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ECONOMIC FEASIBILITY AND MONTE CARLO SIMULATION IN NURSERY FOR NATIVE FOREST SEEDLING PRODUCTION IN THE SOUTHWEST REGION OF BAHIA, BRAZIL

Débora Caroline Defensor Benedito[1], Kemele Cristina Coelho[2], Adalberto Brito de Novaes[3], Vânia Beatriz Cipriani[4], Natália Saudade de Aguiar[5], Liniker Fernandes da Silva[6]

[1*]Federal University of Paraná, Department of Forest Science, Curitiba, Paraná, Brazil - debora_defensor@outlook.com[*]
[2]Southwestern Bahia State University, Department of Forest Science, Vitória da Conquista, Bahia Brazil - kemelecristinacoelho845644@gmail.com
[3]Southwestern Bahia State University, Department of Forest Science, Vitória da Conquista, Bahia Brazil - adalberto@uesb.edu.br
[4]State University of Mato Grosso do Sul, Department of Forest Science, Aquidauana, Mato Grosso do Sul, Brazil - vania.cipriani@uems.br
[5]Federal University of Paraná, Department of Forest Science, Curitiba, Paraná, Brazil - talia.saguiar@yahoo.com.br
[6]Federal University of Recôncavo da Bahia, Department of Forest Science, Cruz das Almas, Bahia, Brazil - liniker@ufrb.edu.br

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Resumo

Viabilidade econômica e simulação de Monte Carlo em um viveiro de produção de mudas florestais nativas na região Sudoeste da Bahia, Brasil. Os viveiros de mudas florestais são projetos que requerem um alto investimento inicial. Portanto, torna-se ainda mais importante a avaliação detalhada da viabilidade econômica e dos riscos que podem influenciar os resultados. Este trabalho teve como objetivo analisar a viabilidade de implantação de um viveiro florestal de mudas de espécies nativas em Vitória da Conquista, BA, Brasil, visando atender à demanda de mudas da região. O estudo foi realizado simulando um projeto de implantação de um viveiro de mudas nativas, com capacidade produtiva de 415.904 mudas por ano. Foi utilizado um horizonte de planejamento de 10 anos e uma taxa de juros de 8% ao ano para analisar a viabilidade econômica do fluxo de caixa do empreendimento. Os seguintes indicadores de viabilidade econômica foram calculados com o Microsoft Excel®: Valor Presente Líquido (VPL); Taxa Interna de Retorno (TIR); Relação Custo Benefício (B/CR); Valor Periódico Equivalente (VPE); e Custo Médio de Produção (APC). O Excel® também foi usado para realizar uma simulação de Monte Carlo para avaliação de risco, que consistiu em executar 10.000 interações. As variáveis de entrada foram a taxa de sucesso da produção de mudas, o preço de venda das mudas e o custo da mão de obra. O VPL foi a variável de saída. Os resultados indicaram a viabilidade de todos os indicadores econômicos calculados. A simulação de Monte Carlo indicou uma probabilidade lucrativa de 82,46%. A avaliação econômica e a avaliação de risco apontaram a viabilidade de implantação de um viveiro de mudas de espécies florestais nativas no sudoeste da Bahia.
Palavras-chave: Avaliação de risco, simulação estocástica, indicadores econômicos, cadeia produtiva, sustentabilidade ambiental

Abstract

Forest seedling nurseries are projects that require a high initial investment. Therefore, a detailed evaluation of economic feasibility and the risks that may influence outcomes becomes even more crucial in such ventures. This study aimed to analyze the feasibility of establishing a forest nursery for native species seedlings in Vitória da Conquista, BA, Brazil, to meet the region's demand for seedlings. The study was conducted by simulating a nursery project with an annual production capacity of 415,904 seedlings. A planning horizon of 10 years and an 8% annual interest rate were used to analyze the economic feasibility of the enterprise's cash flow. The following economic indicators were calculated using Microsoft Excel®: Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost Ratio (BCR), Equivalent Annual Value (EAV), and Average Production Cost (APC). Excel® was also used to perform a Monte Carlo simulation for risk assessment, consisting of 10,000 iterations. Input variables included seedling production success rate, seedling selling price, and labor cost, with NPV as the output variable. The results indicated the feasibility of all calculated economic indicators. The Monte Carlo simulation showed a profitable probability of 82.46%. The economic evaluation and risk analysis demonstrated the viability of establishing a nursery for native forest species seedlings in southwestern Bahia.
Keywords: Risk assessment, stochastic simulation, economic indicators, production chain, environmental sustainability

INTRODUCTION

The production of native and/or exotic forest species seedlings can be performed in forest nurseries, which are physical facilities where operational activities are concentrated until they are large enough to be deployed in the field (EMBRAPA, 2016). Research conducted by Ipea (2015) found that the state of Bahia has 44 operational nurseries dedicated to the production of native forest seedlings. However, this number is insufficient to meet the region's demand. The importance of forest nurseries not only lies in their environmental character, meaning in the

production of seedlings used in plantations, but also in their economic and social consequences, since this activity generates jobs and products that drive the local economy (MENDONÇA, 2017). Hence, the importance of studies aimed at the construction and economic viability of these production units as an income source and generation of social and environmental benefits is evident.

However, it is necessary to carry out technical, economic, and social analyses to successfully implement a forest nursery. Conducting a feasibility study for economic analysis requires the collection and processing of specific data. Once processed, this information generates results that are analyzed to estimate production costs based on the cost structure. In this sense, it is essential to prepare a feasibility project. For Muños *et al.* , (2016), the viability and profitability of a project can be evaluated from different perspectives, but the dimension that automatically presents itself is the economic one. According to Rezende and Oliveira (2013), the main economic analysis methods for evaluating forestry projects are Net Present Value (NPV), Internal Rate of Return (IRR), Average Production Cost (APC) and Benefit/Cost Ratio (B/CR).

Risk assessment is used as a methodology to study the feasibility and recognize the variables that can cause possible damage to the enterprise. Monte Carlo Simulation is an effective and accurate method for risk analysis. This methodology simulates scenarios and is able to identify the uncertainties inherent in the activities of an enterprise and transform them into calculated risks (MOREIRA *et al.* , 2017).

Despite the importance and need for seedling production nurseries, there are still few feasibility studies for implementing this type of enterprise in the southwest region of Bahia, which highlights the importance of economic analysis in implementing these production units in the mentioned region.

In view of the above, this study aimed to study the feasibility of implementing a forest nursery of native forest species seedlings in the municipality of Vitória da Conquista, BA, Brazil, to meet the demand of the southwest region of Bahia.

MATERIAL AND METHODS

The municipality of Vitória da Conquista, located in the state of Bahia, Brazil, was chosen as the study's base area. Situated at an altitude of 939 m, with an average annual temperature of 21ºC, and annual rainfall of 850 mm. The region has typical vegetation that is dense submontane rainforest, seasonal semideciduous forest, and seasonal deciduous forest (CAIRES *et al.* , 2021).

This simulation was carried out considering a nursery with a total area of 6,940 m² (100.0 m long and 69.4 m wide), with production capacity for 138,634 native forest species seedlings. Considering three annual production rotations with maximum production capacity, this nursery will have the potential to produce 415,902 seedlings/year. The data were defined based on the production capacity deemed necessary to meet the demand for seedlings in the region. The total area is divided into productive area and building area.

The productive area will represent 40% of the nursery area (2,772 m²) with three blocks; blocks I and II will be structured for the seedling production system in plastic bags and block III for tube-type containers. The plastic bags for seedling production will have four dimensions (26.0 x 19.5 cm; 20.0 x 14.0 cm; 21 x 10.0 cm; and 14.5 x 8.5 cm), and the substrate will be composed of subsoil soil (60%) and bovine manure (40%), while the fertilization system will be composed of dolomitic limestone and NPK. The tubes for seedling production will be packed in polyethylene trays and will have a volumetric capacity of 288 m³, filled with commercial substrate fertilized with osmocote fertilizer.

The building area will represent 60% of the nursery area and will correspond to the non-productive area, totalling 4,164.29 m². A storage shed for inputs and tools, the nursery house, water reservoirs, office, parking, and restrooms will be built in this area, in addition to small free areas for the purpose of expansion and hardening the seedlings in full sun.

The cost estimate was performed through data collection considering a survey of all costs inherent to the project to build a nursery. The costs were divided into material costs, physical investments, depreciation and other costs, based on Rezende and Oliveira (2013).

The costs of seeds, substrates, fertilizers, containers for seedling production, insecticide and fungicide were all considered in surveying the costs of materials. Investment costs, also known as acquisition cost, corresponded to tools and equipment, irrigation system, utility vehicle, office supplies, and buildings, among others. The annual cost of the land was calculated taking into account an interest rate of 8% p.a, which is the usual rate for the region. The building costs were calculated considering the cost of square meter (m²) built in the Bahia region. Depreciation cost was calculated for all durable goods, being a process that records the loss of value over its useful life (VIEIRA *et al.* , 2016). Other costs such as labor, electricity, internet, telephone, nursery maintenance, insurance, gasoline, records, legalization, advertising, and eventual expenses, etc. were also considered.

Revenues were estimated according to the nursery's productive capacity considering three four-month production cycles and the nursery's production capacity of 415,903 seedlings/year. However, a 10% reduction in annual production was considered, resulting from seedlings that do not present desirable characteristics to be taken to the field; thus, the annual production capacity is 374,313 seedlings, which represents 90% production. A period of four months was considered for establishing the nursery structure in year zero of the enterprise, thus reducing the seedling production cycle in that year, and consequently its revenue. The commercialization value of each seedling varies according to the species. Thus, an average value of R$3.00 per seedling was considered to estimate the project's revenue. The project's planning horizon was 10 years.

A cash flow was prepared with estimated revenues and costs within the planning horizon for the economic viability analysis. Material costs, durable goods acquisition costs and other costs (which normally occur monthly, such as salaries and maintenance) were added in year zero. Depreciation costs for durable goods were added from year 1 to year 10, in addition to material costs along with other costs. The following economic viability indicators were calculated using these data and the Microsoft Excel® program: Net Present Value, Internal Rate of Return, Benefit/Cost Ratio, Equivalent Periodic Value and Average Production Cost. Esses indicadores foram calculados, considerando uma taxa de juros de 8% p.a de acordo com Rezende and Oliveira (2013).

The Monte Carlo Simulation was used in the risk analysis to perform probability projections. The Excel® program was used for this analysis with the inclusion of the Mersenne Twister complement to perform the random distribution, where 10,000 cash flows were generated. A range of values was defined for the random generation of numbers from the cash flow. Three input variables (risk variables) were selected, namely: the seedling production success rate; selling price of seedlings; and labor price. These variables were selected due to their significant impact on the company's revenues and costs.

The seedling production success rate ranged from 80% to 100% and continuous uniform probability distribution was used. Normal distribution was used for the seedling price variable, considering a standard deviation of +-R$1. Normal distribution was also used for the labor price variable, with an average variation factor equal to 1 being used due to the variation in the price of the hour of work of each worker class, with a standard deviation of +- 10%. These values were defined based on the nature of each input variable and their potential variations. The NPV economic viability indicator was used as the model's output variable, as it is commonly applied in long-term investment analyses, according to Simões *et al.* (2015).

RESULTS

Cost and revenue estimates

The costs with physical investments presented the highest expenditures of the enterprise, while the costs with depreciation presented the lowest values when compared with the other cost categories (Table 1).

Table 1. Distribution of costs of a seedling production nursery in the municipality of Vitória da Conquista, BA, Brazil.
Tabela 1. Distribuição de custos de um viveiro de produção de mudas no município de Vitória da Conquista, BA, Brasil.

	Costs (R$)
Aquisition	1,110,861.87
Materials	253,713.96
Depreciation	83,036.21
Others	217,650.00
Total	1,665,262.04

Source: Elaborated by the author (2022).

Table 2 shows the productive capacity of the nursery and the simulation of generated revenues considering the unit value of R$3.00 for the sale of seedlings.

Table 2. Production capacity of the seedling nursery and income considering a rate of 100% and 90% success in production and commercialization in the municipality of Vitória da Conquista, BA, Brazil.
Tabela 2. Capacidade produtiva do viveiro de mudas e receitas considerando uma taxa de 100% e 90% de sucesso na produção e comercialização no município de Vitória da Conquista, BA, Brasil.

	100% production	**90% production**
Seedlings/rotation	138,634	124,771
Seedlings/year	415,903	374,313
Revenue/rotation	R$415,903.45	R$374,313.10
Revenue/year	R$1,247,710.34	R$1,122,939.31

Source: Elaborated by the author (2022).

Economic analyses

The cash flow was prepared by surveying the costs and revenues of the enterprise (discounted for year zero) according to the 10-year planning horizon (Table 3). The cash flow was negative in the initial year of the project due to acquisition costs and lower revenue, attributed to the smaller amount of seedlings produced because of the time taken to establish the nursery structure. Cash flow became positive in subsequent years as revenues exceeded costs due to the increase in seedling production, indicating the financial return.

Table 3. Cash flow of a nursery for producing forest seedlings in the municipality of Vitória da Conquista, Bahia, Brazil.
Tabela 3. Fluxo de caixa de um viveiro de produção de mudas florestais no município de Vitória da Conquista, Bahia, Brasil.

Year	**Decapitalized costs (R$)**	**Decapitalized revenues (R$)**	**Cash flow (R$)**
0	1.582.225,83	748.626,21	-833.599,62
1	513.333,49	1.039.758,62	526.425,13
2	475.308,79	962.739,46	487.430,67
3	440.100,73	891.425,43	451.324,70
4	407.500,68	825.393,92	417.893,24
5	377.315,44	764.253,63	386.938,18
6	349.366,15	707.642,25	358.276,10
7	323.487,18	655.224,30	331.737,13
8	299.525,16	606.689,17	307.164,01
9	277.338,11	561.749,23	284.411,12
10	256.794,55	520.138,18	263.343,63
Total	5.302.296,10	8.283.640,39	2.981.344,28

Source: elaborated by the author (2022).

The cash flow balance is represented in Figure 1, in which the effects of the initial investment costs in year zero and the reduction of a rotation of seedling production are evidenced, making the cash flow negative. The cash flow is gradually reduced in the following years due to the decapitalization of these values for the base year (zero).

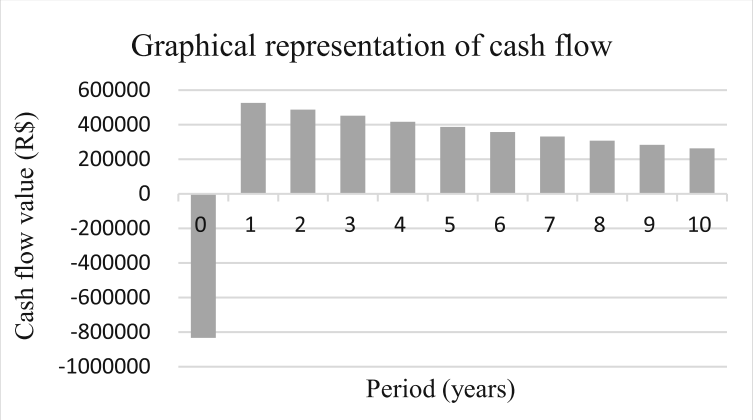

Figure 1. Cash flow balance from the sale of native seedlings in a nursery located in the municipality of Vitória da Conquista, Bahia, Brazil.
Figura 1. Saldo do fluxo de caixa proveniente da venda de mudas nativas em um viveiro localizado no município de Vitória da Conquista, Bahia, Brasil.
Source: elaborated by the author (2022).

All indicators evaluated indicated the feasibility of the enterprise at an interest rate of 8% p.a. (Table 4). The NPV, which corresponds to the return on capital during the planning horizon, was greater than zero. Thus, the value found is a positive indicator when analyzing the attractiveness of the project vis-à-vis the financing agent, which, in addition to showing feasibility, also acts as a profitability security indicator. However, other indicators, such as IRR, B/CR, EPV and APC must be analyzed in the decision making of implementing the enterprise.

Table 4. Economic viability indicators of a nursery for producing forest seedlings in the municipality of Vitória da Conquista, Bahia, Brazil.
Tabela 4. Indicadores de viabilidade econômica de um viveiro para produção de mudas florestais no município de Vitória da Conquista, Bahia, Brasil.

Economic viability indicators	Value
NPV (R$)	2.981.344,28
IRR (%)	56,02
B/CR	1,56
EPV (R$)	238.505,38
APC (R$)	2,11

Source: elaborated by the author (2022).

The IRR proved to be advantageous in view of the characteristics provided about the enterprise, since its value (56.02%) exceeded the project's interest rate (8%). The higher the IRR in relation to the interest rate, the more interesting the project is from a financial point of view. In evaluating the viability of a nursery for the production of native Cerrado seedlings, Santos *et al.* (2013) found similar results (IRR = 57.02%) and highlighted that high IRR values are common in this type of enterprise.

The B/CR of the project was 1.56, indicating that revenues were 56% higher than costs, meaning that for every R$1.00 invested in the project, there is a return of R$1.56, indicating the viability of the enterprise, as the value is greater than 1. Thus, the greater the value of this ratio, the more profitable the project.

The EPV indicated the feasibility of the enterprise, in which its value was greater than zero, since the higher its value, the more attractive the project will be. This indicator makes it possible to compare projects with different planning horizons, since its value consists of annual installments of the NPV.

The average seedling production cost may vary according to the technology and inputs used, and the value found in this project (R$2.11) is consistent with the nursery infrastructure. The APC was lower than the market value of the seedlings, making the project viable.

Risk analysis

The Monte Carlo Simulation was used to conduct the risk analysis, in which simulations of scenarios of NPV values were generated considering the variables studied for the seedling production activity (Table 5).

Table 5. Statistics of NPV variables for the production of native forest seedlings in southwest Bahia, Brazil.
Tabela 5. Estatísticas das variáveis do VPL para a produção de mudas florestais nativas no sudoeste da Bahia, Brasil.

NPV statistics	
Minimum	-R$5,645,708.43
Maximum	R$13,250,570.82
Mean	R$2,896,856.55
Median	R$2,765,106.25
Standard deviation	R$2,960,794.47
Mean - standard deviation	-R$63,937.92
Mean + standard deviation	R$5,857,651.02
NPV > 0	82.46%
NPV < 0	17.54%
Percentiles	
5%	-R$1,696,023.17
10%	-R$828,742.48
15%	-R$268,106.37
20%	R$239,032.37
25%	R$703,122.23
50%	R$2,765,106.25
95%	R$7,926,121.21

Source: elaborated by the author (2022).

It was observed that 5% of the percentile values were below -R$1,696,023.17 and 5% above R$7,926,121.21, with the probability of occurrence of negative NPV values being equal to 17.54 %.

A graphical representation of the distribution probability of the project's NPV can be seen in Figure 2.

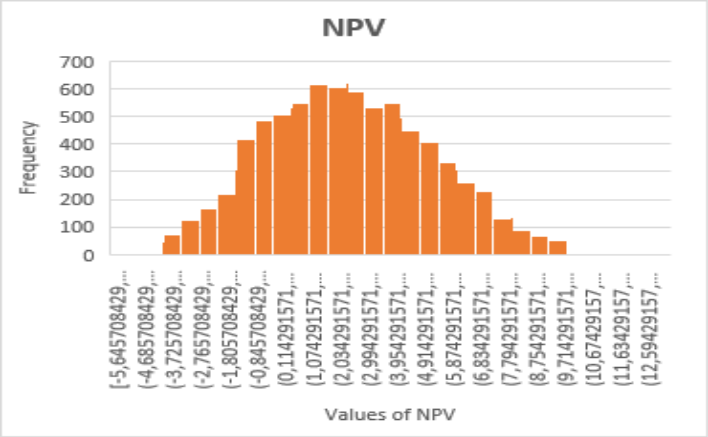

Figure 2. Probability of NPV distribution for the production of native forest seedlings in southwest Bahia, Brazil.
Figura 2. Probabilidade de distribuição do VPL para a produção de mudas florestais nativas no sudoeste da Bahia, Brasil.
Source: elaborated by the author (2022).

The NPV values are symmetrically distributed around the mean, and the mean values are close to the median, not tending to slope sharply to the sides, indicating characteristics similar to the normal distribution. Thus, 68% of the data is between the NPV values of -63,938 and 5,857,651.

DISCUSSION

The cost of materials was the most representative considering only the annual costs of the enterprise. According to Santos *et al.* (2013), the acquisition of raw material is a constant and representative expense in seedling production costs and it is recommended to carefully search for suppliers that provide quality products with better prices and negotiate to reduce its cost, thus increasing the chances of economic viability of the project.

When analyzing four nurseries for forest seedling production, Vasconcelos *et al.* (2012) found that proper cost management is essential for their economic success, since the enterprise demands detailed planning. The authors state that the costing method is an excellent tool for valuing the costs of seedling lots, enabling the economic control of production processes. This tool makes it possible to monitor the evolution of costs, enables defining the most profitable products with the greatest demand and the most expensive, favoring management of the activity in a supported way.

Cost management is essential for the economic success of any business, as it avoids underestimating production lots and controls expenses. Thus, a cost survey must be conducted meticulously, and its underestimation or overestimation can directly affect the viability of the enterprise. According to Dias (2011), the profitability of a nursery depends on the production system adopted. In addition to interfering with the quality of the seedlings, the production system determines the final success of the product, taking into account that poorly developed seedlings will subsequently result in lower quality, longer crop cycles and an increase in production cost (RODRIGUES et al, 2020). Based on the results of this study, the cost assessment and revenue management processes proved to be efficient, ensuring the economic viability of the project.

According to Assaf Neto (2016), the APC corresponds to the minimum price for selling the seedling, where the project reaches a break-even point without obtaining profits or losses. IPEA (2015) carried out a survey of the average production cost of 147 nurseries of native seedlings in Brazil and found values ranging between R$1.21 and R$2.53, with greater variation in the North and South regions. The average cost of producing native seedlings is usually higher than the production costs of exotic species. In working with eucalyptus seedlings, Simões and Silva (2010) found an APC of R$0.13, while IPEA (2015) obtained the value of R$1.94 per unit produced of native species. These values may be related to the precariousness of technologies and the slow progress of genetic improvement for producing native species, which is reflected in an increase of costs when compared with exotic species.

Through the economic evaluation, it was possible to analyze a nursery for producing native forest seedlings and to characterize the distribution of costs, the magnitude of revenues and their influence on the feasibility of the enterprise. Economic viability indicators are essential elements to predict the behavior of forestry projects and are able to indicate the profitability and the probability of successful implementation (REZENDE and OLIVEIRA, 2013). A study by Bonfatti Júnior *et al.* (2019) in a nursery for the production of yerba mate seedlings showed positive values for all economic viability indicators used (B/CR, APC, IRR and NPV); the authors emphasize that this type of venture has high success rates of return on capital even in the worst scenarios. This may be related to the low seedling production cost and the tendency to obtain high revenues according to their market price. This information is essential for decision making regarding the implementation of a project of this nature, providing security regarding the return on invested capital.

Uncertainties in the cash flow were considered to assess the risks of the project, meaning that the estimates of costs and revenues related to the production of forest seedlings of native species are considered sources of risk, since there are inaccuracies in relation to these values. Thus, since the NPV is an estimate derived from the survey of costs and revenues, the greater the uncertainty of these values, the greater the uncertainty of the NPV.

Silveira *et al.* (2014) considers that the results of the simulations would indicate a safe project when the probability of obtaining a positive NPV proved to be very high, equivalent to 70.8%, thus indicating that the present project is safe and has a probability of a profit of 82,5%. However, the decrease in the average of NPV values equivalent to one standard deviation would be enough to make the implementation of the forest nursery economically unfeasible, since this indicator would become negative.

The data dispersion around the mean, represented by the standard deviation, allowed the occurrence of negative values for the NPV. According to Rezende and Oliveira (2013), positive NPV values indicate a direct relationship between project risk variables, while the relationship occurs in an inverse way for negative values.

The production of native forest seedlings proved to be a low-risk activity. However, an oscillation of 20% in the seedling production success rate, in the commercialization price or in the labor price can make the activity unfeasible, since an alteration of these variables commonly has significant impacts on the project's cash flow and may make it negative. Coelho (2016) reports that risk is a subjective variable and it is up to the manager to analyze it. Therefore, assertive decision making depends on knowledge of market conditions, in addition to the availability of reliable information.

According to Viana et al (2013) if the decisions are taken based on the application of the Monte Carlo method and this presents a probability of 50% the producer is able to count on a range of information that will help in the decisions about the viability of the enterprise.

The demand for native forest seedlings in Brazil is growing. However, there is a shortage of nurseries with a large production capacity to meet the demands of the regions. Since the "Green Revolution" in the 1960s, the national scenario has been suffering from the degradation of native vegetation. Laws were simultaneously developed which required compensation for damages, which heated up the market for seedlings and seeds of native species due to the increase in restoration projects and recovery of degraded areas (FREIRE, 2017).

National planning for the recovery of ecosystems is a contributing factor for seedling production and seeds from different Brazilian biomes, generating promising expectations for the sector. However, there are still flaws in the large-scale production chain, requiring adjustments to unite government programs and the actors involved in this process.

CONCLUSION

- The project to implement a forest nursery for native species seedlings in the southwest region of Bahia is economically viable.
- Through the Monte Carlo Simulation, it was possible to observe that the risks of the enterprise are low.
- The cost survey indicated the need for a high initial investment, but on the other hand, revenues exceeded costs.

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