OPEN ACCESS
Journal of Selvicoltura Asean
Vol. 2 No. 4. August 2025, pp. 199-208 DOI. 10.70177/jnhl.v2i4. 1955
Research Article

VEGETATION ANALYSIS ESTIMATING BIOENERGY POTENTIAL AGROFORESTRY RUMBIA VILLAGE BOALEMO DISTRICT

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Article Info
Received: February 2, 2025
Revised: May 12, 2025
Accepted: July 15, 2025
Online Version: August 25, 2025

Abstract
Energy is one of the basic needs to support human survival. Along with the increasingly limited availability of energy from fossils, it is necessary to find other alternative energy sources. In the agroforestry area there are Aren plants which are one of the plants that can be processed into an energy source. the data used are primary and secondary data. Data analysis was carried out quantitatively and qualitatively. The results of the data analysis that have been carried out, found a total of 4 species at the tree level and 5 species at the pole level in Agroforestry in Rumbia. The highest important value at the tree level is Aren (Arenga pinnata) with a value of 155.95, the lowest Durian (Durio zibethinus) 21.53. the highest important value index at the pole level is Aren (Arenga pinnata) with a value of 144.42 and the lowest Chocolate (Theobroma cacao) 22.90.

Keywords: Bioenergy, Agroforestry, Rumbia, Boalemo

Journal Homepage	https://research.adra.ac.id/index.php/selvicoltura
How to cite:	Ruruh, A., Syahputra, F., Haris, S. A., & Suma, Z. N. Y. (2025). Vegetation Analysis Estimating Bioenergy Potential Agroforestry Rumbia Village Boalemo District. *Journal of Selvicoltura Asean, 2*(4), 199–208. https://doi.org/10.70177/selvicoltura.v2i4.1955
Published by:	Yayasan Adra Karima Hubbi

INTRODUCTION

Sustainable natural resource management is crucial in addressing the challenges of climate change and limited fossil fuels (Choden et al., 2026). Agroforestry, an integrated agricultural system that combines trees with crops or livestock, holds significant potential for supporting renewable energy production (Rahayu et al., 2025). Rumbia Village, located in Boalemo District, boasts a high diversity of agroforestry vegetation and has the potential to be utilized as a bioenergy source (Xingfu et al., 2025). Vegetation analysis within the agroforestry system in this village is crucial for identifying the types and distribution of plants that can optimally support bioenergy production (Geier et al., 2025). This study aims to conduct vegetation analysis to estimate the potential bioenergy generated from the agroforestry system in Rumbia Village, Boalemo Regency (Harsha Varthan et al., 2026), thereby contributing to renewable energy development and improving the well-being of the local community.

Furthermore, vegetation analysis in agroforestry systems plays a crucial role in providing a comprehensive overview of the structure and composition of existing vegetation (Wei et al., 2024). Commonly used methods include inventory techniques using a grid system, measuring plant density, frequency, and dominance parameters, and calculating the Important Value Index (INP) (Fariq et al., 2024). This approach allows for the distribution and dominant types of vegetation to be identified, which is then useful for estimating the potential for bioenergy resources that can be produced (Koh et al., 2024). This analysis also helps in understanding the ecological dynamics and stratification of vegetation, both vertically and horizontally, thus providing important information for sustainable agroforestry management (Ruruh et al., 2024). Thus, vegetation analysis methods serve not only as a tool for identifying bioenergy potential but also as a basis for decision-making to increase productivity and environmental conservation in agroforestry areas (Bauer et al., 2024), including in Rumbia Village, Boalemo Regency.

Indonesia is known to have tropical forests covering 1.3% of the earth's surface area, but has a high level of species diversity, 11% of flowering plant species, 10% of mammal species, 16% of bird species, 26% of reptiles and amphibians and 25% of marine and freshwater fish species so that it is known as one of the mega-diversity countries in the world. has very extensive land resources for the development of various agricultural commodities (Lepnaan Dayil et al., 2025). Indonesia's land area reaches 188.20 million ha, consisting of 148 million ha of dry land and 40.20 million ha of wetlands, with various types of soil, climate, physiography, parent material (fertile volcanoes), and elevations (Das et al., 2025). These conditions allow for the cultivation of various types of plants, including bioenergy-producing commodities (Ingram et al., 2025). Some plants that have the potential to produce bioenergy are oil palm, coconut, jatropha, cotton, canola, and rapeseed for biodiesel, and cassava, sweet potato, sugar cane, sorghum, sago, aren, nipah, and lontar for bioethanol (Lawson et al., 2025). In addition to their potential as bioenergy producers, some of these commodities, such as oil palm, coconut, cotton, cassava, sugar cane, and sago, are also commodities that are sources of food and feed (Singh et al., 2025). Therefore, the development of these bioenergy-producing commodities will compete with the need for food and feed (Hoque & Mondal, 2026). Expansion of planting areas (extensification) is one option to increase the production of these various commodities, so that they can meet the needs for food, feed, and bioenergy.

Communities around the forest (local communities) utilize the diversity of species, especially biodiversity, as a source of food, medicine, clothing, building materials and various ecological services (Quintero Bertel et al., 2025). The biodiversity that is owned can be maintained by local communities, by implementing a good management system, creating a balance between the utilization aspect and the protection aspect, which ensures sustainability, meeting the needs of the present generation without sacrificing the interests of future generations (Jan Weger et al., 2025). One of the efforts made is with a land use system and technology, where long-lived trees and short-lived crops or animal feed are cultivated on the same plot of land in a spatial and temporal arrangement, known as an agroforestry system (Paudel et al., 2025). This system allows for interactions that are beneficial from an ecological and economic perspective, such as diversification of income sources, increased biological production, better water quality, and improved habitat for humans and wildlife.

Land use with consideration of the utilization and protection of biodiversity has long been practiced by local communities in Indonesia (Ntawuruhunga et al., 2025). One of these agroforestry practices is called Ilengi (Menin et al., 2025). Ilengi agroforestry is a stretch of mixed gardens, managed from generation to generation to form a vegetation structure that resembles a natural forest, which is located in the Gorontalo area, especially in Rumbia Village (Lima et al., 2026). Ilengi is the main source of income for village communities and as a source of food, medicine, and building materials.

Its utilization prioritizes aspects of preservation and diversity of cultural values by paying attention to and protecting traditional and customary values that exist in the community (den Herder et al., 2025). Rumbia Village has a strategic function as a buffer zone for the Paguyaman River Basin Area (DAS) and Bone Bolango Watershed, in Gorontalo Province (Brandhorst et al., 2025). This village is located in the upstream area of the DAS, with an altitude ranging from 250-600 meters above sea level (asl), the slope is dominated by 25% to 40%. Most of the administrative area (23.45% or 487.67 ha) is a protected forest area and the other part (76.55% or 1592.02 ha) as an agricultural cultivation are (Ray et al., 2025). The existence of the local Rumbia community has resulted in the conversion of forests into traditional agricultural land, by combining types of annual and long-lived plants (trees) with the aim of producing fruit, sap or wood, namely Ilengi Fruit-Sap agroforestry (AF-BN), Fruit (AF-B), Secondary Crops-fruit-sap (AF-PBN), Wood-fruit (AF-KB) and Wood (AF-K).

RESEARCH METHOD

Research Design

This research was conducted in Rumbia Village, Botumoito District, Boalemo Regency. The research was conducted from July to September 2024.The method used is a combination of the path method and the grid line method,where each point is placed systematically (Kakebe Sekajja et al., 2025). The squares on this grid line are rectangular.so that within these lines measurement plots are made.Then the relevance is determined and observation routes are created according to field conditions.The area of the measurement plot for each growth level is as follows: Poles or small trees with a plot size of 10 x 10 m, Trees with a plot size of 20 x 20 m.

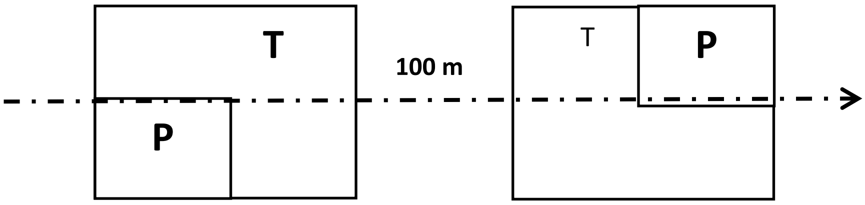

Figure 1. Vegetation Analysis Observation Plot

Information :
T:*Tree*(Tree)
P:*Polish*(Pole)

Research Target/Subject

The subject of the research includes all vegetation stands within the observation plots, covering seedling, sapling, pole, and tree levels. Particular focus is given to species relevant to bioenergy potential, recording characteristics such as species type, diameter, height, and physiological conditions like altitude above sea level.

Research Procedure

Sampling plots were established at the four corners and the center of the grid, marked by red-painted stakes. Vegetation data collection involved identifying individual species, measuring diameters, and recording heights within plots. The Important Value Index (IVI) was computed based on species density, dominance, and frequency using the Mueller-Dombois and Ellenberg (1974) formula. Secondary data were gathered from literature for supporting analysis.

Instruments, and Data Collection Techniques

Instruments included measuring tapes and diameter calipers for physical measurements, GPS devices for geolocation, and data sheets for recording field observations. Vegetation data were collected using plot sampling techniques, with sample plots distributed systematically according to the path and grid line methods.

Data Analysis Technique

Collected vegetation data were analyzed to determine species density, relative density, species dominance, relative dominance, species frequency, and relative frequency. The Important Value Index (IVI) provided a comprehensive measure of species ecological importance. Data analyses focused on identifying dominant species and quantifying vegetation structure relevant to bioenergy potential.

RESULTS AND DISCUSSION

Density of Species

Density is the number of individuals per species per unit area or per unit volume. The density of plant species in ilengi agroforestry consists of several levels of trees and poles (Gu et al., 2026). The results of data analysis show that the speciesArenga pinnatahas an even distribution and can be found at the tree and pole levels (figure 2). This is reinforced by the opinion of Shahrouri et al., (2025) who stated that Arenga pinnata is one of the dominant types of plants in ilengi agroforestry in a community plant area because it is able to adapt well to its environment when compared to other types.

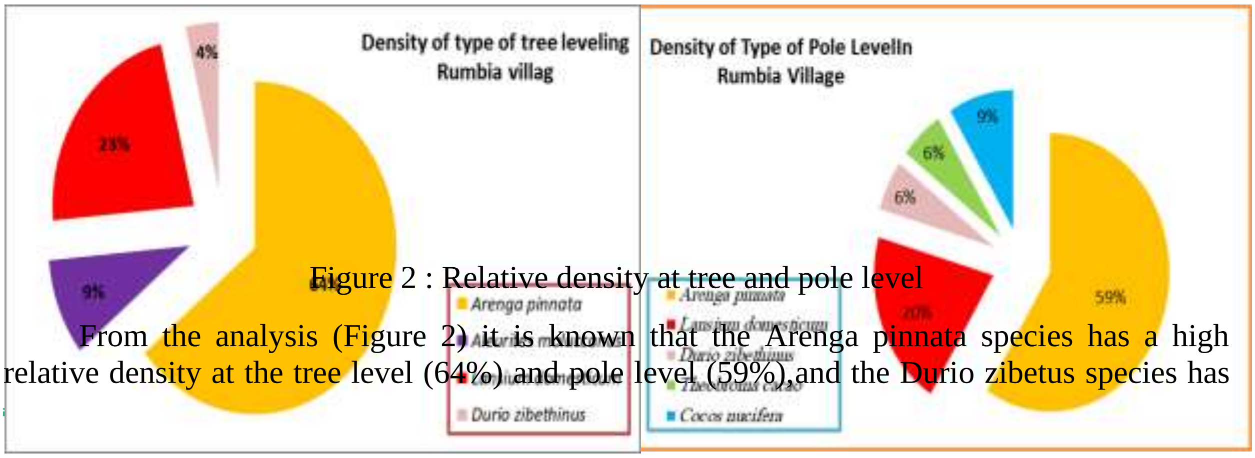

Figure 2 : Relative density at tree and pole level

From the analysis (Figure 2) it is known that the Arenga pinnata species has a high relative density at the tree level (64%) and pole level (59%),and the Durio zibetus species has the smallest density value at the tree and pole levels. This can be because the substrate at the observation location is an inhibiting factor for the spread of the species Haq et al., (2026). Density can be used to see the extent of disturbance to a habitat. While the Durio zibethinus species is a species with the smallest relative density value at the tree and pole levels in a low/small habitat, then the habitat has experienced disturbances adapting to topographic conditions (Raman et al., 2025).On the other hand, if the density value of the plant species is high, then the habitat has not experienced any damage.

Frequency

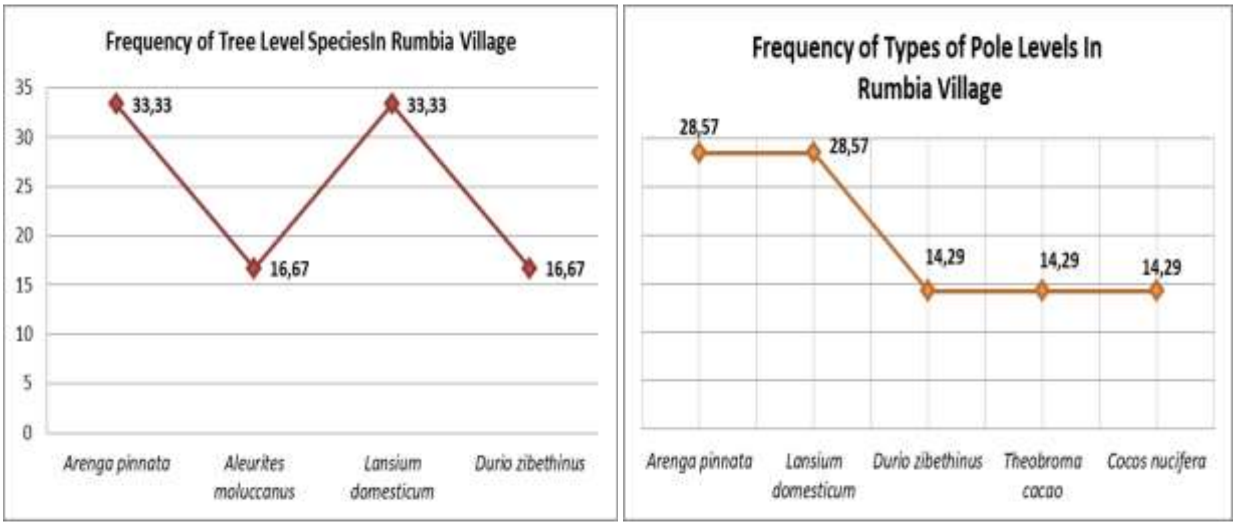

Figure 3: Relative frequencies at tree and pole levels

The results of the data analysis in (Figure 3) show that the type of relative frequency (FR) valueArenga pinnataand Lansium domesticum has the same value (33.33%) at the tree level and pole level (28.57%). If the frequency value ranges between 1-20% it is categorized into class A which is very low, then if the frequency value ranges between 21-40% it is categorized into class B which is low 41%-60% class C which is moderate, 61-80% class D which is high and 82-10s0% very high. This is reinforced by the opinion of Hiola (2015)that Arenga pinnata is one of the dominant plant species in Ilengi Agroforestry because it is able to adapt well to its environment compared to other species.

Importance Value Index (IVI)

Based on the research results, there were 4 species at the tree level and 5 species at the pole level in Ilengi Agroforestry in Rumbia. From the calculation results of the Importance Value Index (IVI) at the tree and pole levels (Figure 4). The Importance Value Index (IVI) can show the importance of a type of plant, whether or not the plant has an influence on the community or ecosystem.

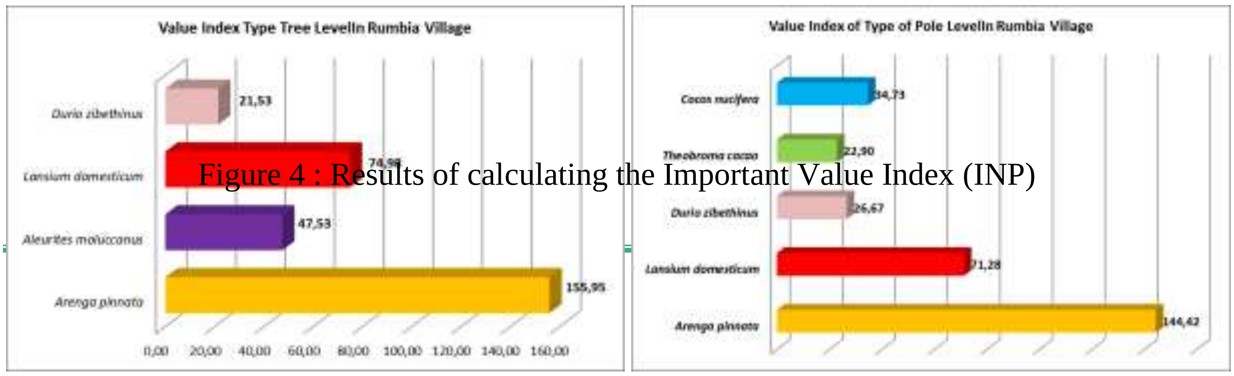

Figure 4 : Results of calculating the Important Value Index (INP)

In (Figure 4), it shows that the highest important value index at the tree level is the Aren (Arenga pinnata) with a value of 155.95. This is followed by the Langsat type (Lansium domesticum) 74.98, Candlenut (Aleurites moluccanus) 47.53, Durian (Durio zibethinus) 21.53. ThenThe highest important value index at the pole level is Aren (Arenga pinnata) which has a value of 144.42. Then followed by the Langsat type (Lansium domesticum) 71.28, Coconut (Cocos nucifera) 34.73, Durian (Durio zibethinus) 26.67, Chocolate (Theobroma cacao) 22.90.

According to Sharma et al., (2025) that dominant species (powerful) in a plant community will have a high importance value index, so that the most dominant species will have the largest importance value index. Types that obtain a high Importance Value Index (IVI) mean they have a greater cumulative value of control and are more in control of their habitat (Bayala et al., 2026). This type is superior in utilizing resources or can better adapt to the local environment.

CONCLUSION

Based on the results of the data analysis that has been carried out, there are 4 species at the tree level and 5 species at the pole level in the Ilengi Agroforestry in Rumbia. The highest important value at the tree level is Aren (Arenga pinnata) which has a value of 155.95, the lowestDurian (Durio zibethinus) 21.53.The highest important value index at the pole level is Aren (Arenga pinnata) which has a value of 144.42 and the lowestChocolate (Theobroma cacao) 22.90.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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