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Economic Viability of Coffee Cultivated in an Agroforestry System in Southwest Goiás

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ABSTRACT
Brazil ranks first in the world as a coffee producer. The increase in productivity has been observed in recent harvests due to new management and automation technologies. Even with the expectation of a reduction in national production, the state of Goiás has shown a growing participation in coffee production. The municipality of Rio Verde, in Goiás, is among the eight largest coffee producers in the state and is where the Fazenda da Mata enterprise is located, the main object of this research. The objective of the research is to evaluate the performance of the production of arabica coffee cultivated in an agroforestry system through studies on economic feasibility comparing the implementation costs plus the estimated costs and revenues of the SAF with the conventional cultivation system. Coffee growing in SAF is a production system that demands research that presents results on economic analysis, so it was sought to research the economic viability of coffee cultivation in SAF as a sustainable alternative for agribusiness, whose information can contribute to the decision making of the rural manager when comparing a conventional cultivation enterprise to the cultivation in SAF. In addition, the AFS can contribute to the increase of agricultural productivity with less impacts on the environment, emerging several possibilities of subsystems with applicability in large, medium and small rural properties, considering the financial advantages and also the motivating values that direct the farmer to this agricultural activity. The economic analysis showed that the conventional cropping system is more financially advantageous, however the SAF also showed excellent results. Thus, it is important to highlight other relevant factors that can be considered when deciding which cultivation system to use in coffee production. Although the SAF has presented financial results lower than those of the conventional system, it is a cultivation system that can provide a second source of income for the producer, such as the use of tree species.

Keywords: Agroecology; Sustainability; Productivity; Coffee plantation; Cost Management

INTRODUCTION

According to the United States Department of Agriculture (USDA), Brazil is the world's largest producer of coffee, with the Arabica variety being the most cultivated, followed by Robusta. According to the National Supply Company (CONAB), national production hit a record in 2020 and should remain stable in 2021, despite the negative biennial. This increase in productivity is due to crop management and technological advances (CONAB, 2021).

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Minas Gerais leads coffee production in Brazil, followed by Espírito Santo and São Paulo, while Goiás occupies the seventh position. Even with the reduction of areas in production due to the biennial, Goiás has shown a growing share in coffee production (CONAB, 2021). Conab mapped 18 coffee-producing municipalities in Goiás in 2019, with eight of them accounting for about 92% of the production area: Cristalina, Campo Alegre de Goiás, Cabeceiras, Paraúna, Sítio D'Abadia, Ipameri, Catalão and Rio Verde.

Rio Verde stands out among the largest coffee producers in the state, and for this reason, in addition to the proximity to Jataí, the research focused on coffee cultivation in Agroforestry System (SAF) in the rural company Mata do Lobo. Originally a dairy producer until the late 1990s, the company now grows soybeans and corn in monoculture, pigs and coffee in SAF. Mata do Lobo maintains a SAF project on 80 hectares with a vision of economic and environmental sustainability.

Objectives: The main objective of this research is to evaluate the performance of coffee production grown in SAF, through economic and financial feasibility analyses. Using cost and return data, the research seeks to calculate the financial feasibility of investing in the SAF.

Rationale: Financial analysis is crucial to mitigate risks and avoid irreparable damage (SEBRAE, 2014). This study will provide relevant economic data on coffee cultivation in SAF, comparing them with conventional cultivation to contribute information to agribusiness.

Hypotheses: The research hypothesizes that coffee produced in SAF will present better economic indicators than conventionally cultivated. Specifically, that SAF will have a higher Net Present Value (NPV) but a lower Internal Rate of Return (IRR), or vice versa. The choice of the most advantageous system will be based on which one maximizes NPV and outperforms IRR.

The survey will use primary data from 2019 and 2020 and secondary data for estimates and projections. The main indicators of financial viability will be NPV and IRR.**2.**

LITERATURE REVIEW

COFFEE PRODUCTION IN BRAZIL AND GOIÁS

In the context of financial feasibility analysis, it is relevant to seek market information in the national and local scenario as a way to concatenate the ideas to survey the considerations built throughout the text. However, on the world stage, coffee production forecast for 2021/2022 is around 10 million tons, with an estimated drop of around 660 thousand tons mainly due to the off-season of the Arabica variety in Brazil. The production forecast for the same period should reach the amount of 3.4 thousand tons.

In addition, adding the robusta and arabica varieties, Brazil is the world's largest coffee producer, followed by Vietnam and Colombia (USDA, 2021). Brazilian coffee production in 2020 was considered a record. However, the production estimate for the Brazilian harvest in 2021 is 2.9 thousand tons of processed coffee, pointing to a decrease of 22.6% compared to the result presented in 2020.

The main factor responsible for this reduction is the negative biennial (Conab, 2021). The effects of biennial and unfavorable climatic conditions are factors that influence productivity and the amount of coffee planted area, which is usually smaller in negative biennial cycles due to the more intense cultural treatments carried out in the crops in order to recover the vegetative potential of the plants (ROCHA, et. al. 2015).

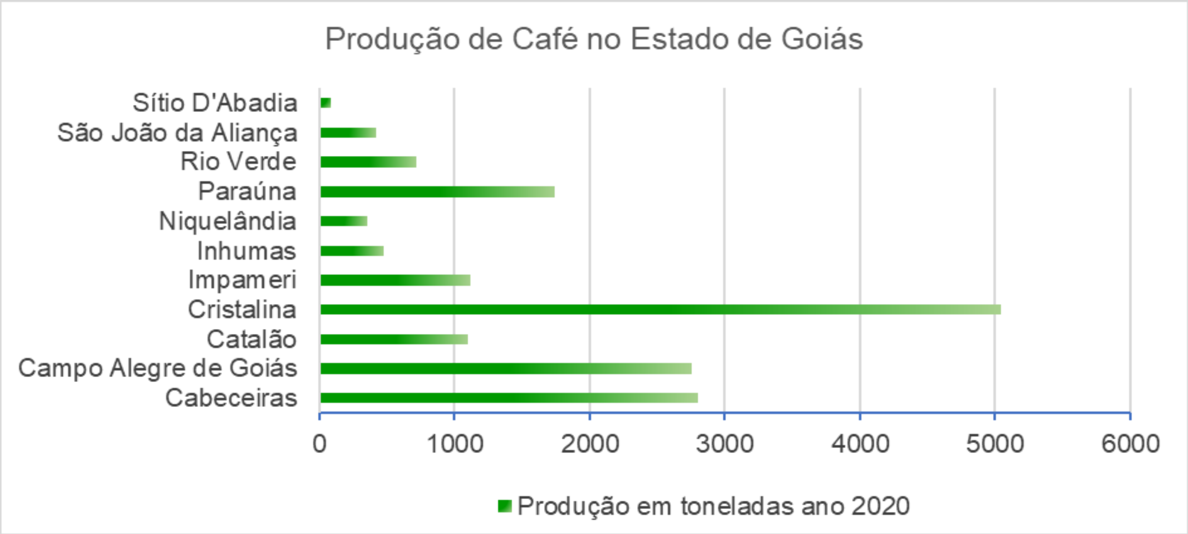
Although the productivity outlook for 2021 is less optimistic compared to the previous harvest, an increase of 2.6% in the area destined to coffee cultivation in the country is estimated, totaling 2,216.9 thousand hectares. Of these, 1,824.7 thousand hectares are for crops in production (a reduction of 3.2% compared to the previous year) and 392.2 thousand hectares are in formation, which represents an increase of 41.4% compared to the previous cycle (Conab, 2021).

According to the Goiás Agency for Technical Assistance, Rural Extension and Agricultural Research – EMATER, coffee production in the state of Goiás should reach 15 thousand tons. This amount is mainly due to the increase in average productivity, which, compared to the previous 2020/2021 harvest, should grow 11.8% and 2.7 tons/hectare, the best performance in the country (EMATER, 2022).

However, it should be considered that coffee production should decrease, especially in the area under production, due to cultural treatments in the crops such as pruning, skeletonization or harvesting to renew the crop, the delay in the rainy season and higher temperatures. The expectation of area for coffee cultivation in Goiás is 5.8 thousand hectares in the 2021/2022 cycle (CONAB, 2021). As for the average productivity, the state of Goiás has the best results for Arabica coffee among the main producing states in Brazil.

Finally, it is worth mentioning that Goiás produces exclusively Arabica coffee, while the other states produce robusta conilon coffee (MAIA; Teixeira, 2020). In Graph 2, it is possible to observe the main coffee-producing municipalities in the state of Goiás

Graph 2. Arabica coffee production in tons in the state of Goiás, year 2020.



Source: Prepared by the author, data from IBGE (2020).

The municipality of Cristalina is the largest coffee producer in Goiás, with a high technological level, with mechanized harvesting and irrigation systems using central pivot. In 2020, Cristalina produced 5,040 tons of coffee, according to the Brazilian Institute of Geography and Statistics – IBGE. The municipality of Rio Verde occupies the seventh position among the largest coffee producers in the state.

This information is based on the conventional coffee cultivation system and is of great importance. This is because one of the objectives of the work is to compare the costs of cultivation in Agroforestry Systems (AFS) with the costs of conventional cultivation. Therefore, understanding how the coffee market in conventional cultivation responds to the aforementioned factors corroborates a more robust comparative analysis of the data.

In this context, it is essential to describe what an Agroforestry System (AFS) is. This system is a planned form of land use that rescues the primitive methodology of cultivation, combining woody tree species, such as fruit or timber, with agricultural crops and/or animal husbandry (ROCHA, 2014).

AGROFORESTRY SYSTEMS

The planning of Agroforestry Systems (AFS), which can be done simultaneously or sequentially, temporally, brings significant economic and ecological benefits (ROCHA, 2014). The planning phase is crucial and complex, as it involves environmental, social, and economic factors. This research focuses on the financial viability indicators of SAFs.

Studies on the economic feasibility of AFS in the Amazon region have served as a reference for other states, while in the Atlantic Forest, research focuses on forest restoration (BENTS-GAMA et al., 2005; MARTINS et al., 2019). Successful examples include the Brazilian Agricultural

Research Corporation (Embrapa) and the German company Unique Forestry and Land Use, which provide technical and economic solutions for rural development.

Technological innovation in AFS promotes crop diversification, combining tree, perennial and annual species, which provides immediate returns and long-term investments (BENTS-GAMA et al., 2005; EMBRAPA, 2020). Compared to plant species consortia, AFS is more complete, integrating different crops and forest species, which preserves biodiversity, protects the soil and controls pests and diseases (PANDOVAM; VENTURIM; AGUIAR, 2010).

Ernst Götsch, a Swiss who dedicated himself to the study and implementation of successional agroforestry in Brazil, demonstrated that a harmonious and productive coexistence between human beings and nature is possible (EMBRAPA, 2007). The organization Mutirão Agroflorestal, created in São Paulo in 1996, defines AFS as biodiverse production systems analogous to natural ecosystems (CALDEIRA; CHAVES, 2011).

Ecological succession is a natural process in which a forest area is constantly changing. Fast-growing pioneer plants prepare the site for other species, promoting a continuous cycle of development until the forest becomes mature again (EMBRAPA, 2007).

SAFs use this natural logic, growing plants in a way that mimics the disorder of nature to protect soil, water, and biodiversity. This technology requires detailed planning of where, how, when and what to produce, within a diversity of crops (CALDEIRA; CHAVES, 2011).

Planned Agroforestry System

The cultivation of the land through technologies that imitate nature is highly complex and requires detailed planning, ranging from planting techniques to the commercialization of products. This agroforestry system integrates animals, fruit trees, annual and forage crops, and the benefits are numerous, as highlighted by Gonçalves (2014).

For this, it is necessary to gather information about the land and the available resources, such as tools and labor, as these elements determine the preparation of the land and planting (GONÇALVES, 2014). A well-designed planning will have a prolonged duration, since it is a regenerative and continuous system, helping in decision-making and fundraising. Public policies, such as incentives in public procurement and facilitated Pronaf credits, support the implementation of SAFs (GONÇALVES, 2014).

Recording events and business data ensures better access to government incentive programs, such as the recovery of degraded forests. In addition, AFS planning can reduce costs by setting up forest restoration similar to native forest (MARTINS et al., 2019).

For effective planning of an AFS, several factors must be considered, such as soil, climate, market, production arrangements, schedule of activities, production chain, environmental legislation, costs, and economic indicators (EMBRAPA, 2020).

ECONOMIC INDICATORS

Research on the financial viability of the Agroforestry System (AFS) is essential to justify a sustainable and profitable remuneration, arousing the interest of rural producers. AFS reduces forest restoration costs and provides ecological efficiency comparable to the plantations of native species, in addition to meeting the agricultural interests of producers (MARTINS et al., 2019).

To assess the feasibility of SAFs, it is crucial to understand the financial calculations used. According to Sanguino (2007), these include:

- Costs: sum of the unit prices of inputs, machinery, labor and other production factors, divided into Fixed Costs and Variable Costs.
- Revenues: amounts accumulated from the sale of production.
- Cash flow: record of amounts invested, expenses, and revenues over time, reflecting the inflows and outflows of funds.

According to CONAB (2022), the criteria for measuring costs are:

- Fixed Costs: expenses independent of the volume of production, including depreciation, improvements, installations, machinery and remuneration of fixed capital and land.
- Variable Costs: expenses that occur only with production, including costing items, post-harvest and financial expenses, which are essential for the continuity of the activity in the short term.

The Net Present Value (NPV) and the Internal Rate of Return (IRR) are the main economic indicators used in the financial feasibility analysis. NPV, according to Castro (2020), takes into account not only the return between the amount initially invested and the final amount to be redeemed, but also whether the investment is viable and whether there will be an appreciation of money over time. To calculate the NPV, the present value of the cash flow is estimated using the Minimum Attractiveness Rate (MAT) (Gitman, 2010).

$$VPL = \sum_{n-1}^{n} \frac{FCt}{(1+i)^t} - Investimento$$

Where:

VPL = Liquid Present Value

FCt = Cash Flow in each period

t = Tempo (t = 1, 2, ... n)

i = Minimum Attractiveness Rate (10% p.a.)

Internal Rate of Return – IRR: The internal rate of return is the discount rate that makes the NPV equal to zero (CASTRO, 2020). An enterprise will be considered viable if the IRR is higher than a given interest rate i, taken as a comparison and that reflects the opportunity cost of capital (GITMAN, 2010).

$$\text{Investimento Inicial} + \sum_{n+1}^{n} \frac{FCt}{(1+TIR)^t} = \sum_{n+1}^{n} \frac{FCt}{(1+TIR)^t}$$

Where:

FCt = Cash Flow in each period

t = Tempo (t = 1, 2, ... n)

IRR = Internal rate of return e (t = 1, ..., n)

These indicators are tools to bring technical basis to decision-making, minimizing risks and uncertainties (CASTRO, 2020). For the calculations of the indicators, spreadsheets and the Excel functions tool were used.

MATERIAL AND METHODS

LOCATION AND CHARACTERIZATION OF THE STUDY AREA

The Fazenda Mata do Lobo project, located in the Ouroana district, Rio Verde (GO), has geographic coordinates S 18° 04' 33" and W 50° 48' 21". With a slightly undulating flat topography and an altitude of 837m, the local tropical climate has dry (May to October) and rainy (November to April) seasons, with a precipitation difference of 243mm in 2021 and an annual temperature variation of 4.4°C, between 20°C and 35°C (CLIMATE-DATA, 2022).

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Figure 1: Satellite image of the areas where the SAFs are implemented in the Fazenda Mata do Lobo project.

Fonte: Google earth, 2021.

The property, located 59 km from Rio Verde and 92 km from Jataí, has an 80-hectare SAF project, shown in Figure 1 of Google Earth (April 2021). The focus of the study is a consortium of eucalyptus, cedar, jambolão, banana and Arabica coffee. Originally a major soybean producer, Fazenda Mata do Lobo is developing 80 hectares in SAFs, with the participation of employees.

According to the manager, coffee is the main crop sold, and the employees' families consume the other crops. Figure 2 shows 35 hectares of agroforestry, with 11 ha planted at the end of 2020 and 17 ha dedicated to coffee. The main commercial species are coffee, banana and Australian red cedar, while eucalyptus, mango and jambolan are for domestic consumption.

Figure 2. Aerial view of the three areas with SAFs of the Mata do Lobo Farm, from 2018 to 2020.

Source: @matadolobo, 2021.

The study of the alternative production system at the Mata do Lobo Farm can guide investment decisions based on the financial indicators NPV and IRR. To assess the financial viability of coffee production in an Agroforestry System (AFS) and to suggest economic management measures, a detailed analysis was carried out.

METHODS

Primary data collected on the farm and secondary data on the production of arabica coffee in Brazil were analyzed. The estimate of conventional production values used information from the IBGE, converted to dollars according to the average annual rate.

The costs of implementing and maintaining the SAF from 2019 to 2021 were analyzed based on data collected during a visit to the project in August 2020. The agronomist in charge was interviewed to provide detailed information.

The data was used to prepare cost and cash flow spreadsheets, covering a period of 15 years. The value of money in time was discounted using a Minimum Attractiveness Rate (MAT) of 10% per year, based on the Selic rate of 9.25% per year, according to Gitman (2010). The NPV and IRR indicators were calculated with this same discount rate.

Secondary Data

The data from the literature were used as a reference to compare the conventional cultivation of Arabica coffee with the agroforestry system. The choice of secondary sources took into account the date of publication, covering the period from 2013 to 2022, and the reliability of the sources, such as the IBGE, Embrapa and Cash Flow reports with details of costs and expenses.

These secondary data were essential for the estimation of partial costs and total revenues, in addition to providing information on the values per hectare of Arabica coffee production in Goiás, the quantity produced and productivity. Information on coffee productivity per plant was also sought. All the values in Table 1 were converted to dollars, using the average exchange rate for the respective year.

Table 1. Production Value, Quantity Produced, Ton Value, Bag Value, Average Coffee Yield in conventional system from 2015 to 2021 in Goiás

Anus	2015	2016	2017	2018	2019	2020	2021
Production value x 1000 ($/t)	23.420	27.589	19.556	27.646	31.616	21.290	48.591
Quantity Produced (t)	18.123	17.301	14.647	17.625	19.591	17.923	16.344
Value of the Ton ($)	1.292,28	1.594,66	1.335,21	1.568,62	1.613,84	1.187,91	2.973,05
Value of the bag ($/60 kg)	77,54	95,68	80,11	94,12	96,83	71,27	178,38
Average yield (Kg/ha)	2.686	2.485		2.623	2.466	2.408	2.420
Average yield (Sc/ha)	45	41	37	44	41	40	40

Source: IBGE data, 2022.

These data reflect significant annual variations in the value of production and productivity of coffee, with a substantial increase in the value of the ton and bag in 2021. The average yield per hectare is stable, although with a slight downward trend. The sources of information are from the IBGE, as shown in Table 1.

Figure 3 shows that 2019 had the best result in seven consecutive years, despite the drop in production in 2017. According to Maia and Teixeira (2020), coffee production in Goiás has remained relatively constant, and the national drop reflects the situation in other states, such as Minas Gerais and Espírito Santo.

Figure 3. National coffee production in Conventional System from 2015 to 2021.

Source: Prepared by the author, data from IBGE (2022).

After the survey of secondary data, the research was directed to the collection of primary data, focusing on the production process in Agroforestry Systems (AFS). Information on cultivated species, quantities, productivity and values were collected.

Primary Data

Each plant species has a specific function in the system, creating ideal conditions for coffee. Coffee trees, naturally found in the lower layers of deciduous forests, need more shade in the rainy season and less in the dry season (MACHADO et al., 2020). In the system studied, this dynamic is replicated with the pruning of shade trees at the beginning of the dry season, using various species in the AFS.

Table 1 lists the different plant species according to their stratum, the potential products that can be marketed and the time for the start of production. The function of each species is detailed, with a focus on the main cash crop: coffee.

Table 1. Function of Cultivated Species in the SAFs of Empresa Mata do Lobo

Name Cientifico	**Common Name**	**Start of Production**	**Primary Role in the System**	**Stratum**	**Leaves the system after:**
Coffea arabica	Coffee	3 years	Production	Low	-
Musa x paradisiaca	Banana	1.5 years	Production and Organic Matter	Medium	-
Persea americana	Avocado	Fruit: 6 years	Organic Matter and shade	High	-
Dypteryx alata	Barú	Walnuts: 4 years; Madeira: 25 years	Shadow	High	-
Magnifera indica	Sleeve	Fruit: 6 years; Madeira: 15 years	Organic Matter and shade	High	-
Syzgium cumini	Jambul	Fruit: 6 years	Organic Matter and shade	High	-
Moringa oleifera	Moringa	Edible Leaves: 3 months	Organic Matter and shade	High	3 years
Euterpe edulis	Jussara	Fruit: 6 years; Heart of palm: 12 years old	Shadow	High	-
Iliataona	Australian Cedar	Madeira: 12 years	Production and shadowing	Emergent	12 years
Handroanthus impetiginosus	Ipê Rosa	Madeira: 20 years	Shadow	Emergent	-
Eucaliptus sp.	Eucalyptus	Wood: 10 years	Organic Matter and shade	Emergent	Gradually after 2, 3 and 10 years
Hymnea coubaril (Native)	Jatoba	Madeira: 20 years	Shadow	Emergent	-
Khaya ivorensis	African Mogno	Madeira: 20 years	Shadow	Emergent	
Karika Papaya	Papaya	Fruit: 1 year	Shadow	Emergent	3 years
Schizolobium parahypa	Guapuruvu	-	Organic Matter and shade	Emergent	-
Miniot very useful	Cassava	Root: 1.5 years			1.5 years
Panicum maximum	Mombasa Grass	-	Organic matter	Medium	-

Source: Survey data, 2021.

Then, five plots with different designs were implemented on the farm. Table 2 provides details on the species, spacing and planting density per hectare in the plot implemented in 2019, which was the main object of the research.

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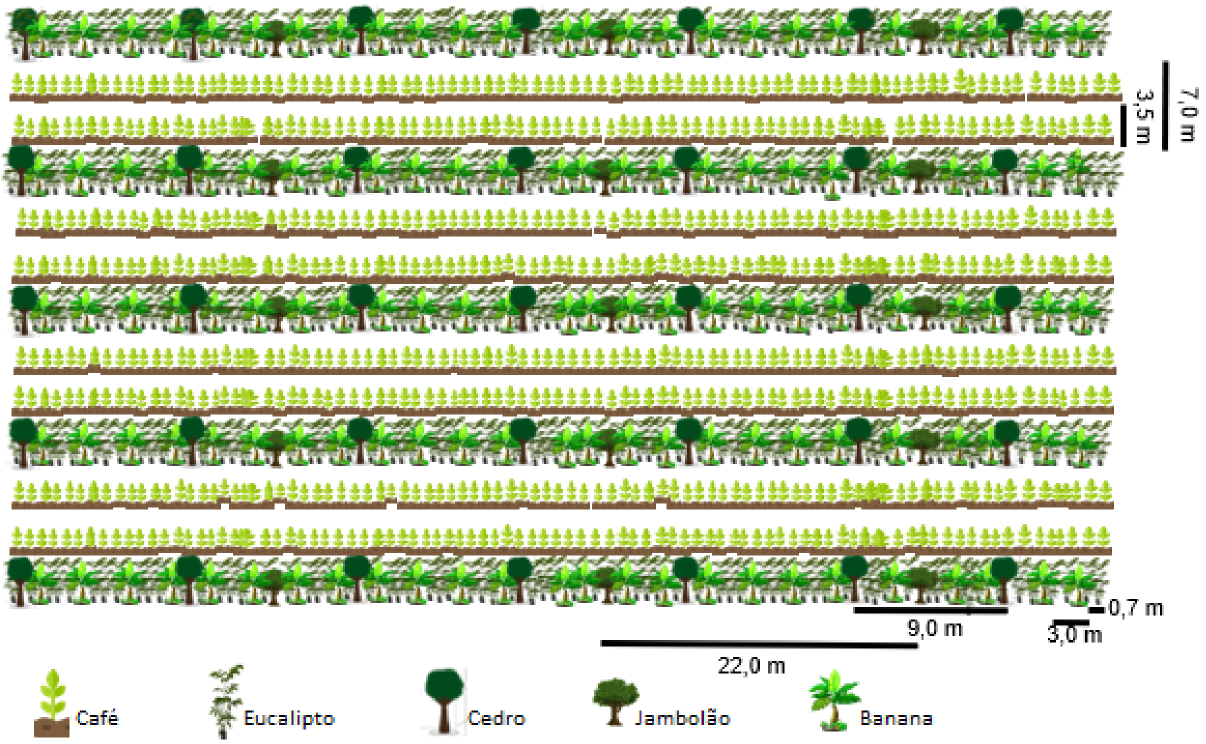
Table 2. Crop Density per Hectare, Mata do Lobo Company

Species	Spacing (m x m)	Density (un./ha)
Eucalyptus Seedlings	7.0 x 1.5	875
Cedar Seedlings	7.0 x 9.0	140
Jambolão Seedlings	7.0 x 22	50
Banana Seedlings	7.0 x 3.0	425
	3.5 x 0.7 (2 of 3 lines)	2.571
Source: Survey data, 2021.		

To illustrate the successional process used in coffee cultivation, Figure 4 was elaborated. In it, it is possible to observe the different spacings present in the field, as mentioned in Table 2. The forest system in rows was created to accommodate coffee seedlings.

Figure 4. Sketch of the Implementation of the SAF, Spacing between Forest Species, Banana, Coffee.



Source: Survey data, 2021.

Figures 5 and 6 provide a detailed view of the SAF adopted in the project. From the terrestrial perspective, it is possible to visualize the alignment of the trees, while the aerial view reveals how the beds were prepared to receive the seedlings.

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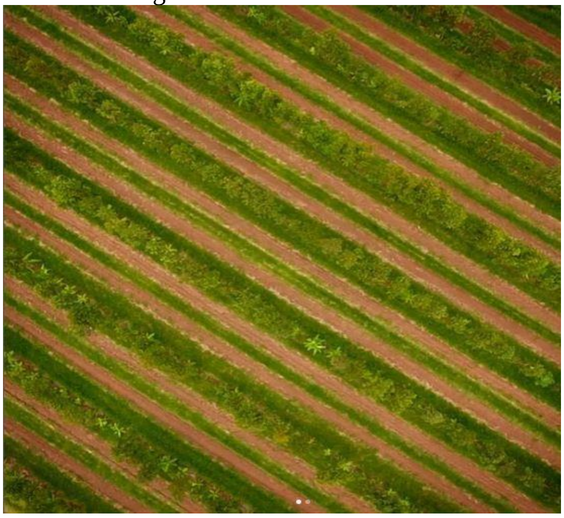
Figure 5. Area intended to receive two rows of coffee between the rows of trees

Source: @matadolobo, 2021.

Figure 6. Aerial view of the area prepared for planting coffee seedlings between rows of trees.



Source: @matadolobo, 2021.

Figure 7 illustrates the beds ready for planting coffee seedlings, between the rows of tree species. In turn, Figure 8 shows the growth of coffee trees over time.

Figure 7. Rows ready to receive the coffee seedlings.

Source: @matadolobo, 2021.

Figure 8. Cafezal in SAF of the Fazenda Mata do Lobo project.

Source: @matadolobo, 2021

Based on the secondary and primary data collected, it was possible to analyze the costs and expenses involved in the implementation, maintenance and harvesting of AFS over a period of 15 years. This analysis resulted in the Total Project Cost and allowed the Feasibility Analysis to be carried out to demonstrate the results obtained.

RESULTS

According to Conab (2022), the separation of the economic components of the Production Cost is essential to allow the producer to better study and understand these costs, enabling a more efficient allocation of resources. In the context of Agroforestry Systems (AFS), inputs play a crucial role in the configuration of costs, and the stability of these costs reflects the relative predictability of the prices of inputs, such as labor and raw materials (GITMAN, 2010).

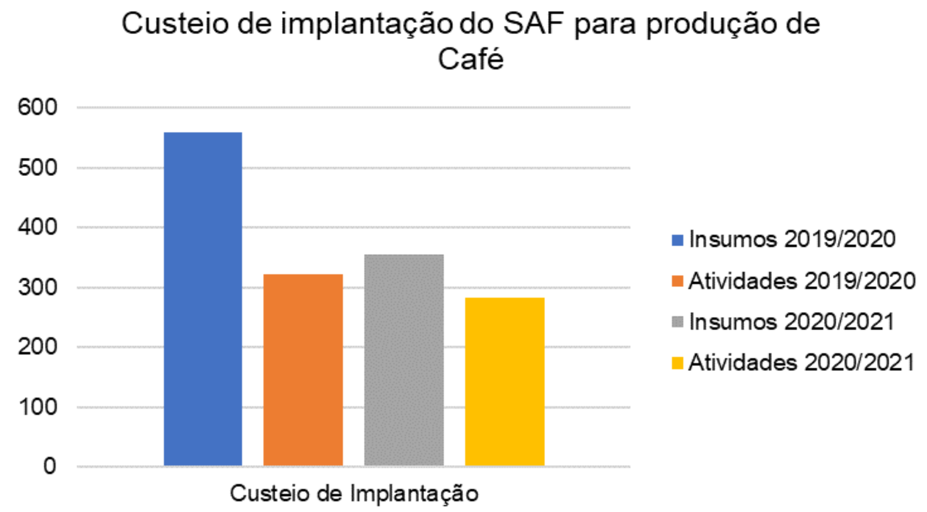
In Table 3, the expenses for costing inputs and activities used at the Mata do Lobo Farm in year zero (2019/2020) are detailed. This was the initial period of implementation of the SAF, when several inputs were needed, including seedlings of different species of trees, chicken litter, Yoorin fertilizer and Mica-schist.

Table 3 - Costing Expenses: Inputs and activities used in the Fazenda Mata do Lobo project Year 0 (2019/2020)

Inputs	Unit	Price ($)	Quantity/ha	Total $/ha
Compound (Cama/Yoorin/Micaxisto)	t	36,12	3,75	135,44
Eucalyptus Seedlings	One	0,12	875	101,94
Cedar Seedlings	One	0,87	140	122,33
Eucalyptus seedlings (Replanting)	One	0,12	125	14,56
Jambolão Seedlings	One	0,39	50	19,42
Banana Seedlings	One	0,39	425	165,05
Total				**558,74**
Activity	**Unit**	**Price (R$)**	**Quant./ha/year**	**Total R$/ha**
Initial Mowing	h/maq.	9,71	1,5	14,56
Subsoiling	h/maq.	9,71	1	9,71
Rotary Hoe	h/maq.	9,71	1	9,71
Construction Site Cleaning	man/day	16,53	2	33,07
Fertilization	h/maq.	9,71	1	9,71
Incorporate Adubo	h/maq.	9,71	1	9,71
Rake	h/maq.	9,71	1	9,71
Tree Planting	man/day	16,53	5	82,67
Weeding 1	man/day	16,53	4	66,14
Weeding 2	man/day	16,53	4	66,14
Mowing 1	man/day	9,71	1,5	14,56
Rake 1	h/maq.	9,71	1,5	14,56
Mowing 2	h/maq.	9,71	1,5	14,56
Rake 2	h/maq.	9,71	1,5	14,56
Mowing 3	h/maq.	9,71	1,5	14,56
Rake 3	h/maq.	9,71	1,5	14,56
Total				**398,50**
Source: Survey data (2021)				

In the context of the Mata do Lobo Farm, Table 3 presents the detailed costing expenses of year zero (2019/2020), which marked the beginning of the implementation of the Agroforestry System (SAF). Figure 9 shows that this was the moment with the highest cost of inputs, due to the intensification of activities and the acquisition of the inputs necessary for the implementation of the SAF.

Figure 9. Costing of the Implementation of the SAF for Coffee Production in the Region of Rio Verde Goiás.



Source: Survey data (2021).

In Table 4, the values corresponding to inputs and activities were converted to the average annual value of the dollar exchange rate for the years 2020 and 2021 (see Table 14). For a better analysis of the costs attributed exclusively to the AFS, specific values of man/day per hectare were estimated.

Table 4 - Costing Expenses: Inputs and activities used in the Fazenda Mata do Lobo project Year 1 (2020/2021)

Inputs	**Unit**	**Price (R$)**	**How much/ha**	**Total R$/ha**
Compost (Bed/Yoorin/Ekosil)	t	186,00	7,43	1.381,71
Amonia Sulfate	One.	1,60	57,14	91,43
Coffee Seedlings	One.	0,55	2.571	1.414,05
Coffee Seedlings / replanting 10%	One.	0,55	257	141,41
Total				**3.028,60**
Activity	**Unit**	**Price (R$)**	**Quant./ha/year**	**Total R$/ha**
Coffee Planting	by seedling	0,25	2.571	642,75
Mowing 1	h/maq.	50,00	1,50	75,00
Rake 1	h/maq.	50,00	1,50	75,00
Mowing 2	h/maq.	50,00	1,50	75,00
Rake 2	h/maq.	50,00	1,50	75,00
Mowing 3	h/maq.	50,00	1,50	75,00
Rake 3	h/maq.	50,00	1,50	75,00
Weeding 1	man/day	80,00	4,00	320,00
Weeding 2	man/day	80,00	4,00	320,00
Total				**R$1.732,75**
Source: Survey data (2021)				

Part of the workforce destined for the SAF is also employed in the company's grain crop production areas grown in a conventional system. Therefore, values for man/day per hectare were estimated for exclusive work in the AFS.

The introduction of coffee seedlings in the AFS was responsible for the reduction in input costs and activities, comparing year zero and year one. This specific activity, in relation to the planting of tree seedlings, resulted in a 25% reduction in overall costs. Some activities were subtracted in this period, but it is important to note that, in the future, these activities will again be necessary and, consequently, estimated, as can be seen in the Cash Flow, specifically in the Activities and Inputs account in Table 9.

Over time, from year 2 onwards, the value of the Costing Expenses with inputs and activities was fixed until year 15, as detailed in Table 5. This stabilization in costs is essential for long-term financial planning, ensuring predictability and facilitating the management of resources over the following years of the SAF operation.

Table 5. Costing Expenses: Activities used in the Fazenda Mata do Lobo project Year 2 to Year 15

Activity	Unit	Price ($)	Qty./ha/year	Total $/ha
Weeding 1	man/day	14,84	2	29,68
Weeding 2	man/day	14,84	2	29,68
Mowing 1	man/day	9,28	1,5	13,91
Windrow cleaning 1	h/maq.	9,28	1,5	13,91
Mowing 2	h/maq.	9,28	1,5	13,91
Windrow Cleaning 2	h/maq.	9,28	1,5	13,91
Mowing 3	h/maq.	9,28	1,5	13,91
Windrow Cleaning 3	h/maq.	9,28	1,5	13,91
Thinning to obtain OM	h/maq.	9,28	1,5	13,91
Total				**156,77**
Source: Survey data (2021)				

Figure 10 shows that the Operating Cost is the sum of the Variable Cost and the Fixed Cost. In year zero, the Variable Cost is higher, falls in year one, increases in year two, and stabilizes until year 15. Fixed Cost, on the other hand, increases sharply from year zero to year two, then stabilizes and follows the Operating Cost curve.

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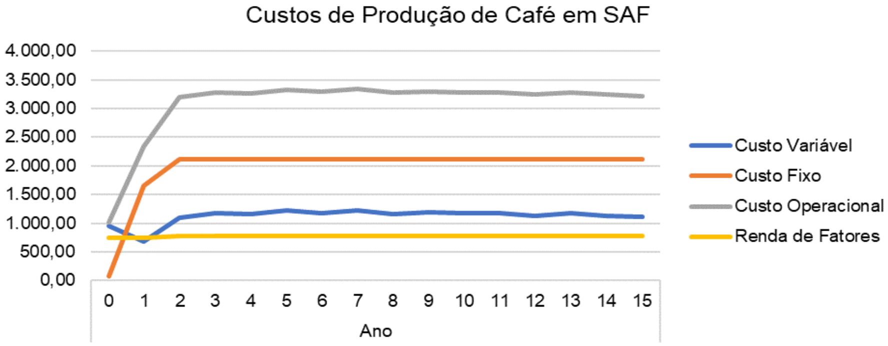
Figure 10. Variation of the Production Costs of Arabica Coffee produced in SAF at the Mata do Lobo Company in Rio Verde – GO.



Source: Survey data (2021).

The Variable Costs of the SAF include several categories, such as activities, inputs, harvesting, coffee processing, soil analysis, various services, administrative expenses, storage expenses and Contribution on the Commercialization of Rural Production. It is important to highlight that the activities and related inputs represent 92% of the total Variable Costs, as shown in the analysis.

Fixed Costs, on the other hand, are composed of depreciation and social charges. In year zero, the costs with social charges predominate due to the absence of depreciation, as shown in Table 6.

This detailed information about Variable and Fixed Costs is essential for a complete analysis of SAF spending. They allow you to better understand the main components of costs and evaluate how to optimize them over time, contributing to efficient management and maximization of results.

Table 6. Total value of labor per hectare for each activity

Year 0				
Activity	**Unit**	**Price ($)**	**Qty./ha/year**	**Total $/ha**
Construction Site Cleaning	man/day	15,53	2	31,07
Tree Planting	man/day	15,53	5	77,67
Weeding 1	man/day	15,53	2	31,07
Weeding 2	man/day	15,53	4	62,14
Mowing 1	man/day	9,71	1,5	14,56
Total				**216,50**
Year1				
Activity	**Unit**	**Price ($)**	**Qty./ha/year**	**Total $/ha**
Coffee Planting	by seedling	0,05	2.571	119,25
Weeding 1	man/day	14,84	2,00	29,68
Weeding 2	man/day	14,84	2,00	29,68
Total				**178,62**
Term: Year 2 to Year 15				
Activity	**Unit**	**Price ($)**	**Qty./ha/year**	**Total $/ha**
Weeding 1	man/day	14,84	2	29,68
Weeding 2	man/day	14,84	2	29,68
Mowing 1	man/day	14,84	1,5	22,26
Total				**81,63**

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Source: Survey data (2021)

However, total depreciation accounts for 96% of total Fixed Costs in the following periods. Depreciation is a non-disbursable expense that affects cash flow over the time an asset depreciates, i.e., its useful life. The shorter the useful life of the asset, the faster the recovery of the cash flow created by depreciation, as highlighted by Gitman (2010). Tables 9 and 10 show the depreciation values of machinery and implements, based on the useful life of the assets, using the following formula for the calculation, according to Conab (2022):

Depreciation (R$) = {[(Value of the asset (R$)) x (1 – Residual value of the asset (%))] / Useful life in hours} x hours worked per hectare (h/ha).

In addition to the Operating Cost, which is the sum of the Variable Cost and the Fixed Cost, it is necessary to calculate the Factor Income to obtain the Total Cost. This includes the Expected Remuneration on Fixed Capital (RESCF), the Expected Remuneration on Cultivation and the value of the Own Land, as described in Table 7.

These elements are essential to fully understand the costs of operating SAF. The detailed analysis of depreciation and Factor Income provides a comprehensive and accurate view of the Total Cost, allowing an efficient and strategic assessment of financial management over the years.

Table 7. Total Expected Return on Fixed Capital, Total Depreciation, Value of Own Land, Mata do Lobo Company

Machinery and implements	Value of the Asset ($)	RESCF $/Unit.
Portable Derriçador	352,50	0,34
Shaker	1.855,29	1,79
Mulcher with coupling for forage tractor	1.484,23	1,43
KUHN 800 ST SPRAYER YEAR 2016	2.782,93	2,69
Agricultural cart 4 tons	2.226,35	2,15
Irrigation pump	1.020,41	0,99
Depreciation implements	**291,65**	
John Deere 5078E Tractor - year 2015	22.263,45	21,52
Coffee tractor	20.408,16	19,73
Computer	927,64	0,90
Depreciation Machinery	**1.307,98**	
Total Expected Return on Fixed Capital (RESCF)		**51,54**
Total Depreciation	**1.599,63**	
Own Land	**90,86**	
Source: Survey data, 2021.		

Table 7 shows in detail the value of the Expected Remuneration on Fixed Capital (RESCF), which includes machinery, implements, irrigation systems and computers. This value is calculated using the formula provided by Conab (2022):

RESCF (R$/ha) = [(Value of the asset / 2 x annual savings rate (%))] / Hours worked per hectare (h/ha)

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According to Peiró (2021), the value of Bare Land in the region of Rio Verde – GO is 6,266 dollars. This value is used to calculate the cost of owning land through the following formula:

Own Land (R$/ha) = {[(Value bare land (R$/ha) x (annual savings rate (%) / 2)] / crops per year} x percentage of own land (%).

According to Conab (2022), the land remuneration rate is half the annual savings rate. This fee is applied to the sale price of 1 hectare of land without improvements and facilities, suitable for cultivation.

By analyzing Table 8, it is possible to calculate the Crop Exhaustion by adding the costs of year zero and year one, and dividing this sum by the number of years since the beginning of production. This method offers a clear view of depreciation throughout the production cycle.

These guidelines and formulas are crucial to accurately understand and assess the different elements of the cost and profitability of assets under the SAF. By analyzing Tables 7 and 8, it is possible to obtain a comprehensive and detailed view of the financial aspects involved, which facilitates strategic and managerial decision-making.

Table 8. Crop Exhaustion in 15 Years, Mata do Lobo Company

Period	**Custo Total ($)**	**Quant. Years**	**Crop Exhaustion ($)**
Year 0	3.068,41	14	396,54
Year 1	2.483,21		
Total ($)	5.551,62		

Source: Survey data, 2021.

The Expected Remuneration on Cultivation, part of the Factor Income, is calculated based on the value of crop exhaustion, according to Conab's formula (2022).

Cultivation Remuneration ($/ha) = (crop exhaustion/2) * annual savings rate (%)

Crop exhaustion only begins from year 2 as shown in Tables 9 and 10.

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Table 9. Estimate of the Total Cost in R$/hectare of Arabica Coffee in the Agroforestry System in 15 years (year 0 to year 9)

DISCRIMINATION	0	1	2	3	4	5	6	7	8	9
I - COSTING EXPENSES	**Cost $/ hectare**									
1. Activities and Inputs: labor, planting and cultivation	880,10	638,28	156,77	156,77	156,77	156,77	156,77	156,77	156,77	156,77
2 Semi-mechanized harvesting			605,44	605,44	605,44	605,44	605,44	605,44	605,44	605,44
3. Benefit	0,00	0,00	210,00	252,00	226,80	252,00	226,80	252,00	210,00	210,00
4. Others:										
4.1 Soil Analysis	24,27	0,00	0,00	0,00	0	23,19	0,00	0,00	0,00	0,00
5. Miscellaneous Services	19,42	19,42	18,55	18,55	18,55	18,55	18,55	18,55	18,55	18,55
TOTAL COST EXPENSES (A)	**923,79**	**657,69**	**990,76**	**1.032,76**	**1.008**	**1.055,96**	**1.007,56**	**1.032,76**	**990,76**	**990,76**
II - OTHER EXPENSES										
6. Administrative Expenses	27,71	19,73	29,72	30,98	30	31,68	30,23	30,98	29,72	29,72
7. Storage costs		4,75	6,81	9,08	6,81	9,08	6,81	9,08	6,81	9,08
8. Contribution on the Commercialization of Rural Production (2.85%)	0,00	0,00	132,19	174,49	171	206,22	199,87	237,94	185,06	198,28
TOTAL OTHER EXPENDITURE (B)	**27,71**	**24,48**	**168,72**	**214,56**	**208**	**246,98**	**236,91**	**278,01**	**221,60**	**237,09**
III - FINANCIAL EXPENSES										
9. Financing Interest	0,00	0,00	0,00	0,00	0	0,00	0,00	0,00	0,00	0,00
TOTAL FINANCIAL EXPENDITURE (C)	**0,00**	**0,00**	**0,00**	**0,00**	**0**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
VARIABLE COST (A+B+C=D)	**951,50**	**682,18**	**1.159,49**	**1.247,32**	**1.216**	**1.302,93**	**1.244,47**	**1.310,77**	**1.212,37**	**1.227,85**
IV - DEPRECIATION										
10. Depreciation of implements	0,00	291,65	291,65	291,65	291,65	291,65	291,65	291,65	291,65	291,65

11. Depreciation of Machinery	0,00	1.307,98	1.307,98	1.307,98	1.307,98	1.307,98	1.307,98	1.307,98	1.307,98	1.307,98
12. Crop exhaustion	0,00	0,00	396,54	396,54	396,54	396,54	396,54	396,54	396,54	396,54
TOTAL DEPRECIATION (E)	**0,00**	**1.599,63**	**1.996,17**	**1.996,17**	**1.996,17**	**1.996,17**	**1.996,17**	**1.996,17**	**1.996,17**	**1.996,17**
V - OTHER FIXED COSTS										
13. Social Charges	71,51	59,00	26,96	26,96	26,96	26,96	26,96	26,96	26,96	26,96
TOTAL OTHER FIXED COSTS (F)	**71,51**	**59,00**	**26,96**	**26,96**	**26,96**	**26,96**	**26,96**	**26,96**	**26,96**	**26,96**
CUSTO FIXO (E+F=G)	**71,51**	**1.658,63**	**2.023,14**	**2.023,14**	**2.023**	**2.023,14**	**2.023,14**	**2.023,14**	**2.023,14**	**2.023,14**
OPERATING COST (D+G=H)	**1.023,01**	**2.340,80**	**3.182,63**	**3.270,46**	**3.239**	**3.326,07**	**3.267,61**	**3.333,91**	**3.235,50**	**3.250,99**
VI - FACTOR INCOME										
14. Expected return on fixed capital - RESCF	51,54	51,54	51,54	51,54	51,54	51,54	51,54	51,54	51,54	51,54
15. Expected remuneration on cultivation	0,00	0,00	23,79	19,83	19,83	19,83	19,83	19,83	19,83	19,83
16. Own Land	90,86	90,86	90,86	90,86	90,86	90,86	90,86	90,86	90,86	90,86
TOTAL FACTOR INCOME (I)	**142,40**	**142,40**	**166,19**	**162,23**	**162**	**162,23**	**162,23**	**162,23**	**162,23**	**162,23**
CUSTO TOTAL (H+I=J)	**3.068,41**	**2.483,21**	**3.348,82**	**3.432,69**	**3.401**	**3.488,30**	**3.429,84**	**3.496,14**	**3.397,73**	**3.413,22**
Source: Survey data, 2021.										

Table 10. Estimate of the Total Cost in R$/hectare of Arabica Coffee in the Agroforestry System in 15 years (year 10 to year 15)

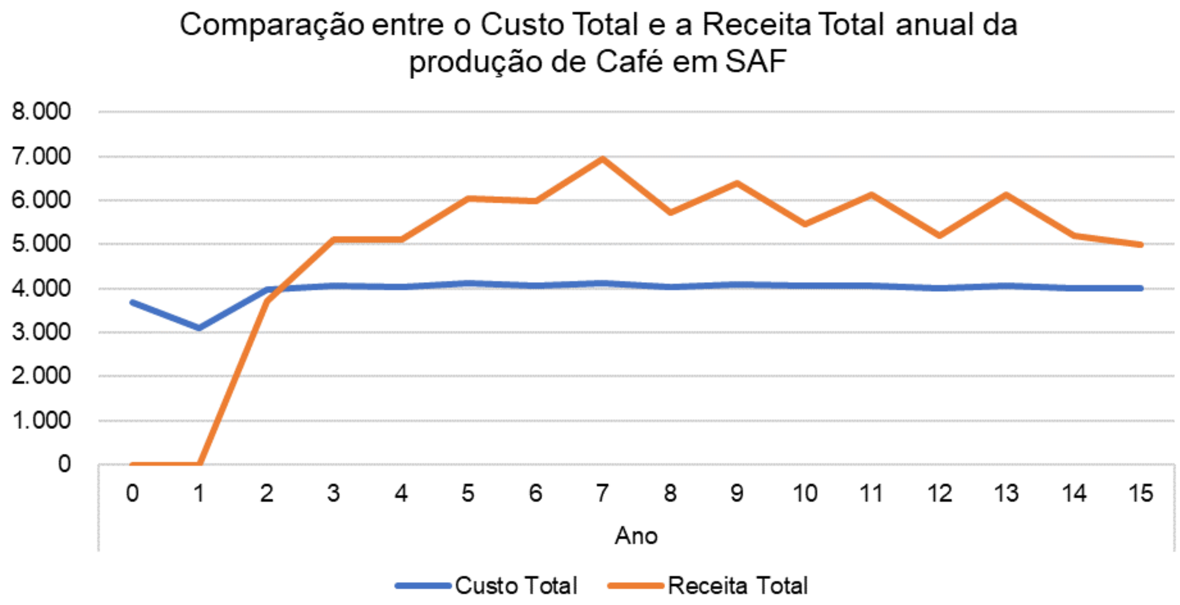
DISCRIMINATION	**10**	**11**	**12**	**13**	**14**	**15**
I - COSTING EXPENSES	**Cost $/ hectare**					
1. Activities and Inputs: labor, planting and cultivation	156,77	156,77	156,77	156,77	156,77	156,77
2 Semi-mechanized harvesting	605,44	605,44	605,44	605,44	605,44	605,44
3. Benefit	210,00	210,00	210,00	210,00	210,00	210,00

4. Others:						
4.1 Soil Analysis	23,19	0,00	0,00	0,00	0,00	0,00
5. Miscellaneous Services	18,55	18,55	18,55	18,55	18,55	18,55
TOTAL COST EXPENSES (A)	**1.013,96**	**990,76**	**990,76**	**990,76**	**990,76**	**990,76**
II - OTHER EXPENSES						
6. Administrative Expenses	30,42	29,72	29,72	29,72	29,72	29,72
7. Storage costs	6,81	9,08	6,81	9,08	6,81	9,08
8. Contribution on the Commercialization of Rural Production (2.85%)	185,06	198,28	185,06	198,28	185,06	198,28
TOTAL OTHER EXPENDITURE (B)	**222,30**	**237,09**	**221,60**	**237,09**	**221,60**	**237,09**
III - FINANCIAL EXPENSES						
9. Financing Interest	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL FINANCIAL EXPENDITURE (C)	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
VARIABLE COST (A+B+C=D)	**1.236,25**	**1.227,85**	**1.212,37**	**1.227,85**	**1.212,37**	**1.227,85**
IV - DEPRECIATION						
10. Depreciation of implements	291,65	291,65	291,65	291,65	291,65	291,65
11. Depreciation of Machinery	1.307,98	1.307,98	1.307,98	1.307,98	1.307,98	1.307,98
12. Crop exhaustion	396,54	396,54	396,54	396,54	396,54	396,54
TOTAL DEPRECIATION (E)	**1.996,17**	**1.996,17**	**1.996,17**	**1.996,17**	**1.996,17**	**1.996,17**
V - OTHER FIXED COSTS						
13. Social Charges	26,96	26,96	26,96	26,96	26,96	26,96
TOTAL OTHER FIXED COSTS (F)	**26,96**	**26,96**	**26,96**	**26,96**	**26,96**	**26,96**
CUSTO FIXO (E+F=G)	**2.023,14**	**2.023,14**	**2.023,14**	**2.023,14**	**2.023,14**	**2.023,14**
OPERATING COST (D+G=H)	**3.259,39**	**3.250,99**	**3.235,50**	**3.250,99**	**3.235,50**	**3.250,99**

VI - FACTOR INCOME						
14. Expected return on fixed capital - RESCF	51,54	51,54	51,54	51,54	51,54	51,54
15. Expected remuneration on cultivation	19,83	19,83	19,83	19,83	19,83	19,83
16. Own Land	90,86	90,86	90,86	90,86	90,86	90,86
TOTAL FACTOR INCOME (I)	**162,23**	**162,23**	**162,23**	**162,23**	**162,23**	**162,23**
CUSTO TOTAL (H+I=J)	**3.421,62**	**3.413,22**	**3.397,73**	**3.413,22**	**3.397,73**	**3.413,22**
Source: Survey data, 2021.						

Having described the values that make up the Total Cost, it can be seen in Graph 6 the Total Cost curve being compared to the Total Revenue curve. The abrupt increase in revenue from year two onwards is noticeable due to the lack of revenues in the period of implementation of the SAF in the period between year zero and year one.

Figure 11. Total Cost and Total Annual Revenue of Arabica Coffee Production in SAF of the Mata do Lobo Company in Rio Verde – GO.



Source: Survey data (2021).

The estimated costs and Total Cost for the production of Arabica coffee in SAF per hectare unit at the Fazenda Mata do Lobo company are shown in Tables 9 and 10. The qualitative and quantitative primary data, provided by the company manager, are equivalent to year zero and year 1, the data from the following years were estimated and the secondary data found in the literature.

The value of the Administrative Expenses was calculated in item 6 of Table 9 using 3% of the Total Costing Expenses. In item 8, Contribution on the Commercialization of Rural Production, 2.85% was calculated on the Gross Revenue from Year 2 onwards.

Table 11 shows the estimated annual revenue according to the average productivity of an Arabica coffee tree (CANAL RURAL, 2016) and the average value of the bag from 2020 onwards (CONAB, 2022). The Variable and Fixed Costs that make up the Total Cost of Table 11 can be verified in Tables 9 and 10. For the discount rate used, the monetary cost of the amount invested in the SAF was considered in relation to possible investments in other segments or activities (GITMAN, 2010), so it was decided to use a Minimum Attractiveness Rate (MAT) of 10% because it is close to the value of the Selic Rate of 9.25% p.a.

Table 11. Summary of Cash Flow and Present Value in 15 years

Annual Period	Revenue ($/ha)	Total Custo ($/ha)	Cash Flow ($/ha)	Minimum Attractiveness Rate (MAT)	Discounted Fluxo ($/ha)	Balance ($/ha)
0	0,00	3.068,41	-3.068,41	10%	-3.068,41	-3.068,41
1	0,00	2.483,21	-2.483,21		-2.257,46	-5.325,87
2	4.638,22	3.348,82	1.289,40		1.065,62	-4.260,25
3	6.122,45	3.432,69	2.689,76		2.020,86	-2.239,40
4	6.011,13	3.401,29	2.609,84		1.782,56	-456,84
5	7.235,62	3.488,30	3.747,32		2.326,79	1.869,96
6	7.012,99	3.429,84	3.583,15		2.022,59	3.892,55
7	8.348,79	3.496,14	4.852,66		2.490,18	6.382,73
8	6.493,51	3.397,73	3.095,78		1.444,20	7.826,93
9	6.957,33	3.413,22	3.544,11		1.503,05	9.329,98
10	6.493,51	3.421,62	3.071,89		1.184,35	10.514,33
11	6.957,33	3.413,22	3.544,11		1.242,19	11.756,51
12	6.493,51	3.397,73	3.095,78		986,41	12.742,92
13	6.957,33	3.413,22	3.544,11		1.026,60	13.769,53
14	6.493,51	3.397,73	3.095,78		815,21	14.584,74
15	6.957,33	3.413,22	3.544,11		848,43	15.433,17

Source: Survey data, 2021.

Table 12 shows the criteria used for the feasibility analysis of coffee cultivation in AFS at the company Fazenda Mata do Lobo. To be considered viable, the project must have an IRR greater than 10%, an NPV greater than zero at an interest rate of 10% p.a.

Table 12. NPV and IRR Statement on the Cash Flow of Arabica Coffee Production in SAF at Mata do Lobo

Indicators	Criteria for Feasibility	Reference Value		Status
Internal Rate of Return (%)	TIR > TMA*	38,97		Feasible
Liquid Present Value ($)	VPL > 0 (TJ = 10 %)	15.433,17		Feasible

*TMA – Minimum Attractiveness Rate 10%.
Source: Survey data, 2021.

The data in Table 13 were collected from government and academic websites, which released values for the period from 2013 to 2021, enabling the estimation of the Cash Flow of Arabica coffee production in a conventional system.

The average price of a bag of Arabica coffee per hectare, in Table 13, was calculated according to Cepea/Esalq/USP (2022) with data released from 2020 and converted to the average annual dollar quoted in 2021.

The values of the Total Cost in Table 13 were converted into dollars, at the average quotation of the year of the referred cost, based on Table 14. For example, the Total Cost of year 2 was estimated from the data released by Conab in the Arabica Coffee Historical Series, so the Total Cost of year 2 represents the Total Cost of 2013 converted to the average dollar value of that same year, so the other total costs were calculated following the annual sequence until the year 2021.

Table 13. Summary of the Simulation of Cash Flow and Present Value of Arabica Coffee Production in Cristalina – GO Cultivated in the Period of 15 years in a conventional system

Annual Period	Average productivity (Sc/ha)	Average price of Sc/ha	Revenue (R$/ha)	Total Custo ($/ha)	Cash Flow ($/ha)	TMA a.a.	Discounted Fluxo ($/ha)	Balance ($/ha)
0		**0**	0,00	4.422,08	-4.422,08		-4.422,08	-4.422,08
1		0	0,00	4.470,23	-4.470,23		-4.063,85	-8.485,93
2		185,53	10.204,08	4.422,08	5.782,00		4.778,51	-3.707,42
3		204,08	11.224,49	4.470,23	6.754,26		5.074,57	1.367,16
4		222,63	12.244,90	5.488,64	6.756,26		4.614,62	5.981,77
5		241,19	13.265,31	5.060,30	8.205,00		5.094,66	11.076,43
6		259,74	14.285,71	5.747,17	8.538,55		4.819,79	15.896,22
7	55	278,29	15.306,12	5.094,02	10.212,10	10 %	5.240,42	21.136,65
8		259,74	14.285,71	4.106,75	10.178,96		4.748,56	25.885,21
9		278,29	15.306,12	3.103,65	12.202,47		5.175,04	31.060,25
10		259,74	14.285,71	2.965,45	11.320,26		4.364,45	35.424,70
11		278,29	15.306,12	2.965,45	12.340,67		4.325,33	39.750,03
12		259,74	14.285,71	2.965,45	11.320,26		3.606,98	43.357,01
13		278,29	15.306,12	2.965,45	12.340,67		3.574,65	46.931,66
14		259,74	14.285,71	2.965,45	11.320,26		2.980,98	49.912,64
15		278,29	15.306,12	2.965,45	12.340,67		2.954,26	52.866,90

Source: Prepared by the author with data from Conab, 2016; Conab, 2021; Cepea/Esalq/USP, 2022.

Next, you can see table 14 with the average annual values of the dollar. This data was used to convert total costs to dollars, as detailed in other sections of the study. The table allows for a clear understanding of currency fluctuations and their impact on costs over the years.

Table 14. Annual dollar exchange rate

	2015		2016		2017		2018		2019		2020		2021	
	Purchase | Sale		Purchase | Sale		Purchase | Sale		Purchase | Sale		Purchase | Sale		Purchase | Sale		Purchase | Sale	
JAN	2,634	2,634	4,051	4,052	3,196	3,21	3,21	3,216	3,733	3,734	4,16	4,161	5,358	5,359
FEB	2,816	2,817	3,973	3,974	3,103	3,104	3,241	3,242	3,723	3,723	4,326	4,327	5,416	5,417
MAR	3,139	3,14	3,703	3,704	3,127	3,128	3,279	3,279	3,845	3,846	4,883	4,884	5,645	5,645
APR	3,043	3,043	3,565	3,565	3,135	3,136	3,41	3,41	3,897	3,897	5,325	5,326	5,562	5,562
MAY	3,061	3,062	3,538	3,539	3,208	3,209	3,642	3,642	4,001	4,002	5,64	5,641	5,293	5,294
JUN	3,111	3,112	3,423	3,424	3,294	3,295	3,772	3,773	3,858	3,859	5,211	5,212	5,03	5,031
JUL	3,223	3,223	3,274	3,275	3,205	3,206	3,828	3,828	3,775	3,78	5,28	5,28	5,156	5,157
AGO	3,514	3,514	3,209	3,21	3,15	3,15	3,929	3,929	4,004	4,005	5,461	5,461	5,251	5,252
SET	3,906	3,906	3,255	3,256	3,134	3,135	4,118	4,118	4,117	4,117	5,399	5,4	5,279	5,28
OUT	3,88	3,88	3,185	3,186	3,19	3,191	3,758	3,758	4,083	4,084	5,62	5,621	5,539	5,54
NOV	3,776	3,776	3,341	3,342	3,258	3,259	3,786	3,786	4,153	4,153	5,417	5,418	5,545	5,556
TEN	3,87	3,871	3,352	3,352	3,291	3,292	3,883	3,884	4,131	4,131	5,145	5,146	5,652	5,653
Annual average	3,3311	3,3315	3,4891	3,4899	3,1909	3,1929	3,6547	3,6554	3,9433	3,9443	5,1556	5,1564	5,3938	5,3955

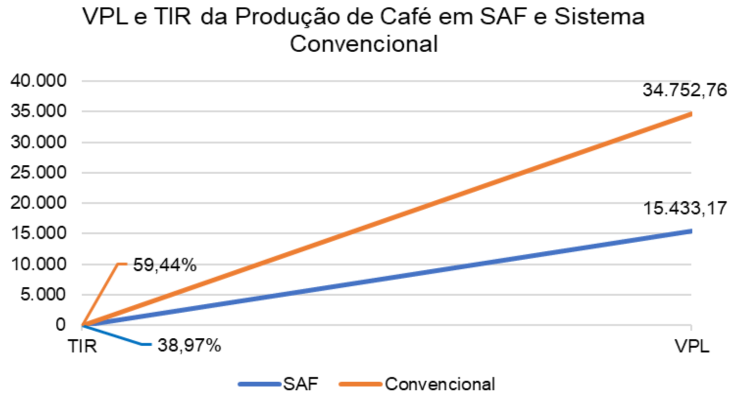
Table 15 shows the criteria used for the feasibility analysis of coffee cultivation in a conventional system. The TMA of 10% based on the Selic Rate of 9.25% p.a. was considered to verify the feasibility of the project. Thus, to be considered viable, the project must have an IRR greater than 10% and an NPV greater than zero at an interest rate of 10% p.a.

Table 15. Statement of NPV and IRR on the Cash Flow of Arabica Coffee Production in Conventional System at Mata do Lobo Company.

Indicators	**Criteria for Feasibility**	**Reference Value**	**Status**
Internal Rate of Return (%)	TIR > TMA*	59,44	Feasible
Liquid Present Value ($)	NPV > 0 (TJ = 10%)	34.752,76	Feasible
*TMA – Minimum Attractiveness Rate 10%. Source: Prepared by the author, 2022.			

In Figure 12 it is possible to observe when the IRR equals the NPV to zero, that is, when the NPV of the SAF is equal to zero the IRR will be 38.97% and when the NPV of coffee cultivation in a conventional system is equal to zero the IRR will be 59.44%, therefore, investments will only be more profitable than coffee cultivation if they provide gains above 38.97% or 59.44% per year.

Figure 12. Comparison between NPV and IRR on Coffee Production in SAF and Conventional System.



Source: Survey data (2021).

The results shown in Figure 12 showed that coffee production, both in the SAF production system and in the conventional system, are economically viable, however the rural producer will be able to make the best decision, also based on technical, agronomic and sustainable aspects which were not addressed in the present research.

FINAL CONSIDERATIONS

This paper presents indicators and references capable of guiding researchers, technicians and rural producers on the economic evaluation of a coffee cultivation project in an Agroforestry System. However, there are inexhaustible strands of studies on APS in the literature, therefore, it is worth mentioning that this research addresses the economic and financial issue, however, according to Consenza et. al., (2016), the feasibility of the System to be complete must cover the social and technical issue, in addition to being subject to current legislation when it comes to proposals for protected areas.

The authors Consenza et. al., (2016) emphasize that in addition, it is necessary to promote environmental benefits, which can generate gains and recognition from society, and agronomic advantages.

Machado et. al., (2020) highlight the agronomic factors enhanced in the Agroforestry System as some advantages for plant development: minimizing extreme temperatures, reducing weed infestation, enabling nutrient cycling, in addition to providing a second source of income for the producer for the use of tree species.

CONCLUSION

The Arabica coffee cultivation systems in SAF and conventional were economically viable according to the analysis criteria studied, and the conventional cultivation system was the most profitable and presented the best results for IRR and NPV. However, the AFS cultivation system should not be discarded, which, in addition to being a highly profitable investment, has factors that go beyond the economic and financial aspects.

According to Machado et. al. (2020) intercropping with other crops has been gaining space and being researched, both from an economic and sustainable point of view, since there is concern with soil, water, productivity and the environment.

In this way, the research can be directed to sustainable environmental gains with coffee production in SAF, adding value to the products from this cultivation system.

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