Financial Analysis of Arabica Coffee Cultivation of Agroforestry Systems in Lembang Bokin, North Toraja Indonesia

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ABSTRACT
Toraja is a centre for a coffee product in South Sulawesi. One of the most famous species is Arabica, one of the national superior-commodities with a high economic value. Given the demand for coffee, Arabica coffee needs to develop the plantation of Arabica coffee in particular. Therefore, it is crucial to analyze the financial feasibility of Arabica coffee for each type of shade. This research was conducted in some cultivated areas of Arabica coffee in Lembang Bokin, North Toraja. It is located at ± 1,237 meters above sea level, and it has coordinates of 03°01'04,7" – 03°01'45,2"N and 119°59'44,9" – 120°00'03,8"S. The study was aimed to analyze the financial feasibility of Arabica coffee cultivation with a combination of *Leucaena glauca* and *Calliandra calothyrsus* and *Elmerrellia ovalis* (agroforestry models) by calculating: (i) the Net Present Value (NPV); (ii) the Net Benefit-Cost Ratio (Net B/C) and (iii)) Internal Return Rate (IRR). The financial analysis of Arabica coffee under combination *Leucaena glauca* and *Calliandra Calothyrsus* was at an interest rate of 10%. The financial analysis result suggests that the production of Arabica coffee shaded by Leucaena glauca and *Calliandra calothyrsus* was feasible because financial analysis showed a positive NPV value B/C>1, and IRR value (greater than MAR value =10%). On the other hand, the Arabica coffee shaded by *Elmerrellia ovalis* was not economically feasible because it gave a negative NPV value and Net B/C <1, IRR less than the MAR value of 5.4%.

Keywords: *Agroforestry, Arabica Coffee cultivation, financial feasibility analysis*

1. INTRODUCTION

The plantation commodity sectors have significant roles in the economic growth of a country worldwide. Coffee is one of the plantation commodity exports, which gives considerable benefits to farmers, employers, and governments in terms of income and foreign exchange; and affects global aspects, including economy, ecology, and social sectors. Besides, the coffee plantation can also support the development of regional and agro-industry in Indonesia. Lembang Bokin in North Toraja is one of the districts located in South Sulawesi Province with the abundant natural resources of coffee types. It is also best known as the center of coffee plantation, for Arabica and Robusta type, which is intensively developed by local farmers, foreign and domestic industries.

Quantitative data on Arabica coffee cultivation using an agroforestry system is needed to stimulate people's interest in conserving trees. Agroforestry is one of the suggested methods for conserving biodiversity, producing food crops, and providing other ecosystem services such as climate change mitigation and carbon deposition. It's land utilization system consists of a mixture of hard plants with or without annual plants [1,2]. The agroforestry system applied to the coffee plant with shade trees is a promising alternative to improve the agricultural system [3]. In a simple agroforestry system, understanding the characteristics and varieties of the shade trees and its function can advance the sustainability of coffee agroecosystem [4] and improve biodiversity conservation [5].

Shade trees used to shade Arabica coffee trees are a combination of (*Leucaena glauca* and *Calliandra*

calothyrsus) and *Ermerellia ovalis*. This plant is used as shade due easy to grow and can adapt to the environment. Growing shade trees is a way that can be undertaken to reach an environmental condition that suitable for coffee growth. Subsequently, giving shade trees on Arabica coffee will reduce light intensity that exposes plants to change the plants' temperature and humidity. The use of shade trees on coffee will influence biotic and abiotic factors, such as other research findings that would affect the temperature, humidity, and wind [6,7]. Agroforestry can be considered a land-sharing strategy to conserve biodiversity and increase agricultural production [8]. An agroforestry coffee system can also maintain the amount of mycorrhiza in the soil effectively compared to the monoculture system [9].

Different shade trees will also give a different light intensity that affects plant physiological and morphological factors and affect plant production [10]. The study was aimed to analyze (1) the financial feasibility of Arabica coffee cultivation with a combination of (*Leucaena glauca* and *calliandra calothyrsus*) and *Elmerrellia ovalis* (agroforestry models) by calculating: the Net Present Value (NPV), the Net Benefit-Cost Ratio (Net B/C), and Internal Return Rate (IRR); (2) How is the development of coffee based on the type of shade and market opportunity.

2. MATERIAL AND METHODS

2.1. Study Area

This study was conducted in Lembang Bokin North Toraja, South Sulawesi province. Bokin village is administratively located in Rantebua district, north Toraja, South Sulawesi province. The geographical location of Bokin village was 03°01'04,7" – 03°01'45,2" n and 119°58'44,9" – 120° 00'03,8" (Fig 1) with the temperature of 22°-24°c and relative humidity (Rh) 80 %. From Rantepao City, Bokin village can be reached in 45 minutes by motor vehicles. The total area of Bokin village is about 2.069 ha, which consists of the settlement area, forest estate, and people's farm and orchard. The majority of the Bokin village population was the Toraja tribe people, and their main livelihood came from coffee cultivation. North Toraja is one of South Sulawesi's districts, Indonesia, famous for its Arabica coffee. One of the most famous species is Arabica, one of the national superior-commodities with a high economic value. The research location was selected by purposive sampling on 17-year-old Arabica coffee plants with spacing 2.5 m x 2.5 m, and direct variables measured in this study including light intensity and several models of shade trees used in the coffee plantation such as the combination of (*Leucaena glauca* and *Calliandra calothyrsus*) with spacing 6 m x 4 m and *Ermerellia ovalis* 8 m x 7 m.

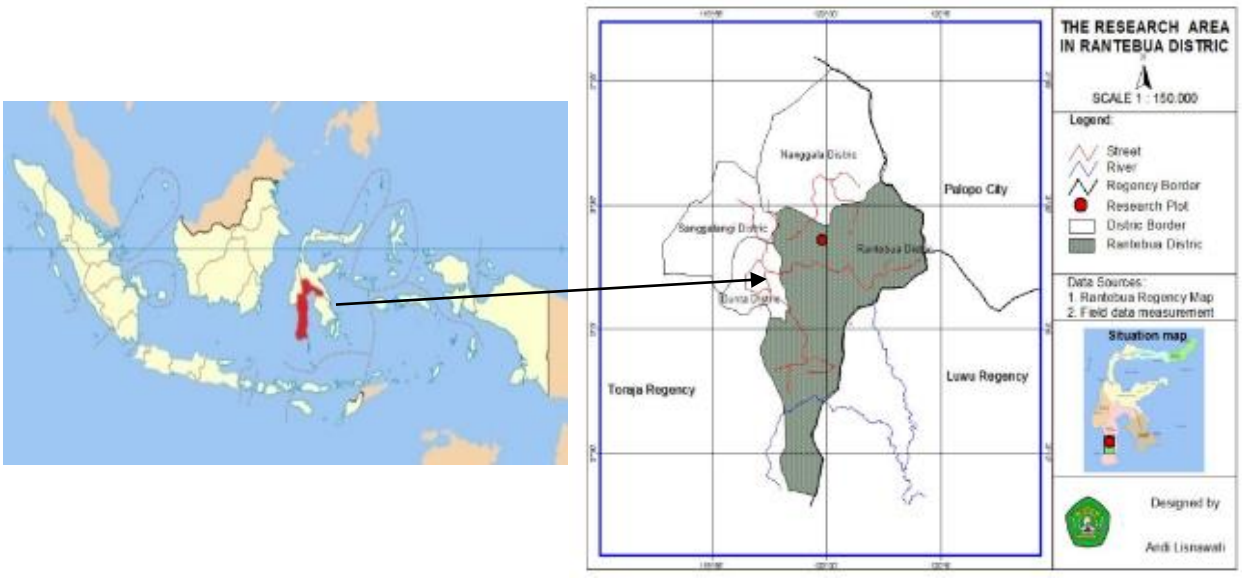

Figure 1 Research location in Lembang Bokin village, Rantebua district village, North Toraja South Sulawesi Province, Indonesia.

2.2. Data Analysis

Production and financial analyses were done for two models of Arabica coffee cultivation, namely: (1) Arabica coffee plantation under shade tree combination/mixed *Leucaena glauca* and *Calliandra Calothyrsus* (Model 1), (2) Arabica coffee under shade tree *Elmerrellia ovalis* (Model 2).

Specifically, data collection was done in the following manner [11]: (1) observation by conducting direct observation on Arabica coffee cultivation activities, including activities undertaken, production costs, and earned income, (2) direct measurements in the field, including diameter Arabica coffee trees, production of cheery, the weight of cherry and dry bean coffee, (3) library research, data collecting through literature review and reports from institutions related to Arabica coffee, Arabica coffee cultivation activities in north Toraja district, south Sulawesi Province; (4) structured interviews with questionnaires, discussions and direct interviews with Arabica coffee farmers and companies.

The method used in the financial feasibility study of this Arabica coffee cultivation is the present value (present value) because it comes from the data at the time of the study. The assumptions used are as follows: (1) costs and benefit are the present value, a value that applied on the market in the year of the research, (2) the age of Arabica coffee is 3-25 years. It is seen from the data obtained when researching primary data and secondary data obtained from the field the selling price applied in 2017, (3) the prices that used in 2017, (4) labour cost is IDR 80,000 day^{-1}, (5) discount rate 10%

In the financial analysis, data analysis of each activity step of Arabica coffee cultivation is cost component analysis, income from Arabica coffee cultivation business, and feasibility analysis using NVP, Net B/C Ratio, and IRR parameters necessary. Analysis of maximum coffee yield was done based on the measurement of time interval (cycle) by calculating average annual production average product (AP) and marginal product (MP) [12] with the formula as follows:

AP = Pt/t

Where:

AP = average product of arabica coffee
Pt = total product at age t of arabica coffee
T = tree age of coffee

$$MP = \frac{Pt - P_{t-1}}{Tt - T_{t-1}}$$

Where:

MP = marginal product of arabica coffee
P_t = total product at age t of arabica coffee
P_{t-1} = total product at age t-1 of arabica coffee
T = time interval between each measurement age of arabica coffee

To calculate how much investment, the financial feasibility in coffee cultivation with agroforestry systems by the company was analyzed using investment criteria [13,14].

$$NPV = \sum_{t=0}^{t=n} \frac{Bt - Ct}{(1+i)^t}$$

$$Net\ B/C = \begin{cases} \frac{\sum_{t=1}^{t=n} \frac{Bt-Ct}{(1+i)^t}}{} & \rightarrow Bt - Ct > 0 \\ \frac{\sum_{t=n}^{t=n} \frac{Bt-Ct}{(1+i)^t}}{} & \rightarrow Bt - Ct < 0 \end{cases}$$

The criterion used in evaluating the business feasibility was the internal rate of return (IRR). IRR is a mean annual return derived from an investment and expressed in percentage [15]. IRR value indicates an interest rate that can be paid by a business, or in other words, the ability to gain income from the cost invested.

$$IRR = i_1 + \frac{NPV1}{NPV1 - NPV2}(i_2 - i_1)$$

Where:

NPV1 = positive NPV of arabica coffee
NPV2 = negative NPV of arabica coffee
i_1 = interest rate when NPV is positive.
i_2 = interest rate when NPV is negative.

3. RESULTS AND DISCUSSION

Coffee has become one of the plantation crops that have been cultivated and have high economic value [16]. The coffee growth needs shade trees in the cultivation. Without preparing the fine quality of land and shade trees, it is hard to reach successful coffee growth. Ten species (28%) of thirty-six kinds of a shade tree in Sumberjaya Lampung are originated from legumes, namely *Gliricida sepium*, *Dalbergia latifolia*, *Paraserianthes falcataria*, *Parkia speciosa*, *Acacia* sp., *Archidendron pauciflorum* and *Archidendron microcarpum* [17], *Calliandra calothyrsus*, and *Leucaena glauca* [18].

The use of shade trees in coffee plantations depends on many factors. The most crucial factor is the one related to production, increasing crop yields, and as a condition modifier of environment that appropriate [19]. The use of different shade trees on coffee undoubtedly results in a different physiological response from the other canopy of shade trees plants. The shade tree is used to manage the intensity of sunlight that enters and is used by coffee for the flowering and fertilization process. The growth and development of coffee can also be affected by the shade trees' condition [19]. The difference occurred because of the different shade trees being used. The mixed shade trees of *Calliandra calothyrsus* and *Leucaena glauca* are different from

Ermerellia ovalis trees in terms of the trunks, size of the trunk, and leaves, so that it causes the light intensity received by the Arabica coffee differently. Some studies reported that the dominant shade tree species affect coffee's growth and productivity [20,21].

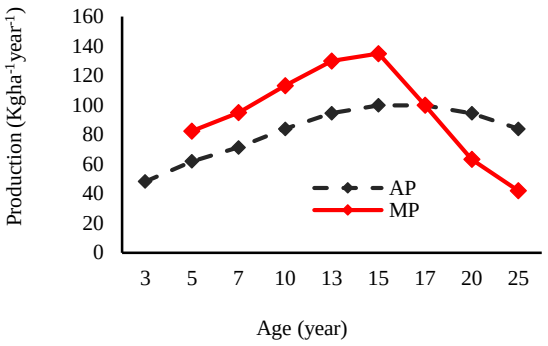

Figure 2 Correlation between average product (AP) and marginal product (MP) of Arabica coffee under mixed *C. Calothyrsus* and *L. Glauca* shading.

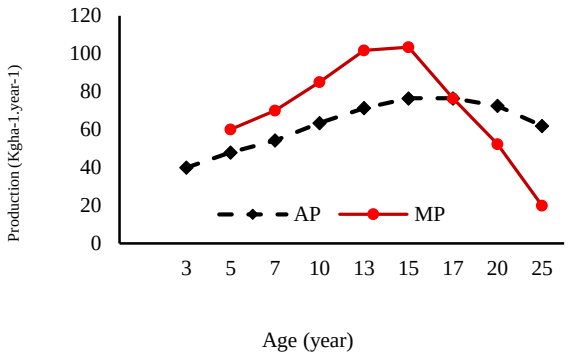

Figure 3 Correlation between average product (AP) and marginal product (MP) of Arabica coffee under *Emerallis ovalis* shading.

The total production of dried coffee seeds from the research result shows the increase of production in each year along with the increase of the age of the tree, that age of coffee trees affects its productivity [22] for the shade tree mixed *Calliandra calothyrsus* and *Leucaena glauca* annual average of production 1135 kg $ha^{-1}year^{-1}$ or coffee production 1.42 kg $tree^{-1}ha^{-1}$ with increased by 12.92% $year^{-1}$ (Fig 2). Meanwhile, under shade trees, *Elmerrellia ovalis* production reached 489 kg $ha^{-1}year^{-1}$ or coffee production, 0.60 kg $tree^{-1}ha^{-1}$ increased by 11.59% $year^{-1}$ by the age of 17. It shows that coffee production maximizes both types of shade trees (Fig 3).

It can be seen (Fig 2) from the intersection of the average product (AP) reached 100 kg $ha^{-1}year^{-1}$ and marginal product (MP) 100 kg ha^{-1} $year^{-1}$ or coffee production 1.42 kg $trees^{-1}ha^{-1}$for the mixed shade tree of *C. calothyrsus* and *L. glauca*. Meanwhile, tree *E. Ovalis* production reached an average 76.47 kg $tree^{-1}ha^{-1}$and marginal product (MP) 76.50 kg $ha^{-1}year^{-1}$ (Fig 3). The dominant shade of legume tree had a positive influence on coffee productivity [23]. There was a positive correlation between shade trees with coffee productivity [17]. Coffee plant growth and productivity with and without shading showed different results. Coffee plants under shading conditions yield much more significant and heavier produce [24]. The use of shade trees in coffee plantations depends on many factors. The most crucial factor is the one related to production, increasing crop yields, and as a condition modifier of environment that appropriate [19]. The traditional agroforestry system is a century-old agricultural practice. It has become an essential agricultural model globally, especially in the tropical and sub-tropical areas, from the economic, ecological, and socio-cultural viewpoints, profitable to the community that runs it [25]. Companies and Toraja people use Uru-Uru's shade tree (Elmerrellia ovalis) as an agroforestry coffee cultivation system. Moreover, because the wood is substantial and round, widely used as building materials for traditional Toraja houses.

Financial analysis on coffee cultivation is the effort made to get an idea of how much activity was undertaken to provide benefits that outweigh the costs (investment) issued. The cultivation cost was including the starting cost for preparing the field up to the cost of harvesting [26]. Activities done in the coffee cultivation consisted of planning, field preparation, supplying seeds, planting, stitching, maintenance, and harvesting. Activities such as planning, field preparation, seed supply, and planting are carried out in the first year. Plant planting is only done in the second year. Maintenance of growing plants is carried out once a year, while harvesting starts in the third year for Arabica coffee. Maintenance is an activity in the form of weeding plants against weeds and pests, and diseases. This activity is carried out every year. The day needed for maintenance in 1 ha is five days, and the cost of maintenance is IDR 2,400,000 $ha^{-1}year^{-1}$ for a 30 person day. Meanwhile, harvesting coffee cherries in 1 hectare in a year is needed 30 days, and the cost for harvesting is IDR 12,112,500 ha^{-1} $year^{-1}$ for 150 person day.

According to the market prices, when this study was conducted, Arabica coffee's local market prices were Arabica coffee under mixed *Calliandra calothyrsus* and *Leucaena glauca* IDR 57,000 kg^{-1}, and Arabica coffee under *Elmerrellia ovalis* IDR 45,000 kg^{-1}.

The financial analysis of Arabica coffee cultivation in the community forest used an internal rate of return (IRR) criterion. This discount rate gives the result to a net present value (NPV) of zero. A feasible cultivation business is indicated by the more significant IRR value than the interest rate applied when the investment takes place [15].

Based on the research results at Lembang Bokin, North Toraja, each investment criterion's value can be

Table 1. Details of analyzing Arabica coffee cultivation (25-year cycle) with discount rate 10%

Shade Tree	Analysis	Total	Criteria	Value
C. calothyrsus and *L. glauca*	Gross Benefit	1,630,300,000	Net B/C Ratio	3.07
	Cost	944,500,000	Gross B/C Ratio	1.73
	Investasi	31,640,000	NPV	99,980,000
	Net Benefit	559,693,000	IRR	19.3
Elmerrellia ovalis	Gross Benefit	554,661,000	Net B/C Ratio	0.50
	Cost	459,051,000	Gross B/C Ratio	1.21
	Investasi	30,255,000	NPV	28,653,000
	Net Benefit	96,610,000	IRR	5.3

Source: Primary data after processed, 1$ = IDR 13,000,-
Note : NPV = Net Present Value, IRR = Internal Rate of Return, Net B/C Ratio = Net Benefit Cost Ratio, Gross B/C Ratio = Gross Benefit Cost Ratio

seen in Table 1. According to calculation, the cash flow of coffee under mixed *C. calothyrsus* and *L. glauca* at 25 years plant cycles shows that the total cost for the entire activity amounted to IDR 944,500,000 and gross benefit IDR 1,630,300,000. Financial analysis of Arabica coffee cultivation with agroforestry systems using mixed shade *(C. calothyrsus* and *L. glauca*) at an interest rate of 10%, resulting in Net Present Value (NPV) and Net B/C resulting in Net Present Value were IDR 99,980,000 and 3,07 respectively. This statement is strengthened by an analysis of the Internal Rate of Return (IRR) model with a value of 19.3%. The results above show that Arabica coffee cultivation under mixed shade (*C. calothyrsus* and *L. glauca*) at 25 years and an interest rate of 10% is feasible, which means that it is profitable. The financial analysis of Arabica coffee cultivation used an internal rate of return (IRR) criterion, a discount rate that gives the result to a net present value (NPV) of zero. Meanwhile, the Net of B/C of the business amounted to 3.07, which means that the value of the rupiah investment return was 3.07 times the value of the rupiah invested. The Net B/C >1 indicates that the business is profitable.

Meanwhile, according to the calculation of the cash flow of coffee under *E. ovalis* at 25 years plant cycles, the total cost for the entire activity amounted to IDR 459,051,000 and gross benefit of IDR 554,661,000. Financial analysis of Arabica coffee cultivation with agroforestry systems, shade tree *E. ovalis* at an interest rate of 10%, resulting Net Present Value (NPV) and Net B/C resulting in Net Present of values were IDR 28,653,000 and 0.50 respectively. This statement is strengthened by analyzing the Internal Rate of Return (IRR) model with a value of 5.4%. The results above show that the Arabica coffee cultivation under shade tree *E. ovalis* at 25 years and an interest rate of 10% are not feasible, which means it is not profitable. Meanwhile, the Net of B/C of the business amounted to 0.50, which means that the value of the rupiah investment return was 0.50 times the value of the rupiah invested. The Net B/C <1 indicates that the business is not profitable and indicated the cultivation model was not feasible to be executed because the profit was still far smaller than the actual bank interest rate (10%). The Arabica coffee cultivation using a combination of *C. calothyrsus* and *L. glauca* can be further developed because this shade provides more outstanding coffee production than the shade of *E. ovalis*. Shade trees like the combination *C. calothyrsus* and *L. glauca* in the agroforestry system offer many benefits, i.e., increasing organic matter and soil nutrients through litter and nitrogen fixation legumes as shade trees, to encourage biodiversity function and to suppress the weed growth [19].

The use of shade trees in coffee plantations related to production, increase crop yields, and as a condition modifier of environment that appropriate [20]. The use of different shade trees on coffee undoubtedly results in a different physiological response that coffee received due to the different canopy of shade trees plants. The shade tree is used to manage the intensity of sunlight that enters and is used by coffee for the flowering and fertilization process. The growth and development of coffee can also be affected by the shade trees' condition [20].

4. CONCLUSION

The conclusions that can be derived from this study were the combination of (*C. calothyrsus and L glauca*) provides the highest productivity compared to *E. ovalis* with an annual average of production 1135kgha^{-1}year^{-1} or coffee production of 1,42 kg tree^{-1}ha^{-1} with increased by 12.92% year^{-1}, the maximum output of Arabica coffee in model 1 under mixed (*C. calothyrsus* and *L. glauca*) and model 2.

E.ovalis was reached at 17-year Arabica Coffee in model 1 under shade tree (*C. calothyrsus* and *L.*

glauca) resulted in IRR 17.2%, Net B/C Ratio 2,43 (>1) and meanwhile model 2 IRR 5.4%; Net B/C Ratio 0.5 (<1). Arabica coffee cultivation models under the shade tree mixed (*C. calothyrsus* and *L. glauca*) are feasible to be developed, while under the shade tree, *E. ovalis* is not feasible.

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