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Feasibility of utilization of eucalyptus leaves (*Eucalyptus spp*) from logging waste in industrial plantation forests to produce essential oils

A Purwoko^{1*}, I Azhar¹, S E Damanik² and W B N E Taufik¹

¹Forestry Study Program, Faculty of Forestry, Universitas Sumatera Utara, Medan, North Sumatra, Indonesia 20155.

²Faculty of Agriculture, Universitas Simalungun, Simalungun, Indonesia.

E-mail: *agus9@usu.ac.id

Abstract. Eucalyptus is a type of industrial plantation forest (HTI) tree that has high economic value. Almost all parts of eucalyptus can be used. In addition, wood can be used as raw material for pulp, leaves and twigs containing cineol can be used as raw material for essential oils. This study aims to analyze the feasibility of using eucalyptus leaves from a financial perspective for essential oil production in the plantation forest area of PT. Toba Pulp Lestari Tbk. The analytical method used is descriptive analysis, financial analysis with two selling price scenarios, namely the high target scenario and the low target scenario with the criteria of Net Present Value (NPV), Benefit Cost Ratio (BCR), and Internal Rate of Return (IRR). The results showed that the use of eucalyptus leaves as a raw material for essential oils from logging waste in plantation forest areas is financially feasible. With details of the high target scenario, it produces an NPV value of IDR 134,903,510,450 (USD 8,895,714.5), an IRR value of 33.01% and a BCR value of 3.76. The NPV value for the low target scenario is IDR 84,029,947,498 (USD 5,541,045), the IRR value is 21.90% and the BCR value is 2.72.

1. Introduction

Forest products are divided into two main categories, namely timber, and non-timber. Non-timber forest products (NTFPs). are native biological products other than wood taken from forests, timberland, and trees [1]. One of the non-timber forest products is essential oils [2,3]. Eucalyptus plants are one of the plants developed in the cultivation of industrial plantation forests. Eucalyptus is commonly found in industrial plantation forest areas, for example in industrial plantation forest areas of PT. Toba Pulp Lestari (TPL) Tbk. in North Sumatra [4]. So far, industrial plantation forest (HTI) companies that grow eucalyptus species in Indonesia still prioritize wood forest products in the form of fiber as raw materials for pulp dan crayon. The potential of the commodity developed, namely, eucalyptus is not only from wood but also from leaves containing essential oils. Forest products in the form of essential oils can have a fairly high economic value, especially during the Covid-19 pandemic, eucalyptus oil is needed as one of the natural remedies for prevention and control [5,6].

Through testing the potential of raw materials and essential oil rendements contained in eucalyptus, the level of business feasibility for companies to develop essential oils as forest products can be found. The purpose of this study was to analyze the financial feasibility of processing essential oils from the use of eucalyptus leaves of logging waste in industrial plantation forest areas. The results of this study



can be a policy reference for companies to able to develop various models of the utilization of eucalyptus leaf waste in logging areas to be processed into essential oils.

2. Materials and methods

This research was carried out in the area of PT. Toba Pulp Lestari Tbk sector Aek Nauli, North Sumatra Province, Indonesia. Testing and data processing were carried out at the Integrated Forest Management Laboratory, Faculty of Forestry, University of North Sumatra. This research was conducted together with other aspects of research, namely the analysis of the potential raw materials for eucalyptus leaf waste from logging and the amendment of essential oils from eucalyptus leaves.

2.1. Research equipment and materials

The equipment used in this study is digital cameras for documentation of research objects, field survey equipment, scales, distillation equipment, and computer devices for processing data. The materials used are raw material potential data, oil amendment data, time series data on the area of harvesting, data on all costs of production inputs, and related literature studies

2.2. Data collection techniques

Data collection techniques carried out in the field are calculating the potential of raw materials through the collection and weighing of leaf samples, calculation of essential oil rendement through laboratory testing, field observations, interviews, and secondary reference tracing.

2.3. Data analysis

This study used descriptive analysis and financial analysis. Descriptive analysis is used to find out and analyze the data collected from interview results and under reference search results expressed in the form of a table (tabulation) consisting of investment costs and operational costs. Financial feasibility analysis by calculating the amount of Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR) using the following formula [7-9].

a. Net present value (NPV)

The analysis used to measure the profitability of a long-term investment in agricultural activities is NPV, which is the difference between the value of benefits and the value of costs over a certain period at the specified interest rate.

$$NPV = \sum_{t=0}^{t=n} \frac{B_t - C_t}{(1+i)^t} \quad (1)$$

Description:

NPV = Net present value
 Bt = Benefit (cash inflow in the t-period)
 Ct = Cost/total cost
 i = Interest (the prevailing bank interest rate)
 t = Time period

b. Internal rate of retrain (IRR)

The IRR is a parameter that shows how much one investment can provide a large profit from the general interest rate as an indicator that the investment is quite profitable.

$$IRR = i^1 + (i_2 - i_1) \frac{NPV_1}{NPV_1 - NPV_2} \quad (2)$$

Information:

IRR = The maximum interest rate that a project can pay.

NPV₁ = A positive NPV value at a certain interest rate.

NPV₂ = A negative NPV value at a certain interest rate.

i₁ = The first discount factor (interest rate) where a positive NPV is obtained.

i₂ = The second discount factor (interest rate) where a negative NPV is obtained.

c. Benefit cost ratio (BCR)

The Benefit Cost ratio (BCR) is a comparison between the value of benefits and the cost value of an investment at a predetermined interest rate.

$$BCR = \frac{B_t}{C_t} \quad (3)$$

Information:

BCR = Comparison between income and expenses

B_t = Benefit (t-period cash inflow)

C_t = Cost/total cost

3. Results and discussion

In planning a project, several assumptions are needed in making cost calculations. In the case of the eucalyptus oil refining business in PT. Toba Pulp Lestari Tbk, some of the assumptions used include: basic assumptions, physical analysis, cost analysis, depreciation, production projections, cost projections, and profit and loss projections. Some of these assumptions are used to make it easier to calculate the financial feasibility used, including Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit Cost Ratio (BCR).

3.1. Potential raw materials for eucalyptus leaves

Raw materials are materials or elements that have not been processed and will be made into a product and will be used in the manufacturing stage to be processed into finished goods [10,11]. In this study, what is intended with raw materials is eucalyptus leaves. The potential of eucalyptus leaf raw materials in the plantation forest concession area is quite potential if utilized in the manufacture of essential oils considering the company's fairly large concession area of 188,564 ha [12].

Table 1. Potential raw materials for eucalyptus leaves.

Year	Land (ha)	Raw material volume	
		Tree (unit)	Leaves (kg)
2010	8,492	14,156,164	101,075,010
2011	10,525	17,545,175	125,272,549
2012	9,527	15,881,509	113,393,974
2013	24,081	40,143,027	286,621,212
2014	16,190	26,988,730	192,699,532
2015	16,219	27,037,073	193,044,701
2016	10,994	18,326,998	130,854,765
2017	17,814	29,695,938	212,028,997
2018	11,998	20,000,666	142,804,755
2019	15,043	25,076,681	179,047,502
Total	140,883	234,851,961	1,676,843,002
Average		23,485,196.1	167,684,300.2

The average weight of eucalyptus leaf waste is 7.14 kg/tree [13]. The potential of raw materials that can be processed into eucalyptus oil refers to the harvesting plan data based on the HTI PT Timber Forest Product Utilization Business Plan (RKUPHHK). Toba Pulp Lestari Tbk, for a period of ten years, is seen in Table 1.

Based on Table 1, data on the potential of raw materials for 10 years can be seen in PT. Toba Pulp Lestari Tbk. The amount of potential of raw materials is greatly influenced by the area of land to be harvested. The wider the land harvested, the more raw materials for eucalyptus leaves can be produced. The average potential raw material for eucalyptus leaves produced is 167,684,300.2 kg/year.

3.2. *Eucalyptus oil rendement*

The yield of eucalyptus oil obtained from the results of this study was determined by the comparative value between the weight of the oil obtained from the distillation results and the weight of the distilled sample. Distillation on various varieties/eucalyptus clones derived from PT. Toba Pulp Lestari Tbk obtained an average rendement of 0.16% with an oil-specific gravity of 0.98035 [13]. The yield on *Eucalyptus spp* leaves is 0.16% [14]. Data on the amendment of eucalyptus oil that can be produced by PT. Toba Pulp Lestari Tbk can be seen in Table 2.

Table 2. Eucalyptus oil rendement.

Year	Leaf raw materials (kg)	Oil production potential	
		(kg)	(l)
2010	101,075,010	161,720	164,961
2011	125,272,549	200,436	204,453
2012	113,393,974	181,430	185,066
2013	286,621,212	458,594	467,785
2014	192,699,532	308,319	314,499
2015	193,044,701	308,872	315,062
2016	154,659,525	209,368	213,564
2017	212,028,997	339,246	346,046
2018	142,804,755	228,488	233,067
2019	179,047,502	286,476	292,218
Total	1,676,843,002	2,682,949	2,736,725
Average	167,684,300.2	268,294.9	273,672.5

Based on Table 2, it can be seen that the average potential yield of eucalyptus oil at the study site was 273,672.5 liters/year. The amount of essential oil yield produced is influenced by several factors. Several factors affect the yield and quality of eucalyptus oil, including the way it is refined, the environment in which it grows, the time of picking the material, and the handling of the material before distillation [15].

3.3. *Details of eucalyptus oil processing costs*

Details of the costs that must be incurred if PT. Toba Pulp Lestari Tbk, utilizing eucalyptus leaves in essential oils, is broadly distinguished by investment costs and operational costs.

3.3.1. Investment costs. Investment costs are costs incurred at the beginning of a project or basic costs used in starting a business that is incurred at the beginning of the investment and is only incurred once in a project. The details of investment costs can be seen in Table 3.

Table 3. Investment cost.

Nu.	Description	Unit	Volume	Unit price (IDR)	Amount (IDR)	Economic age (years)
1	Land	Ha	2	250,000,000	500,000,000	-
2	Factory	Unit	1	5,100,000,000	5,100,000,000	20
3	Warehouse	Unit	1	1,020,000,000	1,020,000,000	20
4	Office	Unit	1	500,000,000	500,000,000	20
5	Distillation equipment	Unit	320	129,000,000	41,280,000,000	15
6	Packaging equipment	Unit	5	25,000,000	125,000,000	10
7	Scales	Unit	4	2,500,000	10,000,000	5
8	Office supplies	Package	1	150,000,000	150,000,000	5
9	Other fixed assets	Package	1	75,000,000	75,000,000	5
Total					48,760,000,000	

3.3.2. *Operational costs.* Operational costs are costs incurred so that the production process of eucalyptus oil refining continues. Operating costs consist of fixed costs and variable costs. The operational costs consisting of fixed costs and variable costs can be seen in Table 4 and Table 5 below.

Table 4. Fixed cost per year.

Nu.	Description	Amount (IDR)
1	Salary of permanent employees	2,639,712,000
2	Office administration supplies	120,000,000
3	Electricity, telephone and internet costs	180,000,000
4	Transportation costs	412,500,000
5	Machinery and building maintenance	300,000,000
6	Depreciation	3,142,500,000
7	Promotion	1,800,000,000
8	Public relations	600,000,000
Total		9,194,712,000

The fixed costs of this refining business are costs that are not affected by the volume of eucalyptus oil production and in this analysis are assumed to be fixed annually. This means that the volume of raw materials to be produced will not affect the magnitude of the value of fixed costs. While the description of variable costs can be seen in Table 5.

Table 5. Average variable costs per year.

Nu.	Description	Amount (IDR)
1	Raw materials	110,783,427,800
2	Refining operator wages	731,528,400
3	Fuel	20,414,744,000
4	Water	191,388,300
5	Packaging	890,995,400
Total		266,024,167,800

Variable costs are costing whose magnitude is influenced by changes in the volume of eucalyptus oil production. This means that the more volume of raw materials that will be produced, the greater the costs that will be incurred. Conversely, the less volume of raw materials to be produced, the smaller the costs that will be incurred.

3.4. *Eucalyptus oil sales price assumptions*

Eucalyptus oil is a type of essential oil that is still developing in Indonesia, unlike patchouli oil, eucalyptus oil, agarwood oil and others that already have a fairly developed industry in Indonesia. Based on the secondary reference search conducted, the selling price data of eucalyptus oil was obtained as follows.

Table 6. Eucalyptus oil selling price at distributor [16].

No	Unit (liter)	Price (IDR)
1	0.025	50,000
2	0.1	180,000
3	1	750,000

The price above is the sales price from the distributor level to consumers. In this study, two price scenarios were used, namely scenario I (high yield, 10 percent discount from the distributor's initial price) and scenario II (low yield, 15 percent discount from the distributor's initial price). Based on the price cuts made, data on the selling price of eucalyptus oil were obtained as follows.

Table 7. Selling price of eucalyptus oil at the producer level.

Nu	Unit (liter)	Distributor Starting Price (IDR)	Price After Deduction 10% (IDR)	Price After Deduction 15% (IDR)
1	0.025	50,000	45,000	42,500
2	0.1	180,000	162,000	153,500
3	1	750,000	675,000	637,500

The price above is a direct sales price at the producer level which is considered more affordable to the market. Affordability is the actual price of a product paid by the customer [17]. Customers tend to look at the final price and decide whether to receive a good value as expected.

3.5. *Financial feasibility analysis of eucalyptus oil refining*

An effort is made to obtain the maximum possible profit. Therefore, business planning must take into account whether the business can bring profit or not. The size of the profit value is determined by the production results and the selling price. For this reason, every effort that will be made needs to be analyzed how much benefit is obtained, the costs incurred, the amount of profit and the period of how long the investment can return. This is done to find out whether a business has the feasibility of being a useful business. To find out that, it is necessary to conduct a financial analysis.

3.5.1. *Financial analysis scenario I (at a 10 Percent Discount from the Distributor's Selling Price).*

Financial feasibility analysis is seen from the criteria for the value of NPV, IRR and BCR. Based on the calculation results of the three criteria, with a discount of 10 percent, the results of the financial analysis were obtained as follows.

Table 8. Scenario I financial analysis results (high yields).

Criterion	Yield
Net present value (IDR)	134,903,510,450
Internal rate of return (%)	33.01
Benefit cost ratio	3.76

Based on the financial analysis above, it can be seen that if the eucalyptus oil refining business is cultivated by the HTI management company, it will obtain a Net Present Value (NPV>0) of IDR

134,903,510,450 (equivalent to USD 8,895,714.5). This figure shows that the net benefit received from the eucalyptus oil refining business by the company during the life of the project (10 years) is at the applicable interest rate (discount rate) of 10.5%. This result also shows that this eucalyptus oil refining business is also still worth cultivating [18].

Another criterion analyzed was the Internal Rate of return. The IRR value obtained from the analysis carried out was 33.01 percent where the IRR was greater than the applicable discount rate of 10.5 percent. The IRR value shows the project's internal rate of return of 33.01 percent and because of the $IRR > 33.01$ percent, this business is feasible and profitable [19]. In addition to NPV and IRR another criterion analyzed was the Benefit Cost Ratio. The BCR value obtained is greater than 1 ($BCR > 1$) which is 3.76 which states that the eucalyptus oil refining business in PT. Toba Pulp Lestari Tbk, this is worth the effort. The BCR value is equal to 3.76 meaning that every IDR. 1,- spent during the life of the project produces IDR 3.76,- net benefit units [20,21].

Based on the three criteria above, with a 10 percent discount, the business of utilizing eucalyptus leaf waste from logging in the HTI area is feasible to be cultivated. This means that if the business is carried out, in addition to being able to take advantage of the wasted waste, it will also provide financial benefits for the company.

3.5.2. Financial analysis scenario II (at a 15 Percent Discount from the Distributor's Selling Price).

The financial analysis of the second scenario was carried out because there was no definite reference regarding the rebates on essential oils at the producer level. Based on the results of calculating the value of NPV, IRR, and BCR with a discount of 15 percent, the results of the financial analysis were obtained as follows.

Table 9. Scenario II financial analysis results (low yield).

Number	Criterion	Yield
1	Net present value (IDR)	84,029,947,498
2	Internal rate of return (%)	21.90
3	Benefit cost ratio	2.72

Based on Table 9, it can be seen that the Net Present Value ($NPV > 0$) is IDR 84,029,947,498 (equivalent to USD 5,541,045). This value shows that the net benefit received from the eucalyptus oil refining business by the HTI management company during the life of the project (10 years) is at the applicable interest rate (discount rate) of 10.5 percent. These results show that this eucalyptus oil refining business is worth cultivating [18].

The IRR value obtained from the analysis carried out was 21.90 percent where the IRR was greater than the applicable discount rate of 10.5 percent. The IRR value shows the project's internal rate of return of 21.90 percent and because of the $IRR > 21.90$ percent, this business is feasible and profitable [19]. The BCR value obtained is greater than 1 ($BCR > 1$) which is 2.72 which states that the eucalyptus oil refining business in PT. Toba Pulp Lestari Tbk, this is worth the effort. The BCR value is equal to 2.72 meaning that every IDR 1 spent during the life of the project produces IDR 2.72 net benefit units [20,21].

Based on the analysis of the two scenarios above, the effort to utilize eucalyptus leaf waste in PT. Toba Pulp Lestari is feasible to implement, both with a 10 percent and 15 percent discount. The 15 percent rebate is already considered high enough for the sale of essential oils, so the business can be recommended to be carried out because it provides a profit. The results of the financial analysis are an indicator of the capital invested, namely the comparison between the total benefits received and the total costs incurred in the form of present value during the economic life of the project [22]. If the calculation results have shown feasible, the implementation will rarely fail.

4. Conclusion

Based on the results of the three financial analyzes using the NPV, IRR and BCR criteria and using two selling price scenarios, namely scenario I (high yield, 10% discount) and scenario II (low yield, 15% discount), the eucalyptus oil refining business in PT. Toba Pulp Lestari Tbk (TPL) meets the "feasible" criteria for implementation. In scenario I, the Net Present Value (NPV) is IDR 134,903,510,450 (USD 8,895,714.5), the Internal Rate of Return (IRR) is 33.01%, and the Benefit Cost Ratio (BCR) is 3.76. In scenario II, the Net Present Value (NPV) is IDR 84,029,947,498 (USD 5,541,045), the Internal Rate of Return (IRR) is 21.90%, and the Benefit Cost Ratio (BCR) is 2.72. Therefore, TPL as a company that owns HTI concessions must prepare policies, technologies, and alternative models for utilizing eucalyptus leaves from logging waste to be processed into essential oils as an additional product of industrial plantation forests.

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