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Renewable Energy and Kaliandra Plant Utilization for Eco Edu Tourism

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keyword;
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ABSTRACT

This research investigates the multifaceted potential of Kaliandra plant cultivation beyond its established use as a renewable energy source for wood pellets. The study highlights Kaliandra's significant capacity to enhance local economic income through eco-tourism, emphasizing the strategic role of direct and indirect benefits in empowering local communities by involving them as eco-tourism actors. Furthermore, the research underscores Kaliandra's crucial contribution to reducing carbon emissions. By integrating Kaliandra cultivation with eco-tourism and educational initiatives, the study concludes that the "Eco Edu Wisata Kaliandra" business model holds substantial promise and warrants further development. Future research should focus on optimizing this integrated bioenergy and eco-tourism model through economic viability studies and synergistic management practices, delve deeper into community empowerment and socio-economic impacts, quantify additional environmental benefits, and explore the scalability and policy implications for broader adoption.

INTRODUCTION

The world faces a pressing global issue: the urgent need to transition from fossil fuels to sustainable energy sources while simultaneously fostering economic development and mitigating climate change impacts (Abbasi et al., 2024; Batra, 2023; Zhang, 2024). This challenge is exacerbated by a growing global population and increasing energy demands, leading to heightened greenhouse gas emissions and environmental degradation (Al-Shetwi, 2022; Singh & Singh, 2016; Wang & Azam, 2024). The pursuit of renewable energy is no longer merely an environmental concern but a critical component of global economic stability and social equity (Burke & Stephens, 2018).

Globally, biomass energy plays a crucial role in diversifying energy portfolios and reducing reliance on fossil fuels. According to the International Renewable Energy Agency (IRENA, 2023), bioenergy accounts for a significant portion of renewable energy consumption worldwide, offering a dispatchable and versatile energy source. However, the sustainable sourcing and utilization of biomass remain key considerations, necessitating approaches that minimize environmental impact and maximize socio-economic benefits.

In Indonesia, a nation with abundant biomass resources, there is a specific issue regarding the sustainable and multifaceted utilization of fast-growing tree species for both energy generation and local community development. While coal remains a dominant energy source, the potential of dedicated energy crops to supplement or replace it, particularly in a way that generates broader community benefits, is under-explored.

Previous research has extensively documented the versatility of *Calliandra calothyrsus*, commonly known as Kaliandra, as a multipurpose tree species. Studies have highlighted its rapid growth rate, ability to fix nitrogen and improve soil conditions, its use as animal feed, and its potential as a source of energy wood with high calorific value. For instance, Nurtjahyaningsih et al. (2016) discuss Kaliandra's recognition in Indonesia for greening and animal feed, while Siregar et al. (2017) identify it as an ideal energy crop. Research by Minarti S. Jaya et al (2016) also points to its suitability for honey bee cultivation. Economically, the conversion of Kaliandra wood into pellets significantly increases its market value, from Rp. 550,000 per ton for wood to Rp. 1.4 to 2.5 million per ton for pellets.

Despite the extensive research on Kaliandra's individual benefits, a significant research gap exists in developing and evaluating a comprehensive, integrated model that simultaneously leverages its potential for renewable energy production, eco-tourism, education, and holistic community empowerment. While some studies touch upon aspects like integrated farming, there is a lack of focus on a cohesive "Eco Edu Wisata" business model that combines these diverse applications into a single, sustainable framework.

The urgency of this research stems from the need to accelerate the transition to a green economy in regions like Indonesia, where sustainable land management and community-based enterprises can drive both environmental protection and economic growth. Developing a replicable and profitable model for Kaliandra eco-edu tourism provides a tangible pathway to achieve these intertwined goals, offering an alternative to purely extractive industries.

The novelty of this research lies in its proposition and preliminary assessment of the "Eco Edu Wisata Kaliandra" business model. This integrated approach is unique in its deliberate combination of Kaliandra cultivation for wood pellets (renewable energy), various integrated farming activities (dairy cows, laying hens, fish, rabbits, honey bees), carbon reduction initiatives, and educational/recreational tourism activities. This holistic framework for community empowerment and sustainable development goes beyond individual applications to create a synergistic system.

The primary purpose of this research is to demonstrate the substantial potential of the "Eco Edu Wisata Kaliandra" business as a viable and attractive model for sustainable development. It aims to show how a single plant species can be a cornerstone for generating renewable energy, increasing local income, empowering communities, and contributing to carbon emission reduction.

This research contributes a novel framework for local economic empowerment and sustainable resource management. By outlining the components and benefits of the "Eco Edu Wisata Kaliandra" model, it provides a blueprint for communities to diversify their income streams, enhance environmental stewardship, and engage in educational tourism.

The implications of this research are significant, extending to policy development and the scalability of integrated sustainable land-use models. A successful "Eco Edu Wisata Kaliandra" model could inform government policies on renewable energy, rural development, and eco-tourism, potentially leading to its replication in other suitable regions and contributing to national climate change mitigation targets.

METHOD

This research employs a qualitative research approach, drawing conclusions and suggestions based on the synthesis and interpretation of existing literature and the conceptualization of an integrated model. The study does not involve primary data collection through surveys or experiments. Instead, it relies on a comprehensive review of the characteristics and applications of Kaliandra plants, as detailed in various academic and technical reports.

The data population for this research consists of all available information and studies pertaining to *Calliandra calothyrsus* cultivation, its various uses (bioenergy, animal feed, soil improvement, honey production), and concepts related to eco-tourism and integrated farming. The data sample for this conceptual paper includes specific, relevant research articles, technical reports, and established knowledge on Kaliandra's biophysical requirements, growth patterns, yield, economic value, and ecological benefits. The sampling technique is purposive, selecting literature that directly supports the multi-faceted potential of Kaliandra and the proposed integrated eco-edu-tourism model.

The research instrument is the researcher's analytical framework, used to synthesize information from the collected literature. Validity and reliability are addressed through the rigorous selection of peer-reviewed articles and reputable organizational reports, ensuring that the foundational knowledge about Kaliandra is well-established and consistent across multiple sources. The data collection technique is primarily desk research, involving extensive literature review from academic databases and relevant publications. The procedure involves identifying key characteristics and applications of Kaliandra, analyzing their economic and environmental implications, and then conceptualizing how these diverse uses can be integrated into a sustainable eco-edu-tourism business. The research does not utilize specific software for data analysis beyond standard document processing tools, as it is a conceptual paper. The data analysis technique is qualitative content analysis, where information from various sources is critically reviewed, categorized, and synthesized to build the argument for the "Eco Edu Wisata Kaliandra" model and identify areas for future research.

RESULTS AND DISCUSSION

The Calliandra genus, part of the pea family (Leguminosae), encompasses approximately 200 species of medium-sized trees or shrubs characterized by their compound, arranged flowers. In Indonesia, Kaliandra Red Flowers (*Calliandra calothyrsus*) are widely recognized as beneficial for greening initiatives and as a source of animal feed (Nurtjahyaningsih, et al, 2016).

The Kaliandra plant is a woody shrub with a dense growth habit, capable of reaching heights of up to 25 meters. Its deep root system extends 1.5 to 2 meters into the ground (Amirta et al., 2016). describes kaliandra as a small, branched tree with a maximum trunk diameter of 20 cm, featuring red or gray bark that becomes jagged towards the top. Its root system comprises several taproots and numerous finer roots that spread near the surface. The leaves are soft and divided into small leaflets, with the main leaf reaching up to 20 cm in length and 15 cm in width. This resilient plant thrives in various soil types, tolerates pruning, flowers quickly, and grows densely. Notably, its roots form nodules that absorb nitrogen, enhancing soil fertility (Treasurer, J.R., 2001).

Indonesia is home to several Kaliandra species, including *C. calothyrsus* and *C. surinamensis*. While *C. surinamensis* is commonly cultivated as an ornamental plant around homes, *C. calothyrsus*, with its distinctive red flowers, originates from Mexico to Panama and has proven to be a highly versatile species in Indonesia (Stewart et al., 2001).

C. calothyrsus, often simply called Kaliandra, offers a multitude of uses. It serves as an energy wood source, animal feed, and is effective for erosion control. Its ability to fix nitrogen and

produce litter significantly improves soil conditions. Furthermore, it acts as a fire retardant, and its attractive flowers make it suitable for roadside decoration and as a valuable nectar source for bees (Rina, 2014).

C. calothyrsus is considered an ideal tree species for energy crops (Siregar et al., 2017). Its selection as a raw material for biomass energy is based on careful consideration of technical, ecological, and social factors relevant to its cultivation.

Several criteria underpin the choice of *C. calothyrsus* for various applications. It is easy to grow even on marginal land (Stewart et al., 2001), making it suitable for vacant or abandoned areas and land unsuitable for agriculture, potentially involving local communities (Bendahara, 2001). The species also demonstrates adaptability to diverse locations, climates, and growth conditions (Nurtjahyaningsih, et, al, 2016).

Cultivation of *C. calothyrsus* is straightforward, with easy regeneration and accessible seed sources, simplifying seedbed application (Nurtjayhayningsih et al, 2016). It can be harvested as early as two years old (Kaho et al., 2007). Its rapid growth and nitrogen fixation ability enable it to maintain and improve soil conditions due to its knotted roots (Nurtjahyaningsih, et al, 2016). The harvesting system is simple, combining harvest cycles and crop density with a coppicing (trubusan) system (Treasurer, J.R., 2001).

As a Multiple Purpose Tree Species (MPTS), *C. calothyrsus* provides firewood, improves soil conditions, serves as livestock feed, and presents opportunities for honey bee cultivation (Minarti et al., 2016). It possesses the ability to repair damaged land (Stewart et al., 2001) and exhibits high adaptability, thriving on damaged land and demonstrating resilience to forest fires, pests, and diseases (Akbar, 2017).

Furthermore, *C. calothyrsus* produces energy wood with a high calorific value (± 4000 Kcal) and minimal ash content (Rostiwati et al., 2006). Its flowers are particularly favored by honey bees, producing excellent kaliandra-type honey (Minarti et al., 2016). The flowers are also known as "angel flowers" due to their delicate and beautiful appearance (Rostiwati et al., 2006).

Economically, the selling price of *C. calothyrsus* wood is Rp. 550,000 per ton. When processed into pellets, the selling price significantly increases to Rp. 1.4 to 2.5 million per ton (Zakaria et al., 2013).





Species	Biophysical Requirements	Regeneration methods	Density/ Distance	Rotation	Growth/ yield	Reference
Calliandra	Altitude: 250-	Generative	Optimal	Every 1-2	35-65	Orwa and
Callothyrs	Annual average	and	is 1 x 2 m	Annual	15-40	al. (2009);
U.s.	22-28 degrees C,	Vegetative	with	Continue to	with harvest	Ecocrop.
	Annual Rainfall:		Minimum 1	10-20 years	Annual	FAO
	700-		x 1			
	4000 mm; Soil		m (for		for 10-20	
	Type:		wood		years;	
	Grows well on the		burn)		25 t/ha/th (di	
	range					
	wide soil type,				Indonesia);	
					39	
	but it is more in				t/ha/th (di	
	line with					
	Textured soil				Cameroon)	
	light, slightly					

	acidic.
	Tolerant of soil
	infertile and dense,
	or soil with aeration
	Bad but intolerant
	on the ground that
	waterlogged and dirty
	base

Source: Biomass for Energy Pre Feasibility Study, Danida, 2018

Although the market value of energy wood is several times lower than that of hardwood, there are a number of benefits associated with energy wood such as C.Calothyrsus, the main ones: 1) Higher productivity (t/ha/year) 2) It does not have to wait 20 -30 years to start earning income, and 3) it is more likely to combine the forestry side with the production of animal feed (leaves), and other ventures that benefit the local community (Siregar et al., 2017).

Timber harvest

The targeted timber yield can be produced in a relatively short time (crop rotation every 2-3 years), obtained through a trubusing system. The trubusan system is a method of obtaining repeated timber harvests by cutting tree trunks near the ground level and re-exploiting tree trunks derived from trubusan that grow back as new trunks through the trunk and roots when the trunk is cut down (Amirta et al., 2016). With a sprinkler system,

Biomass harvesting can be done every 1-3 years, and continues until the trees are 15-20 years old, at which time they have only been replanted. To obtain high biomass productivity, Calliandra or Gliricidia trees should be planted tightly, resulting in a tree population of 5,000-10,000 trees/ha (Stewart et al., 2001).

Species Tree	**Density/Planting distance**	**Firewood products**	**Source**
	5,000-40,000 trees/ha or	5-20 m3/ha/yr (medium fertile soil,	ICRAF 2015;
	1.5x2; 2x2.5 m (between rows	first harvest);	Wiersum then
Calliandra			
	wood);	35-65 m3/ha/th (good site,	Rick 1997;
Scarlett O'Neill			
	1 m x 1 m sd 1 m x 2 m; deep	Annual Distribution for 10-20	Wiersum then
	Planting rows	year). 15 - 40 tons/ha/yr (a year after planting, annual harvest continues for 10 - 20 years).	Rick 1992

Source : Biomass for Energy Pre Feasibility Study, Danida, 2018

Kaliandra Plants for Animal Feed

The use of Kaliandra in dairy cow rations has an impact on increasing milk production and farmers' profits. reported that giving 10 kg of Kaliandra leaves to dairy cows per day produced milk of 15.34 liters/day/head and the largest profit for dairy farmers (Daning & Foekh, 2018).

Meanwhile, in Kenya, giving 3 kg of fresh Kaliandra to dairy cows can replace 1 kg of concentrate containing 16% protein. The administration of Kaliandra as a substitute for concentrate varied depending on the place or environment, reporting on his research with five kinds of rations containing Kaliandra levels of 0, 5, 10, 15, 20 kg, the results showed that the milk production in each treatment was 12.87; 14,51; 15,84; 15.32 and 14.48 liters/head/day. The data provides an idea that the use of Kaliandra up to 20% as a ration component provides a response to increase milk production (Yatno et al., 2019).

Calliandra calothyrsus is also useful for the production of non-ruminant livestock. Although there is little information about its productivity level, there are reports from Vietnam that C. calothyrsus is used as fish feed in small ponds. The leaves can also be used as rabbit feed in limited quantities as a mixture of other feeds. Good results have been obtained from rabbits fed pellet food containing 30% dried C. calothyrsus leaves (Yatno et al., 2019).

The addition of a small amount of kaliandra leaves to the laying hen feed (0.6-2.5% of the staple food) will result in a more yellow color in the yolk without a negative effect on the amount of sludge produced or on the comparison of nutrient conversion (Paterson et. al.,. 2000; Vienna and Tangendjaja, personal communication).

Eco Edu Wisata Caliandra

Smallholder forests have potential carbon stocks and can play a role in climate change and also have implications for increasing people's incomes. The type of plant that is generally cultivated is a type of plant that has a long cycle, and no one has tried to cultivate a type of plant that grows quickly, such as the kaliandra plant (C. calothyrsus) which was developed to be used as wood

pellet. Kaliandra plants are multipurpose plants that are easy to grow on various types of soil and are tolerant of pruning, with many side shoots making the kaliandra terubusan faster to provide more effective land cover. Since 1937, kaliandra has been planted in Perhutani and the wider area along with the greening and support programs for firewood and animal feed. Another function of Kaliandra planting is as a boundary plant between forest areas and rural areas or agricultural land (Stewart et al., 2001).

Based on the multi-purpose Kalaindra plant, the author proposes that the cultivation of kaliandra can be integrated with other activities besides energy in the form of livestock activities (Integrated Farming), because from the roots of the twigs to the stems can be used as income (increasing economic value) which is very potential. In addition to integrated farming activities, it can also be realized as an educational tourism area in the form of kaliandra cultivation utilization for dairy cow farming, laying hens, fish feed, rabbits and honey bee cultivation, carbon reduction programs, the use of biogas from cattle farm waste into organic fertilizers both liquid and solids and the use of electrical energy from the biogas process and other educational recreational activities, So it can be termed the activity as Eco Edu Wisata Kaliandra.

ECO

(Ecology)

Utilizing Kaliandra wood as wood pellets as renewable energy for coal substitution in the cement industry/manufacture, textile, fertilizer, pulp/paper and as a co-firing of the State Power Plant (PLN) through its coal-fired power plants (Akbar, 2017). (Adang Rahmat et al, 2016)

Can reduce carbon emissions by planting green vegetation Kaliandra as a green stand People 's forests have the potential for carbon stocks and also for the industry by utilizing wood pellets as environmentally friendly burners while reducing CO2 in the industry (Haryana, 2018).

The use of biogas from cow manure that utilizes animal feed from kaliandra plants will produce electrical energy from the biodigester process that will be planned and also produce liquid and solid organic fertilizers (Rostiwati et al., 2006).

EDU

(Education)

Tourist visitors from both ordinary people and from school children and students can do direct practice on how to milk cows, raise fish and rabbits as well as harvest them, learn about the cultivation of kaliandra shrubs, honey bee cultivation and see the energy production process from Kaliandra plants and bio digesters from cow manure.

Tour

Taking advantage of the beautiful green natural environment, jogging in the production forest area, and camping in the forest are.

Eco Edu Tourism Area Kalaindra

The entire expanse of community forest is planned to cover an area of 30 hectares, consisting of Kalaindra plants and other perennials in the form of pine, and teak as shade covering an area of 23.5 hectares. Fisheries and livestock areas include for bio digester installations covering an area of 1.5 hectares, honey bee cultivation areas of 1.0 Ha, camping grounds 2Ha, commercial areas (Pendopo, Gubukan, restaurants, souvenirs, sidewalks, offices, warehouses, workshops, prayer rooms, toilets, and parking areas covering an area of 2 Ha.

CONCLUSION

The cultivation of Kaliandra plants offers substantial potential beyond its use in producing wood pellets for renewable energy. It can significantly boost local economies through eco-tourism and education (eco-edu tourism), involving local communities to create direct and indirect benefits. Furthermore, Kaliandra cultivation plays a vital role in reducing carbon emissions. Future research should focus on optimizing this integrated eco-edu-tourism and bioenergy model through economic viability studies and synergistic management practices, deeply exploring community empowerment by assessing livelihood impacts and governance models, quantifying environmental benefits via life cycle assessments and biodiversity impact studies, and examining scalability and policy implications for broader implementation.

REFERENCE

Abbasi, K. R., Zhang, Q., Ozturk, I., Alvarado, R., & Musa, M. (2024). Energy transition, fossil fuels, and green innovations: Paving the way to achieving sustainable development goals in the United States. *Gondwana Research*, *130*, 326–341.

Akbar, R. I. N. (2017). *Characteristics of Red Kaliandra Pellets (Calliandra calothyrus) as environmentally friendly fuel energy*. Bogor Agricultural University.

Al-Shetwi, A. Q. (2022). Sustainable development of renewable energy integrated power sector: Trends, environmental impacts, and recent challenges. *Science of The Total Environment*, *822*, 153645.

Amirta, R., Yuliansyah, Angi, E. M., Ananto, B. R., Setiyono, B., Haqiqi, M. T., Septiana, H. A., Lodong, M., & Oktavianto, R. N. (2016). Plant diversity and energy potential of people's forests in East Kalimantan, Indonesia: Searching for fast-growing timber species for energy production. *Nusantara Biosciences*, *8*(1), 22–31. https://doi.org/10.13057/nusbiosci/n080106

Batra, G. (2023). Renewable energy economics: achieving harmony between environmental protection and economic goals. *Social science chronicle*, *2*(2), 1–32.

Bendahara, J. R. (2001). *Calliandra calothyrsus is an agroforestry tree for humid tropics* (Vol. 40). United Kingdom.

Burke, M. J., & Stephens, J. C. (2018). Political power and renewable energy futures: A critical review. *Energy research & social science*, *35*, 78–93.

Daning, D. R., & Foekh, B. (2018). Evaluation of nutrient production and quality in the leaves and bark of Calliandra callotirsus and Gliricidia sepium. *Animal Science*, *16*(1), 7–11. https://doi.org/10.20961/sainspet.v16i1.14984

Haryana, A. (2018). Development of the use of biomass as renewable energy to achieve an optimal national energy mix. *Bappenas' Working Paper*, *1*(1), 55–65.

Kaho, F., Yemefack, M., Yongue-Fouateu, R., Kanmegne, J., & Bilong, P. (2007). The potential of Calliandra calothyrsus Meissner to improve soil fertility and corn performance in the transition zone of Cameroon's savannah forests. *Nigerian Journal of Soil and Environmental Research*, *7*(1), 33–44. https://doi.org/10.4314/njser.v7i1.28416

Minarti, S., Jaya, F., & Merlina, P. A. (2016). The effect of the harvest period of bee honey in the area of the kaliandra plant (Calliandra calothyrsus) on the amount of water content, viscosity and sugar content of honey. *Journal of Livestock Products Science and Technology*, *11*(1), 46–51. https://doi.org/10.21776/ub.jitek.2016.011.01.5

Rina, N. S. (2014). *Kaliandra honey bee favorite red flower nectar*.

Rostiwati, T., Heryati, Y., & Bustomi, S. (2006). *Review of the Results of R\&D of Energy Wood and Its Derivatives* (S. S. P. Priyono (ed.)). Center for Research and Development of Plantation Forests. Forestry Research and Development Agency.

Singh, R. L., & Singh, P. K. (2016). Global environmental problems. In *Principles and applications of environmental biotechnology for a sustainable future* (hal. 13–41). Springer.

Siregar, N. J., Narendra, B. H., Suryana, J., Siregar, C. A., & Weston, C. (2017). Evaluation of community tree plantations as a source of sustainable rural bioenergy in Indonesia. *IOP Conference Series: Earth and Environmental Sciences*, *65*, 12019. https://doi.org/10.1088/1755-1315/65/1/012019

Stewart, J., Mulawarman, Roshetko, J. M., & Powell, M. H. (2001). *Production and Utilization of Kaliandra (Calliandra calothyrsus): Field Guidelines*. International Agroforestry Research Center (ICRAF).

Wang, J., & Azam, W. (2024). Natural resource scarcity, fossil fuel energy consumption, and total greenhouse gas emissions in top emitting countries. *Geoscience frontiers*, *15*(2), 101757.

Yatno, Nelson, Murni, R., Suparjo, & Syarifa, H. L. (2019). Protein isolation and amino acid analysis of kaliandra leaf protein concentrate as an effort to provide animal feed supplements: the quality of amino acid protein concentrate from kaliandra leaf extraction. *Proceedings of the National Seminar: Sustainable Agriculture Development Based on Local Resources, Faculty of Agriculture, University of Jambi*, 699–707.

Zakaria, Z., Muslim, D., Sophian, R. I., Kuswaryan, S., & Tanuwiria, H. H. (2013). Bio-engineering, through the use of kaliandra plants (Caliandra calothyrsus) in the landslide-prone zone area of West Java. *Bulletin of Scientific Contributions*, *11*(3), 168–175. https://doi.org/10.24198/bsc geology.v11i3.8297

Zhang, J. (2024). Energy access challenge and the role of fossil fuels in meeting electricity demand: Promoting renewable energy capacity for sustainable development. *Geoscience Frontiers*, *15*(5), 101873.