage in Monoculture *G. sepium*

Category	Biomass (kg/ha)	Carbon Storage (kg/ha)
Stakes	17,007.10	8,503.55
Poles	33,511.38	16,755.69
Trees	20,223.60	10,111.80

According to the table 1, the results of the calculation of the largest biomass and carbon storage are in the category pole of 33,511.38 kg / ha, equivalent to 33.51 tonnes / ha, while for carbon storages 16,755.69 kg / ha, equivalent to 16.75 tonnes / ha. This is because the sample plots commonly found plants that fall into the category pole density and very high frequency, which resulted in having the potential of biomass and carbon storage are greatest when compared to a stake or a tree well. Biomass and carbon storage value depends heavily on the density and frequency contained in each respective category in field trials. The higher level of density and frequency in a region, the greater the value of the biomass and carbon storage in the region. Based on study conducted by Fuwape and Akindele [8] obtained the results of research on Gamal plant biomass of 37.4 tons / ha. The value of biomass and carbon stock depends greatly on the density and frequency levels found in each category on the experimental field.

3.2 Inventory of biomass and carbon storage on intercropping G. sepium and L. leucochepala

Inventory of biomass and carbon storage on intercropping *G. sepium* and *L. leucochepala* is located at coordinates S 09^0 27' 51" E 124^0 57' 65" and at an altitude of 148 meters above sea level. Inventory made on 5 experimental plots, inventory data for biomass and carbon storage of data obtained by the above ground biomass and carbon storages that include categories stakes, poles, and trees. Table will present the results of the inventory of biomass and carbon storage found on imtercropping *G. sepium* and *L. Leucochepala*.

Table 2. Inventory of Biomass and Carbon Storage on Intercropping *G. sepium* and *L. leucochepala*

Category	Biomass (kg/ha)	Carbon Storage (kg/ha)
Stakes	9,516.38	4,758.19
Poles	7,700.95	3,850.47
Trees	20,437.94	10,218.97

According to the table 2, the results of the calculation of the largest biomass and carbon storage are in the category tree of 20,437.94 kg / ha, equivalent to 20:44 tons / ha, while for carbon deposits generates 10,218.97 kg / ha, equivalent to 10:22 tons / ha. The results of a quantitative analysis of vegetation found indicates that stands found in the category of samplings have higher numbers than other categories. Density and high-frequency plant on intercropping *G. sepium* and *L. leucochepala* no contribution of biomass and carbon storage means. Biomass and carbon storage value is also influenced by the size of the diameter of the plant. Study from Rahayu *et al.* [9] in Nunukan stated that the diversity of the size of the diameter, the presence of trees with a diameter >30 cm in a land use systems, contributing to significant biomass to the total carbon storage. This causes that the biomass content at the level of the tree has a value greater than the rate of saplings and poles.

3.3 Inventory of biomass and carbon storage on intercropping G.sepium and Zea mays

Inventory of biomass and carbon storage on intercropping *G.sepium* and *Zea mays* are on the coordinates S 09^0 29' 43" E 124^0 56' 86" and at an altitude of 281 meters above sea level. Inventory made on 5 experimental plots, inventory data for biomass and carbon storage of data obtained by the Biomass stand up (Above Ground Biomass) and carbon deposits that include categories stakes, poles, and trees. Table will present the results of the inventory of biomass and carbon storage contained in Gamal and corn fields.

Table 3. Inventory of biomass and carbon storage on intercropping *G.sepium* and *Zea mays*

Category	Biomass (kg/ha)	Carbon Storages (kg/ha)
Stakes	25,426.81	12,713.41
Poles	1,053.19	526.595
Trees	1,105.16	552.58

According to the table 3, the results of the calculation of the largest biomass and carbon storage is at stake category of 25,426.81 kg / ha, equivalent to 25.42 tonnes / ha, while for carbon deposits generates 12,713.41 kg / ha, equivalent to 12.71 tonnes / ha. This result is obtained because the sample plots *G. sepium* and *Z. mays* crops is very much a crop plant regeneration. The sample plots are also found *Z. mays*, because when the research was ongoing planted corn has been harvested by the local community. The difference in the acquisition of biomass is influenced by the density of vegetation, the diversity of its diameter size and density distribution of vegetation [9]. Data on the ground suggest that the category of the stake has a number of stands more than the category resulting poles and tree biomass and carbon storage values obtained at different stake levels much to the value of biomass and carbon storage in small trees and tree level.

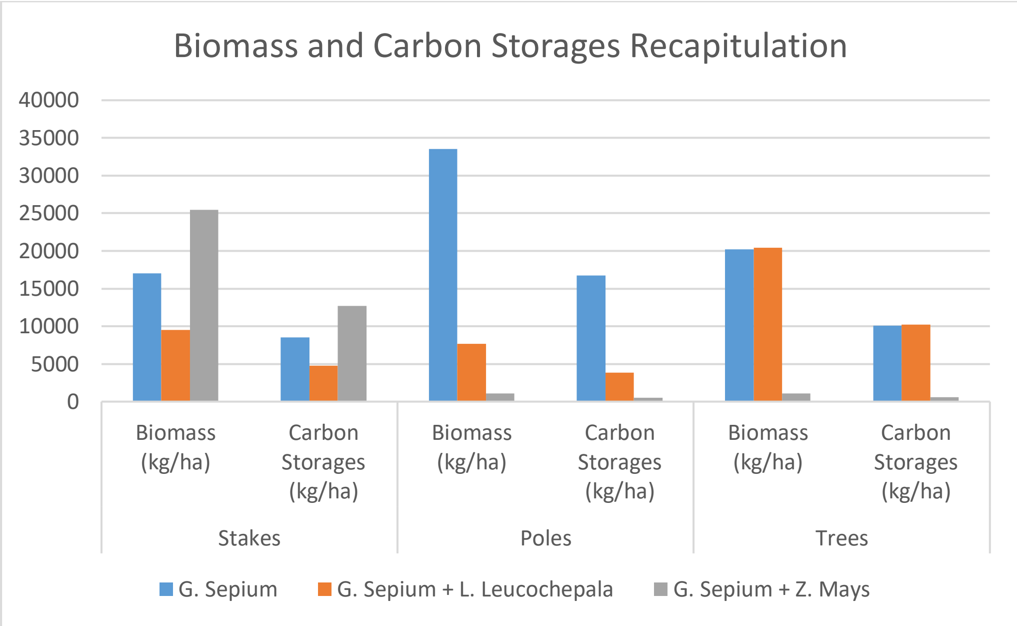

Figure 1. Biomass and Carbon Storages Recapitulation

According to the figure 1, the category of stakes has a value of biomass and carbon storage site that is on the sample plot *G. sepium* and *Z. mays* amounting to 25,426.81 kg / ha and 12,713.41 kg / ha. Category poles at monoculture sample plots *G. sepium* has the highest value than other sample plots that have a biomass value of 33,511.38 kg / ha with a total carbon storage of 16,755.69 kg / ha. Category trees that has value is the largest biomass plant sample plots *G. sepium* and *L. leucochepala* with a value of 20,437.94 kg / ha and the total carbon storage of 10,218.97 kg / ha. Based on previous research conducted by Yuniati [10] in Kupang, the highest carbon stocks amounted to 148.48 tons / ha using allometric equations Ketterings. Value to its lowest carbon stocks worth 106.59 tons / ha. This value was very different from what obtained in this study. The biomass value of 70 tons / ha with a total carbon storage of 35 tonnes / ha. This is caused by the frequency and the relative abundance of low crop, the size of the diameter of a small plant, density of plants, nutrients in the soil that affect biomass and carbon storage value obtained from this study.

Tree growth is determined by the interaction between three factors namely genetic factors, environmental factors and cultivation techniques or silviculture techniques applied [11]. Genetic factors and cultivation techniques can be manipulated through tree breeding and the selection of appropriate cultivation or silviculture techniques that can increase tree productivity that is closely related to increased tree biomass and carbon storage.

All this time, *Gliricidia* are used as garden barriers, as firewood, as ruminant animal feed, and some studies have explained that *Gliricidia* have high carbon stores that can reduce air pollution, as well as large biomass and calorific values that can be developed as materials raw alternative energy. Based on study conducted by Amirta *et al* [12] showed that calorific value of *Gliricidia* higher than another fast growing species. *Gliricidia* has calorific value amounted to 4026.77 kCal/kg. These result explained that *Gliricidia* has a high calorific value compared to other fast growing species. In addition to, with the advantages of tolerant and one of the fast growing species, *Gliricidia* is one of raw materials that can be cultivateed in dry land and also has a low electrification ratio as an alternative energy.

4. Conclusions

Based on the results of the research potential of biomass and carbon storage in Humusu Sainiup, Timor Tengah Utara Regency, East Nusa Tenggara Province obtained the largest potential of biomass and carbon storage in land monoculture *G. sepium.* This is a preliminary study of the potential biomass and carbon stocks *G. sepium* as an alternative energy. Assessing the theoretical potential of biomass energy provides a large energy estimation because the energy contained in each biomass is taken into account in a region. But not all theoretical potential can be used as an energy source. Barriers such as climate, policy, local wisdoms can hinder access to theoretical potential. Therefore, it is necessary further research for the development *G. sepium* as an alternative energy source in Humusu Sainiup, East Nusa Tenggara Province.

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