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The Potential of Calliandra (Calliandra calothyrus) As Conservation Plants Based on Economic Analysis

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ABSTRACT

Kaliandra (Calliandra calothyrsus) is a leguminous plant native to Central America, belonging to the Fabaceae (Leguminosae) family. This plant is a multipurpose species known as a source of high-quality forage for livestock and mostly used for soil conservation. Therefore, Kaliandra is suitable for businesses in both plantation and livestock sectors. Primary data collection was conducted through field observations, captured in digital form (photos or images), and interviews with representative sources. Secondary data were obtained from literature reviews related to theories underlying the background and problem formulation, reviews of official documents or archives from the Seed Control Agency of the Department of Agriculture and Plantations in Aceh regarding the physical and non-physical data of the study objects, as well as journals, internet sources, and others. The financial feasibility analysis of the kaliandra business was conducted by calculating the Net Present Value (NPV), Net Benefit Cost Ratio (Net B/C), and Internal Rate of Return (IRR) using a discount factor of 10%. The results showed an NPV of IDR 416,538,245.51 (NPV > 0). Additionally, the B/C ratio was calculated to be 6.2 (B/C > 1), and the IRR was 12.3% (IRR > i). Based on these calculations, all evaluation criteria were met: NPV is positive, B/C is greater than 1, and IRR is 12.3%, which is higher than the Opportunity Cost of Capital of 10%. Thus, it can be concluded that the development of kaliandra (Calliandra calothyrsus) business is profitable and feasible.

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Introduction

Kaliandra (Calliandra calothyrsus) is a leguminous plant originating from Central America, belonging to the Fabaceae (Leguminosae) family. Kaliandra is an important plant for animal husbandry, as it can be used as an inexpensive and easily accessible source of protein for livestock. Additionally, this plant is very suitable for the development of energy plantations because its wood can be utilized as biomass for fuel (Siregar, 2006). According to Maulidani et al. (2024) which study on shoot root induction and plantlet acclimatization of Calliandra calothyrsus or red kaliandra, stated that this plant plays an important role in environmental conservation and agriculture. Furthermore, kaliandra has great potential in agroforestry systems, serving as a plant that functions as a source of biomass for energy, as well as high-quality livestock feed. Sofyan et al. (2023) demonstrated that supplementing goat feed with kaliandra leaves can improve feed utilization efficiency and daily weight gain. The optimal supplementation level was found to be 30% of the total ration. Whereas, Widodo et al. (2024) reported that kaliandra is potential as a biomass source

for bioenergy production. It was found that kaliandra has a high calorific value (approximately 4500 kcal/kg) and can be effectively used in small-scale biomass power plants. Kaliandra performed good climate change adaptation to extreme weather variations in several tropical countries (Johnson et al., 2023). Moreover, recent research conducted by Santoso et al. (2024) showed the successful integration of kaliandra in silvopastoral systems on dry lands. It was reported that there was a 25% increase in livestock productivity and significant improvement in soil quality. Based on the points mentioned above, it can be concluded that kaliandra can be an excellent choice for business ventures in both plantation and livestock farming.

A business project feasibility study is conducted to determine whether an investment project can be implemented and successful (Suad Husnan & Suwarsono, 2014). A business can be considered feasible if the financial feasibility meets the terms and conditions in its calculations. Financial feasibility analysis involves several important components such as: Initial financial point (investment), Operational Costs, Financial Benefits, and Assumptions (Kledo, 2024). A comprehensive financial feasibility analysis can increase a company's credibility in the eyes of investors. By presenting strong data and projections, companies can convince investors or lenders that the project is worthy of funding (Brigham & Ehrhardt, 2014). The main purpose of financial feasibility analysis is to assess the sustainability of investments and identify the potential for success or failure of an investment based on strong data and information.

This present study aims to analyze a business feasibility study on kaliandra plants, particularly focusing on the supply of high-quality livestock feed and kaliandra wood. This analysis helps avoid significant financial losses and helps direct resource allocation wisely. This research uses three types of financial feasibility analysis, namely: Net Present Value (NPV), Net Benefit Cost Ratio (Net B/C), and Internal Rate of Return (IRR).

Literature Review

Calliandra calothyrsus is recognized as a highly versatile species with multiple ecological and economic benefits. Its applications extend beyond energy production to include animal feed, soil and water conservation, fire prevention, ornamental planting, and honey production. As a nitrogen-fixing leguminous species, calliandra improves soil fertility through litter decomposition and natural nitrogen enrichment, making it an effective tool for sustainable land management and erosion control, particularly when planted along hill slopes where it naturally forms terrace-like structures (Hendrati et al., 2014). The species has also been successfully used in the rehabilitation of degraded and acid soils dominated by Imperata cylindrica, highlighting its ecological adaptability and role in land restoration programs. From an energy perspective, calliandra has gained international attention as a potential feedstock for wood pellets.

Hartono (2015) reported a growing demand in international markets, particularly in Europe and South Korea, for biomass derived from calliandra. Although Indonesia has yet to produce wood pellets on a large scale for export, several local industries in Java have already utilized them for production. Given its rapid growth characteristics, calliandra can be harvested annually with relatively high yields, offering a sustainable response to concerns over the scarcity of raw materials for wood pellet production. Consequently, ensuring a consistent supply of biomass feedstock has become one of the most critical factors for the success of calliandra as a renewable energy resource (Putri et al., 2014). Agronomically, calliandra also provides substantial benefits to intercropping systems. Kaho (2007) found that calliandra cultivation led to significant improvements in soil fertility and increased maize yields from the first year of planting onwards. Its moderate decomposition rate ensures a gradual release of nutrients, thereby benefiting subsequent crops. Nutritionally, calliandra leaves contain approximately 22% crude protein, 31% crude fiber, and 3.7% fat, with a potential to produce 10.4–16.6 tons/ha/year of fresh forage or 3.5–5.4 tons/ha/year of dry matter (Tanuwira et al., 2006). These properties make it highly suitable as a livestock feed supplement, especially in integrated farming systems.

In addition, calliandra plays a crucial role in supporting apiculture. Sila (1996) demonstrated that calliandra serves as an important nectar source for honeybees, with honey production in Indonesia increasing from 650 tons in 1989 to 1,300 tons in 1994. Farmers currently manage approximately 50,000 artificial beehives, with each hectare of calliandra cultivation estimated to produce up to one ton of honey annually. This has spurred significant interest among local communities and has inspired further research globally to evaluate the species' potential in improving soil quality, providing sustainable forage, and supporting rural livelihoods (Stewart et al., 2001).

Overall, the multifunctionality of Calliandra calothyrsus demonstrates its value as a multipurpose tree species capable of simultaneously delivering environmental services, energy security, and socio-economic benefits. This broad range of applications strengthens its attractiveness for feasibility studies, particularly in contexts that combine ecological restoration with bioenergy and rural enterprise development.

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Method

This study applies a qualitative-quantitative approach and is exploratory-evaluative in nature. The research design adopts and develops an applied research cycle (Larasati, 2019), which was adapted into five stages: **Practical Problem** (description and interpretation), **Diagnosis** (generalization and design), **Plan** (determining plans and objects), **Intervention** (action or process), and **Evaluation** (intervention).

Research Procedure

Primary data were collected through field observations, documented digitally (photographs and images), and interviews with representative informants. Secondary data were obtained from literature reviews (reference books) related to the theoretical background and problem formulation, as well as official documents and archives from the Seed Supervision Agency of the Department of Agriculture and Plantation of Aceh concerning both physical and non-physical aspects of the research object. Additional data were sourced from scientific journals, internet databases, and other relevant references.

Data Analysis

The financial feasibility of Caliandra cultivation was assessed using **Net Present Value (NPV)**, **Net Benefit-Cost Ratio (Net B/C ratio)**, and **Internal Rate of Return (IRR)**, applying a 10% discount factor. Financial analysis is a crucial aspect in business decision-making as it evaluates the viability of a project or investment. NPV measures the project's contribution to firm value, where projects with positive NPV are considered feasible (Brealey, Myers, & Allen, 2022). Meanwhile, IRR represents the discount rate that equates the project's NPV to zero, and a project is deemed feasible when the IRR exceeds the firm's cost of capital (Ross, Westerfield, & Jordan, 2018). In addition, the Net B/C ratio was calculated to provide a comparative assessment of alternative projects under consideration.

Results and Discussion

Financial Eligibility of Kaliandra Entrepreneurs

Analysis can be conducted after determining the management period based on rotation/cycle and the division of management plots. The planting pattern used is a monoculture system with an artificial regeneration strip cutting silviculture system. The management cycle is conducted over 5 years with a spacing of 1m x 2m on a scale of 5 hectares. The analysis yield good results if a detailed calculation of costs, both periodic and non-periodic, as well as the income from the Kaliandra management derived from seeds/pods and timber, has been performed. Financial feasibility analysis uses the parameters NPV, Net B/C, and IRR (Winarti et al., 2017). The following is the result of the financial calculation for Kaliandra plant management:

Investment Costs

Contemporary accounting experts define investment costs as capitalized expenditures, with the expectation of providing economic benefits over more than one accounting period. These costs include physical facilities, equipment costs, and seed costs. The construction of facilities and infrastructure aims to support the smooth execution of activities. The infrastructure includes workshops, greenhouses/nurseries, and work shelters. The equipment used consists of machetes, hoes, and pry bars, which are employed in land preparation, planting, and maintenance activities. The price of Kaliandra seedlings is Rp. 1,000/seed. The total seedling requirements to be planted are calculated based on the planting pattern and spacing used, plus an allocation for replanting of about 20% of the normal seedling requirements. The following is the formula used:

$$\text{Seed Requirements} = \frac{\text{Land Area}}{\text{Planting Distance}} + 20\%$$

The planting pattern used is a monoculture planting pattern, with a spacing of 2m x 1m and a land area of 5 hectares; thus, the number of seedlings required is 25,000 + 20% = 30,000 plants/ha. The details of the investment costs can be seen in the following Table 1:

Table 1. Investment Costs.

Variables		Costs
Physical Facilities	Workshop Construction	Rp. 2.000.000,-
	Nursery	Rp. 2.000.000,-
	Work Shelter	Rp. 1.500.000,-
Equipment	Equipment Procurement	Rp. 1.250.000,-
Seedlings	Seed Procurement	Rp. 30.000.000,-
Sum		Rp. 36.750.000,-

Operational Costs

Operational costs are expenses incurred to carry out the company's main business activities, which include labor and fertilizer. Labor is an essential factor in the management and development of Kaliandra plants because almost all activities are performed manually. Labor is needed for activities such as land clearing, hole digging, planting, replanting, weeding, fertilizing, protection, harvesting, and transportation. The unit cost used to calculate labor costs is Work Days, which refers to daily workers. The standard cost is Rp. 150,000/day, based on the Aceh Governor's Regulation No. 150 concerning the determination of unit work price standards in the Aceh government.

Therefore, it is assumed that land management costs per hectare amount is Rp. 750,000, while the costs for hole digging, planting, replanting, and pest control are each Rp. 600,000 per hectare. The weeding costs from year 1 to year 5 are Rp. 600,000 per hectare. Meanwhile, the costs for fertilizing and mound building from year zero to year five are Rp. 600,000 per hectare. The cost of purchasing petroganic fertilizer is Rp. 800/kg, and urea fertilizer is Rp. 2,250/kg, which will be needed from year 2 to year 5, with a 16% reduction in requirements. The following are the details of operational costs from year 0 to year 5:

Table 2. Operational Costs of Fertilizer Requirements for 5 Years

Fertilizer	Requirements (Kg)	Costs
Organic Fertilizer Application	90000	Rp 72,000,000.00
Urea Fertilizer Application	2250	Rp 5,062,500.00

Table 3. Details of Operational Costs over 5 Years

Operasional Cost	0	1	2	3	4	5
Land Clearing	Rp 3,750,000.00	Rp 3,750,000.00	Rp 3,750,000.00	Rp 3,750,000.00	Rp 3,750,000.00	Rp 3,750,000.00
Hole Digging	Rp 3,000,000.00	Rp -	Rp -	Rp -	Rp -	Rp -
Planting	Rp 3,000,000.00	Rp -	Rp -	Rp -	Rp -	Rp -
Gap Filling (replanting)	Rp 3,000,000.00	Rp -	Rp -	Rp -	Rp -	Rp -
Pest Control	Rp 3,000,000.00	Rp 3,000,000.00	Rp 3,000,000.00	Rp 3,000,000.00	Rp 3,000,000.00	Rp 3,000,000.00
Weeding	Rp -	Rp 3,000,000.00	Rp 3,000,000.00	Rp 3,000,000.00	Rp 3,000,000.00	Rp 3,000,000.00
Organic Fertilizer Application	Rp 72,000,000.00	Rp -	Rp -	Rp -	Rp -	Rp -
Urea Fertilizer Application	Rp -	Rp -	Rp 1,687,500.00	Rp 1,406,250.00	Rp 1,125,000.00	Rp 843,750.00

Income

Kaliandra is known for its fast growth, reaching a height of 2-3 meters within one year. At 6 months, it reaches a height of 2.5–3.5 meters, and in the first year, it can grow up to 3–5 meters on suitable land. As a raw material for wood pellets, kaliandra can be harvested at the age of 1 year. Afterward, new shoots that emerge from the cut stems can be harvested 6 months later and so on, allowing for harvesting every 6 months. At 1 year of age, kaliandra can produce 5–20 m^3/ha of wood, and at 20 years old, it can produce 30–60 m^3/ha of wood per year (Bernando, 2022). It is assumed that a kaliandra plantation with a population of 30,000 trees on a 5-hectare plot and a management period of 5 years, with each tree producing around 5 kg of wood per tree, would yield a total of 150 tons of wood per harvest. This is consistent with ICRAF's 2015 research, which stated that red kaliandra wood yields 5–20 m^3/ha in the first year of harvest on moderately fertile soil, and on a good site, the shoots can yield 35–65 m^3/ha in a year. Meanwhile, research by Wiersum & Rika (1997) indicated that one year after the initial harvest, the annual shoots of

kaliandra wood would yield 15–40 tons/ha in one year. Research by Orwa et al. (2009) reported that kaliandra wood biomass produces 30–54 tons/ha in one year, with a specific gravity of 0.55–0.7, and generates heat energy of 4,200 kcal/kg (Herdiawan et al., 2005).

Based on the above information, it can be assumed that the wood production of kaliandra for the first to fifth year is 165, 215, 280, 195, and 80 tons/ha/year, respectively, with a price of Rp. 800,000/ton. Kaliandra seeds are found in pods, with a pod length of 5-7.5 cm, and each stem contains 2-9 pods, with each pod containing 3-7 seeds. There are approximately 19,000 seeds per kg (Allen & Allen, 1982; Neal, 1965). It is assumed that if each tree produces 6 pods, with each pod containing 5 seeds, the total number of seeds produced from 30,000 kaliandra trees would be 47.5 kg in the first year. Therefore, the seed production for the second to fifth year would be 130, 165, 215, 170, and 140 kg, respectively, with a price of Rp. 70,000/kg. In addition, a financial analysis of kaliandra wood and pod production is analyzed using the cash flow analysis method from discounted costs and revenues. The interest rate used is 10%.

The following table contains data on revenue and profit, presented in Table 4.

Table 4. Data on Revenue and Profit

Thn	Cost	Benefit	Net Benefit	DF (10%)	PV (10%)
0	Rp 124,500,000.00	Rp 3,325,000.00	-Rp 121,175,000.00	1	Rp 124,500,000.00
1	Rp 9,750,000.00	Rp 141,100,000.00	Rp 131,350,000.00	0.91	Rp 8,863,636.36
2	Rp 11,437,500.00	Rp 183,550,000.00	Rp 172,112,500.00	0.83	Rp 9,452,479.34
3	Rp 11,156,250.00	Rp 239,050,000.00	Rp 227,893,750.00	0.75	Rp 8,381,855.75
4	Rp 10,875,000.00	Rp 167,900,000.00	Rp 157,025,000.00	0.68	Rp 7,427,771.33
5	Rp 10,593,750.00	Rp 73,800,000.00	Rp 63,206,250.00	0.62	Rp 6,577,885.27

DISCUSSION

The financial feasibility analysis of Calliandra calothyrsus cultivation demonstrates a promising outlook for its development as both a commercial crop and a renewable energy resource. The results reveal that the required initial investment, operational costs, and projected revenues align with international benchmarks for sustainable biomass production systems. By examining both costs and benefits over a five-year management cycle, the analysis highlights the economic advantages of calliandra while also underscoring areas where efficiency gains may be possible.

Investment and Operational Costs

The total investment of IDR 36,750,000 covers the construction of supporting facilities, procurement of equipment, and seedling acquisition. Although this amount may appear relatively high for smallholder farmers, it is modest compared to other perennial plantation crops such as oil palm or rubber, where establishment costs are substantially higher. Investment in basic infrastructure, such as nurseries and work shelters, plays a crucial role in ensuring operational efficiency and reducing risks associated with environmental exposure. Operational costs, on the other hand, are dominated by labor expenses, reflecting the manual nature of silvicultural practices in Aceh. Land preparation, planting, replanting, weeding, fertilization, and harvesting all require significant human resources, with labor costs calculated based on standard daily wages regulated by the provincial government. Fertilizer expenditures also represent a recurring cost, though their proportion relative to labor costs remains moderate. This cost structure suggests that efficiency improvements in labor organization, mechanization of selected processes, or the introduction of community-based cooperative management could further improve profitability.

Main Revenue: Wood Biomass

The primary source of revenue from calliandra cultivation is derived from wood biomass production. Calliandra's rapid growth rate allows for harvestable yields as early as one year after planting, with subsequent harvests possible every six months due to its coppicing ability. The yield estimates obtained in this study-ranging from 165 tons/ha in the first year to a peak of 280 tons/ha in the third year-fall within the range reported by previous studies (Orwa et al., 2009; Wiersum & Rika, 1997; Bernando, 2022). This confirms the species' capacity to generate large volumes of biomass under relatively short rotations, making it a highly suitable raw material for wood pellets and other forms of bioenergy production. The market value of wood biomass, calculated at IDR 800,000 per ton, provides substantial revenue streams that comfortably offset both investment and operational costs. This reinforces the role of calliandra as a high-

yield, fast-return forestry crop, capable of contributing not only to household income but also to regional energy security strategies.

Supplementary Income: Seed Production

In addition to wood production, calliandra generates supplementary income from seed production. Although the volume of seeds is relatively small compared to biomass output, their market value (IDR 70,000/kg) enhances the overall profitability of the plantation. The results show that annual seed yields range from 47.5 kg in the first year to as high as 215 kg in subsequent years, depending on tree maturity and pod production rates. These findings are consistent with Allen & Allen (1982) and Neal (1965), who documented the seed-bearing potential of the species. While secondary in nature, seed income contributes to financial stability, particularly during years of lower biomass yield. It also provides opportunities for value chain diversification, such as seed trade for reforestation projects, community-based nurseries, or even export markets for biofuel crop development.

Financial Indicators: NPV, IRR, and Net B/C

The combined analysis of investment, operational costs, and revenue demonstrates that calliandra cultivation is financially viable. The Net Present Value (NPV) is positive under a 10% discount rate, indicating that the project contributes economic value beyond the cost of capital. The Internal Rate of Return (IRR) exceeds the applied discount rate, fulfilling one of the primary criteria for investment feasibility (Ross, Westerfield, & Jordan, 2018). Moreover, the Net Benefit-Cost (Net B/C) ratio surpasses 1, further reinforcing the profitability of the venture and confirming that the benefits outweigh the costs across the management cycle. These results are in line with the findings of Winarti et al. (2017), who also reported strong financial indicators in bioenergy crop feasibility studies.

Broader Implications and Literature Comparison

The results of this study position Calliandra calothyrsus as an attractive option for bioenergy development in Indonesia and beyond. Compared with traditional plantation crops, calliandra offers shorter rotation cycles, lower establishment costs, and multiple streams of revenue, making it well-suited for smallholder adoption. Its financial viability also aligns with global trends in renewable energy investments, where multipurpose tree species are increasingly valued for their ability to provide biomass while simultaneously supporting soil fertility, carbon sequestration, and rural livelihoods (Herdiawan et al., 2005). Nevertheless, the reliance on manual labor in the current production system highlights the need for strategic interventions. Introducing cooperative labor schemes, enhancing silvicultural practices, and facilitating access to micro-financing could significantly increase adoption among small-scale farmers. From a policy perspective, government support in the form of subsidies, technical extension services, and guaranteed purchase agreements for biomass could accelerate the scaling up of calliandra cultivation.

Conclusion

The financial analysis of Calliandra calothyrsus cultivation demonstrates that this species is both technically feasible and economically viable under a five-hectare silvicultural management system. The investment and operational costs, although significant in the initial stages, are outweighed by revenues generated from biomass and seed production. The ability of calliandra to provide multiple streams of income-primarily from wood biomass and secondarily from seeds-ensures financial resilience and enhances the attractiveness of this crop for smallholder farmers and local investors. Key financial indicators, including a positive Net Present Value (NPV), an Internal Rate of Return (IRR) exceeding the discount rate, and a Net Benefit-Cost ratio (Net B/C) greater than one, confirm the profitability of calliandra cultivation. These findings are consistent with previous studies on bioenergy crops, reinforcing the potential of calliandra as a renewable energy source and a driver of rural economic development. Beyond financial viability, calliandra presents broader benefits by contributing to sustainable land management, renewable energy production, and poverty alleviation in rural areas. However, the heavy reliance on manual labor suggests that improvements in cooperative management systems, mechanization, and government support are necessary to optimize efficiency and promote wider adoption. In conclusion, Calliandra calothyrsus cultivation offers a promising opportunity for integrating economic, social, and environmental objectives. It can serve as a strategic commodity for advancing bioenergy initiatives, supporting local livelihoods, and

fostering sustainable rural development. Future research should focus on scaling up production, improving silvicultural practices, and evaluating long-term ecological impacts to strengthen its role in renewable energy strategies and policy frameworks.

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