ECONOMIC FEASIBILITY ANALYSIS OF A FOREST-LIVESTOCK INTEGRATION SYSTEM IN ALTA FLORESTA, MATO GROSSO STATE, BRAZIL

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Resumo

Análise econômica de um sistema de integração pecuária-floresta localizado em Alta Floresta, estado de Mato Grosso. Este estudo teve como objetivo analisar a viabilidade econômica de um sistema de integração pecuária-floresta com gado Nelore e teca, localizado na Fazenda Bacaeri, município de Alta Floresta, Mato Grosso, Brasil. A análise econômica foi baseada no conjunto de dados fornecido pela Embrapa Agrossilvipastoril e usada para elaborar um fluxo de caixa para cálculo do Valor Presente Líquido, Taxa Interna de Retorno e Índice de Rentabilidade, sendo a Taxa Mínima de Atratividade usada de 4,15 % ao ano. A análise de risco também foi realizada pelo método probabilístico de Monte Carlo, considerando sete variáveis, sendo elas o preço da madeira no corte raso e no desbaste, preço de venda do boi magro, custo de aquisição de animais e da colheita florestal, produtividade no desbaste e no corte raso. O conjunto de indicadores analisados indicaram a viabilidade econômica desse projeto, com VPL de R$ 4.083.307,77, TIR de 6,48% a.a., e IL no valor de 21,36%. A análise de risco indicou baixo risco envolvido nesse projeto, com uma probabilidade de 14,4% do VPL ficar negativo. No entanto, não importa quão eficientes sejam as ferramentas de previsão de riscos, os produtores devem ter assistência técnica de profissionais treinados para interpretar e mitigar adequadamente os riscos. O sistema de integração floresta-pecuária estudado é economicamente viável e de baixo risco.
Palavras-chave: sistema integrado de produção, indicadores econômicos agrícolas, simulação de Monte Carlo.

Abstract

This study investigates the economic feasibility of a livestock-forest integration system between Nellore cattle and teak species implemented in Fazenda Bacaeri, in the municipality of Alta Floresta, Mato Grosso state, Brazil. The economic analysis was based on the dataset provided by the Embrapa Agrossilvipastoril and used to elaborate a cash flow, as well as on the following selected criteria, Net Present Value, Internal Rate of Return, and Profitability Index, for a Minimum Attractive Rate of 4.15% annually. The risk analysis was also carried out using the Monte Carlo probabilistic method, considering seven variables, such as the clearcut and thinning wood price, lean cattle selling price, animal acquisition and forest harvesting costs, thinning and clearcutting yield. The calculated analyzed economic indexes are as follows R$ 4,083,307.77 NPV, 6.48% IRR and 21.36% PI, which indicates the economic feasibility of the studied integration system. The risk analysis shows that this is a low-risk project since the probability of NPV being negative was calculated as 14.4%. However, no matter how efficient the risk prediction tools are, producers must have technical assistance from trained professionals to adequately interpret and mitigate the risks. The studied forest-livestock integration system is economically feasible and low risk.
Keywords: integrated production system, agricultural economic indicators, Monte Carlo simulation.
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INTRODUCTION

The agricultural sector has been developing faster than others in Brazil in the last decades. This growth has encouraged a review of the main production model used in Brazilian agriculture, which consists of monoculture and/or extensive production, in favor of new production systems, such as crop-livestock-forest integration system. However, scientific studies addressing especially the technical and economic indicators are necessary to show that the new production models can be beneficial and have advantages over the current business models.

According to Balbino *et al.* (2012), the high demand for energy and natural resources of the predominant production model in rural properties has been showing signs of fragility such as environmental degradation caused by the agricultural activity and, consequently, the low sustainability of the current agricultural models.The integration of forest species into the agricultural component or livestock can be an interesting alternative to traditional monoculture and extensive systems, as it includes the environmental benefits generated by the forests and diversification of production.

To this end, the concept of Integrated Crop-Livestock-Forestry System (ICLFS) is inserted into a sustainable production strategy that integrates agriculture/crops, livestock and forestry activities carried out as consortium, succession or rotation in the same area (BALBINO *et al.*, 2011). These systems, according to Salton *et al.* (2014), are configured as an alternative to meet the needs for ecological, economic and social improvements, especially in regions where cattle ranching and the use of natural resources have already been highly intensified, as the Northen region of Mato Grosso state.

In addition to the aforementioned benefits, diversification of production is an interesting strategy for producers due to the possibility of distributing revenues throughout the year and the possibility of relying on more than one activity since unforeseeable occurrences, market troubles or any other, may compromise the performance of the property (VITALE; MIRANDA, 2010).

Although proven to be advantageous, integrated production systems, such as forest-livestock system, still arouse distrust and uncertainty for the rural producer. Furthermore, Coelho Júnior *et al.* (2008) adds that the decision to adopt these systems on a large scale is extremely complex, especially due to the scarce economic information available.

Thus, in a constantly changing macroeconomic scenario, the evaluation of the economic feasibility and the risks involved in such production systems is fundamental to subsidize the decision making, especially for rural producers. Additionally, Moreira *et al.* (2017) affirm that such information is also important for generating knowledge and formulating and/or evaluating public and sectoral policies.

To this end, the economic analysis is fundamental to inform the producer of the financial results of the activity and safely direct the investments. Furthermore, it is also important to identify the risks associated with the production systems and market conditions.

Thus, in view of the need to deepen the economic analysis of the crop-livestock-forestry integration systems, the present study aims to economically evaluate a Livestock-Forest integration system between Nellore cattle and a teak plantation, located in the municipality of Alta Floresta, in Mato Grosso.

MATERIAL AND METHODS

Study Site

The study site, Fazenda Bacaeri, is a farm located in the municipality of Alta Floresta, state of Mato Grosso, and integrates one of the nine Technological and Economic Reference Units (TERU) monitored by the Embrapa (Brazilian Agricultural Research Corporation) Agrossilvipastoril.

This farm has been planting the species *Tectona grandis* L. f. (teak) for commercial purposes for more than thirty years but has begun intensive livestock farming of Nellore cattle in the last fifteen years. Recently, part of the farm productive area has been running as a Livestock-Forest Integration (LFI) system with a consortium between teak trees and pasture by inserting the forest in the cattle ranching intensive system, allowing the integration between livestock and forest.

The farm has a total area of 111 hectares (ha) that was implemented in 2013. However, in this study, the investment data, revenues, and costs were adjusted for an area of 1,000 ha, as to represent a modal farm of the northern region of Mato Grosso. This scale is defined annually by the Mato Grosso Institute of Agricultural Economics (Instituto Mato-Grossense de Economia Agropecuária - IMEA, 2017), together with producers, local companies and other institutions for each state region. This premise contributes to characterizing the farms at the regional level so that the results express a scenario close to the regional reality. Thus, 774 hectares were considered as a productive area in the forest-livestock integration system, that is, an area where the system was effectively deployed whereas the remaining (226 ha) was considered as an area for improvements, roads, a permanent preservation area, and legal reserve.

According to Köppen-Geiger climate classification (ALVARES *et al.*, 2013), the regional climate is Aw, tropical wet and dry or savanna, with two well defined seasons, dry and wet. The extended dry season during the winter lasts four months (May to August) whereas the annual precipitation is 1,750 mm, reaching maximum intensity in the summer months of December, January, and February. During August and September, relative humidity lower than 12% can be recorded sometimes while the average annual temperature is about 24ºC and the average altitude, 270 meters.

The municipality is in the transition areas of the Amazon and Cerrado biome, with forests and dense savannas. In particular, the relief is unfavorable for agriculture so that livestock is the main activity in the municipality. Besides, the agroindustrial sector has been growing and, recently, industries such as agricultural (preserves, coffee and rice processing), livestock (dairy and beef cattle), and forestry (furniture, timber, and non-timber such as guarana) were implanted (IBGE, 2016).

Technical and Production Data

The data (technical, revenues and costs) provided by Agrossilvipastoril Embrapa and Fazenda Bacaeri were collected between November 2013 and August 2017.

In this integrated system, the animals were introduced in the area when they reached 240kg, averaging 16 months (calf), and remained until reaching 380kg, a one-year period on average. After this period, the animals were commercialized as lean cattle for fattening, totaling a productivity gain of 140 kg/animal live weight. The stocking rate considered for the site was 1.72 animal/ha, after a period of 12 months, discounting the animal mortality rate.

The forest component consists of teak trees planted in simple lines, 2.5x20m spaced, totaling 200 trees per hectare while cattle ranching occurs between the tree lines. At 9 years old, the selective thinning performed in 50% of the tree plantation removed 100 trees per hectare, generating 30 m³/ha of timber. The clearcutting occurs in the twentieth year, generating 100 m³/ha of timber.

The data on forest yield regarding the first thinning and clearcut result from the volumetric evaluations conducted in the integrated system areas until the year 2017. For the economic analysis, it was necessary to identify the activities required by the production system. Thus, Table 1 presents the description of activities that generate operational costs, associated with the forest-livestock integration system.

Table 1. Performed activities required by the forest-livestock integration system.
Tabela 1. Atividades envolvidas no sistema de integração pecuária-floresta.

Activities	Year
Forest Component	
Soil fertilization and correction	0
Herbicide application (Pre and Post-planting)	0,1
Harvest	9,20
Ant control	0-4
Termite Control	0,1
Crowning	2
Thinning	9
Delimber	2,4,9,11,14,17
Planting and replanting	0,1
Soil Preparation	0
Deweeding	1-3
Outsourced services	1-4, 9,11,14,17,20
Livestock Component	
Animal Acquisition	2-19
Animal Management	2-20
Pasture reform	9
Health	2-20
Outsourced services	1-20
Supplementation	2-20

Economical Analysis

Initially, the cash flow was dimensioned considering the revenue and expenses at constant prices from 2017. However, because some prices were pre-2017 values, the required monetary adjustment was made using Equation 1, following the methodology of Coelho Júnior *et al.* (2008). For this purpose, we used the Extended National Consumer Price Index (Índice Nacional de Preços ao Consumidor Amplo, IPCA), considering the period from December 2017, adopted as the country official financial indicator and, consequently, used by the Ministry of Agriculture, Livestock and Supply and by other authors (SOARES *et al.*, 2016; CHICHORRO e*t al.*, 2017; NOGUEIRA FILHO *et al.*, 2017) as well, in economic analyses of agricultural projects.

$$Pr = \left(\frac{P_i}{I_i}\right) * I_j \tag{1}$$

Where: Pr = actual price of the product during the period i in value of period j; Pi = nominal price of the product in period i; Ii = price index in period i; Ij = price index in period j.

The prices used to calculate the revenues generated by the sale of the lean beef were obtained using the historical series provided by the Mato Grosso Institute for Agricultural and Livestock Economics, and the price adopted was R$ 5.11 per kg (live weight), calculated by means of econometric analyses and available for consultation at the Embrapa Agrossilvipastoril.

For the wood sale price, a survey on the price of teak wood was carried out in northern Mato Grosso, in the forest-based industries, direct buyers and teak producers. The price considered was R$ 180.00 and R$ 445.00 per m³ for thinning wood (lumber) and clearcut (timber), respectively, these prices do not consider the difference of the wood assortment.

The prices used here are those practiced in 2017 and maybe under seasonal effects since there was no teak price series available, and the occurrence of seasonality for some forest products has been evidenced by other authors (NOCE *et al.*, 2005; SOARES *et al.*, 2015; VALERIUS *et al.*, 2022).

In this study, the operating costs that preceded the first revenue entry, the sale of lean cattle, were considered as working capital. At the end of the planning horizon, the working capital invested throughout the project and the residual value of the improvements, machinery, and equipment were returned to the cash flow.

The initial investment needs in this project were provided by the Embrapa Agrossilvipastoril and involved the purchase of machinery, equipment, and improvements. Throughout the project, reinvestments were also made to restore the depreciated assets (computers, machinery, equipment, and improvements). In addition to the investments, the present project counted as outputs the variable and fixed costs (labor and administrative costs), implementation costs and taxes.

After obtaining the cash flow with the inflows and outflows along the planning horizon, economic engineering tools were used to evaluate the project profitability. For this, the Net Present Value (NPV), Internal Rate of Return (IRR) and Profitability Index (PI) methods were used.

The minimum attractive rate of return (MARR) was set as 4.15% annually, determined based on the 7.10% nominal interest rate of the Special System of Settlement and Custody (Selic), in December 2017, minus the 2.95% inflation, as measured by the Extended National Consumer Price Index (IPCA) for the same period (Central Bank of Brazil [BCB], 2017). Additionally, reference rates such as Selic have been used to determine the MARR in agricultural and forestry projects due to the low associated risk (SANTOS; GRZEBIELUCKAS, 2014; NOGUEIRA FILHO *et al.*, 2017; MOREIRA *et al.*, 2017).

The cash flow values are discounted by the Minimum Attractive Rate, and according to Rezende and Oliveira (2013), the NPV can be expressed by the following Equation (2):

$$NPV = \sum_{j=0}^{n} Rj(1+i)^{-j} - \sum_{j=0}^{n} Cj(1+i)^{-j} \tag{2}$$

Where: Rj = revenue in the considered time period j; Cj = costs in the same time period; n = duration of the project in years or number of time periods; j = period adopted; i = annual interest rate, expressed as decimal.

The IRR informs the maximum percentage of return that the project can pay for the used resources, that is, it can cover the investment and operational costs realized in the project. In this way, the IRR was calculated by interactively comparing the revenue flow with the project cost flow, updated each year, given by Equation (3) (REZENDE; OLIVEIRA, 2013):

$$IRR = \sum_{j=0}^{n} Rj(1+i)^{-j} - \sum_{j=0}^{n} Cj(1+i)^{-j} = 0 \tag{3}$$

Where: Rj = revenue in the considered time period j; Cj = costs in the same time period; j = adopted period; n = duration of the project in years or number of time periods; i = annual interest rate, expressed as decimal.

The Profitability or Rentability Index (PI) was created to allow classifying the projects based on return. It is the ratio between the project operating profit and gross revenue, expressed by Equation (4) (Araújo *et al.*, 2012):

$$PI_t = \frac{\sum_{j=1}^{n} \dfrac{L_j}{(1+i)^j}}{\sum_{j=1}^{n} \dfrac{RB_j}{(1+i)^j}} x100 \tag{4}$$

Where: Lj = operating profit in period j; RB = gross revenue in period j; j = adopted period; n = duration of the project in years or number of time periods; i = annual interest rate, expressed as a decimal number. Operating profit is given by the difference between gross revenue and total costs.

Risk Analysis

The sensitivity analysis verifies the effects of the variables alone and does not provide the probability of occurrence of each value within the time interval, making it difficult to visualize the relationships between the variables. The Monte Carlo method indicated as an instrument for decision making was used in this study to overcome this difficulty. This method incorporates all possible combinations between variables, considering the occurrence of each value and their associations.

Because it was not possible to evaluate the influence of all items simultaneously, the best alternative was to identify the items with the greatest impact. NVP was considered as an output variable while the random and deterministic variables were considered as input, using the triangular probability distribution that consists of defining a minimum, most probable and maximum values of the variables, to vary the risk analysis as suggested by the Monte Carlo method.

Thus, 10,000 Monte Carlo simulations were performed by @RISK tool, considering the seven input variables presented in Table 2. For the "price" and "cost" variables, a 30% variation down and up monetary variables were adopted as proposed by Cordeiro *et al.* (2015) and Palisade Corporation (2004). The other variables varied according to the physical characteristics of the site.

Table 2. Most probable, minimum and maximum values of risk variables.
Tabela 2. Valores mais prováveis, mínimos e máximos das variáveis de risco.

Distribution	Variable	Minimum	More probable	Maximum
triangular	Timber price (R$/m³)	311,50	445,00	578,50
triangular	Thinning wood price (R$/m³)	126,00	180,00	234,00
triangular	Lean cattle sell price (R$/kg)	3,58	5,11	6,64
triangular	Animal acquisition cost (R$/kg)	3,32	4,74	6,16
triangular	Forest harvesting cost (R$/m³)	50,83	72,62	94,41
triangular	Thinning yield (m³/tree)	0,2	0,3	0,4
triangular	Clearcut yield (m³/tree)	0,9	1	1,1

RESULTS

Economic Feasibility Analysis

Table 3 presents the economic indicators for the Livestock-Forest integration system.

Table 3. Economic and financial indicators of the forest-livestock integration system.
Tabela 3. Indicadores econômicos e financeiros do sistema de integração pecuária-floresta.

Indicators/ indexes	Values
NVP (R$)	4,083,307.77
IRR (%)	6.48
PI (%)	21.36

Note: An NPV above zero indicates the minimum recovery of the initial capital invested at the required rate.

Risk Analysis

The simulations carried out in the risk analysis allowed to verify the accumulated probabilities of the NPV for the forest-livestock integration system. According to the statistical analysis, the average NPV was R$ 4,083,617.84, the minimum was R$ -8,254,712.55 and the maximum was R$ 16,638,258.01. For positive NPV values, the lower the standard deviation, the lower the risk.

The impact of these results on investment risk can be understood by analyzing Figure 1, which presents the distribution probability of NPV (in millions of R$).
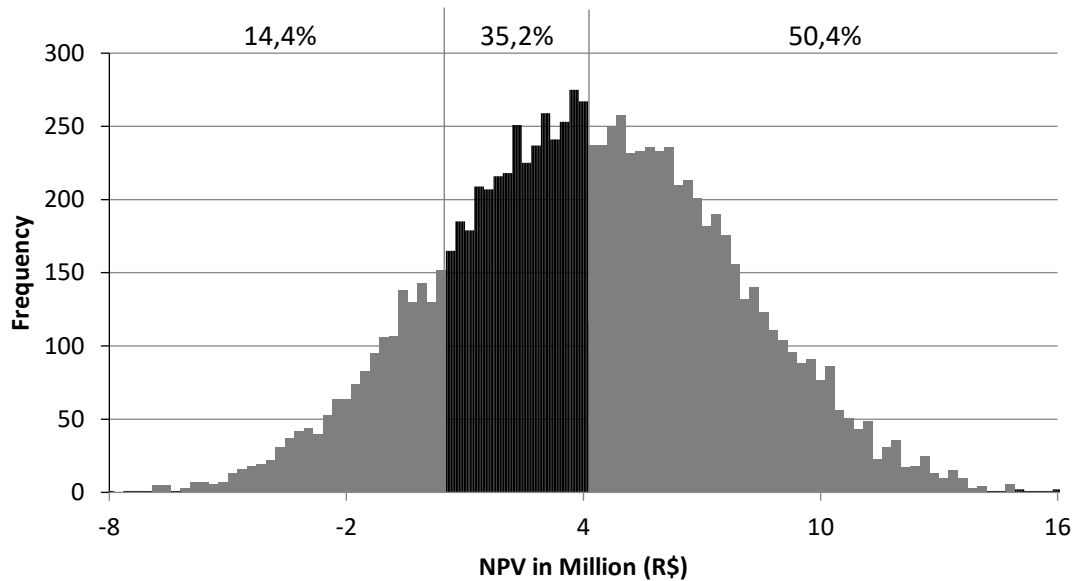
Figure 1. Distribution probability of net present value (in millions of R$).
Figura 1. Probabilidade de distribuição do valor presente líquido (em milhões de R$).

DISCUSSION

Economic Feasibility Analysis

Economic indicators offer a realistic assessment of the project, providing a broad view of the economic feasibility of the investment to the decision maker, in this case, the rural producer.

The calculated NPV of R$ 4,083,307.77 shows that for the evaluated conditions are considered economically feasible, with a discount rate of 6.0% p.a. That is, they paid their implementation and maintenance costs, as well the invested capital at a rate equal to or higher than 4,15%. Indeed, the economic feasibility of integration systems has been reported in studies by other authors such as Salton *et al.* (2014) for a crop-livestock system, Santos and Grzebieluckas (2014) for a forest-livestock integration system, for crop-livestock and crop-livestock-forest integration systems.

The positive NPV indicated that if implemented, this integration system would cover its implementation and maintenance costs (JOAQUIM *et al.*, 2015), i.e., the generated revenues would be sufficient to cover the expenses necessary to produce, and it would be possible to recover the financial capital invested in the integrated production system.

The comparison of the stipulated MAR with the IRR, 4.15% and 6.48%, respectively, indicated the economic feasibility since the IRR value is higher than the minimum attractive rate. Although the IRR also demonstrates the economic viability of the project, the joint analysis of all proposed indicators is important to ensure a safer assessment.

The profitability index of 21.36% indicates the proportion of gross revenue that constitutes profit after covering costs. In this way, the forest-livestock integration system generates revenues that cover the costs showing the profitability at the end of its planning horizon. Araújo *et al.* (2012) stated that this profitability measurement represents the added value after covering the total costs, allowing to infer the good profitability of the project when combining the two components, as well as a good return on invested capital in the long term.

Likewise, the technologies and the production arrangements called integration systems provide several benefits for both the producer and the sustainability of Brazilian agribusiness. Among the benefits generated by the integration systems, as proposed by different authors throughout the bibliographic review conducted for this study, the economic benefit was verified in this evaluation since it demonstrated good production coefficients, indicating an economically attractive system.

Furthermore, Cordeiro *et al.* (2015) concluded that a forest-livestock integration system is expected to optimize the use of production factors (land, labor, capital technology) while decreasing costs. Consequently, allowing higher income provided by the property and indirectly increasing the synergy among the components to make soil use more efficient.

Risk Analysis

The data statistics presented by the model showed an asymmetry of -0.0251 (negative), indicating a slight shift of the values to the left of the graph (Figure 1), and the average obtained in the model for the NPV (R$ 4,083,617.84) was lower than the median (R$ 4,127,027.22); and kurtosis was 2.76, indicating a normal distribution.

Also, the values are distributed symmetrically, following a normal distribution, corroborating the economic evaluation results of a crop-livestock-forest integration system reported by Coelho Junior *et al.* (2008) and Cordeiro *et al.* (2015). The symmetric distribution of the data indicates that the values are placed around the mean with no tendencie, so that the distribution probability of the values is equal in the area included in the graph.

The NPV has a 14.4% probability of resulting in a negative financial return considering the following variables: clearcutting and thinning wood prices, lean cattle selling price, animal and forest harvesting costs, thinning and clearcutting yields. However, there is a 50.4% chance that the NPV will be higher than R$ 4,083,307.77.

According to Hacura *et al.* (2001), the project is considered low risk when the probability of NPV being negative is less than 20%. Thus, the results found (14.4%) in this study indicate that, under these conditions, the Livestock-Forest integration system is considered low risk, althogout, according to Silva *et al.* (2011), risk is a subjective variable and each manager has an aversion measure for it.

By associating these values with the minimum values presented by the financial methods used, it can be stated that the forest-livestock integration system presents low investment risk, considering that all market stability conditions are maintained throughout the project. Therefore, this type of evaluation must be performed in areas where the inflows and outflows of products and services of the said production system can be monitored in order to prove this result.

Furthermore, Oliveira Júnior *et al.* (2016) state that knowledge on the items with greater impact and influence on the activity results, allows the investor to plan adequately according to market behavior and commercialization of the products. Therefore, attention should be paid to the considered high-risk factors that can determine the success or failure of the integration system.

In this sense, among the variables considered in this risk analysis, the NPV was more sensitive to the varying selling price of the lean cattle (39.10%), followed by animal acquisition cost (24.83%) and the timber price (17.94%). The probabilistic results indicated the price as the main limiting and determinant factor to obtain desirable profitability indexes for the producers.

The price margin practiced in the commercialization of the animals, both when acquiring and when selling, was not greatly different due to the low valuation between the products, calf and lean cattle, and could negatively impact the cash flow if precipitated negotiations, buy and sell, are conducted.

To minimize the risk involved in the commercialization of the animals, the producer must always seek the best time to sell the lean cattle at prices higher than the average prices practiced in the region. On the other hand, Oliveira Júnior *et al.* (2016) concluded that when buying replacement calves into the system, lower prices should be negotiated, as well as a combination of zootechnical characteristics, considering the genetic potential of the animals, at purchase prices.

The price practiced in the commercialization of wood was the third most sensitive item to the NPV, which may be indicative of the high valuation of teak wood in the region due to the great interest in the product, especially internationally.

Nonetheless, the forestry component allows greater flexibility in the timber sale negotiations. If prices are lower than expected at the time set for cutting, the producer may prefer to delay the cut and wait, before making any decision, to ensure adequate pricing.

No matter how efficient the risk prediction tools are, producers must have trained professionals to ensure proper technical assistance to adequately interpret and mitigate the risks. In turn, it is important to have reliable results to reduce risks and maximize opportunities.

In this sense, Gonçalves *et al.* (2017) concluded that the great advantage of using the Monte Carlo simulation is the possibility of combining risk-prone variables, allowing to develop strategies for mitigating the risks. The risk analysis provides a great deal of information to the decision maker, allowing to understand the impact on the NPV when making a more or less conservative decision.

Additionally, the data presented can assist producers in accessing the economic information inherent to the forest-livestock integration system, aiming at improving the management process in the production system. Planning and optimizing the activities, especially those aiming at improving the technical management of each component and qualifying the workforce, may have a positive impact on the activity profitability, given their importance in the composition of operating costs.

CONCLUSIONS

- The Livestock-Forest integration system is economically feasible, indicating a profitable activity in the northern region of Mato Grosso.
- The risk analysis identified a low risk associated with this project, but the NPV may be negative. The variables with the greatest impact (positive and negative) on the NPV were the selling price of the lean cattle, followed by animal acquisition cost and clearcutting wood price.
- The livestock-forest integration system, besides being economically viable, is an investment alternative that provides income diversification for rural producers, as well as regional development.

REFERENCES

ALVARES, C. A.; STAPE, J. L.; SENTELHAS, P. C.; GONÇALVES, J. L. M.; SPAROVEK, G. Köppen's climate classification map for Brazil. **Meteorologische Zeitschrift**, Berlin, v. 22, n. 6, 711-728, 2013. https://doi.org/10.1127/0941-2948/2013/0507

ARAÚJO, H. S.; SABBAG, O. J.; LIMA, B. T., M.; ANDRIGHETTO, C.; RUIZ, U. dos S. Aspectos econômicos da produção de bovinos de corte. **Pesquisa Agropecuária Tropical**, Goiânia, v. 42, n. 1, 82-89, 2012. https://www.revistas.ufg.br/pat/article/view/13840/10449

BALBINO, L. C.; CORDEIRO, L. A. M.; OLIVEIRA, P.; KLUTHCOUSKI, J.; GALERANI, P. R.; VILELA, L. **Agricultura sustentável por meio da Integração Lavoura-Pecuária-Floresta (ILPF)**. Piracicaba: Informações Agronômicas IPNI, n. 138, 2012.

BALBINO, L. C.; BARCELLOS, A. O.; STONE, L. F. (Ed.). **Marco Referencial: integração lavoura-pecuária-floresta.** Brasília: Embrapa, 2011.

BCB - Banco Central do Brasil. **Taxas de Juros**. 2017. Retrieved from http://www.bcb.gov.br

CHICHORRO, J. F.; SILVA, A. L. P.; ANDRADE, W. S. de P.; HEGEDUS, C. E N.; KUBOYAMA, F. A. Q. Custos e índices econômicos de povoamentos de eucalipto do Programa Produtor Florestal no Espírito Santo. **Pesquisa Florestal Brasileira**, Colombo, v. 37, n. 92, 447-456, 2017. https://doi.org/10.4336/2017.pfb.37.92.1232

COELHO JÚNIOR, L. M.; REZENDE, J. L. P. de; OLIVEIRA, A. D. de; COIMBRA, L. A. B.; SOUZA, A. N. de. Análise de investimento de um sistema agroflorestal sob situação de risco. **Cerne**, Lavras, v. 14, n. 4, 368-378, 2008. http://cerne.ufla.br/site/index.php/CERNE/article/view/649

CORDEIRO, L. A. M.; VILELA, L.; MARCHÃO, R. L.; KLUTHCOUSKI, J.; MARTHA JÚNIOR, G. B. Integração Lavoura-Pecuária e Integração Lavoura-Pecuária-Floresta: Estratégias para intensificação sustentável do uso do solo. **Cadernos de Ciência & Tecnologia**, Brasília, v. 32, n.1/2, 15-53, 2015. https://seer.sct.embrapa.br/index.php/cct/article/view/23294/0

GONÇALVES, J. C.; OLIVEIRA, A. D.; CHAVES E CARVALHO, S. P.; GOMIDE, L. R. Análise econômica da rotação florestal de povoamentos de eucalipto utilizando a simulação de Monte Carlo. **Ciência Florestal**, Santa Maria, v. 27, n. 4, 1339-1347, 2017. http://dx.doi.org/10.5902/1980509830215

HACURA, A.; JADAMUS-HACURA, M.; KOCOT, A. Risk analysis in investment appraisal based on the Monte Carlo simulation technique. **European Physical Journal**, Madrid, v. 20, n. 4, 551-553, 2001. https://doi.org/10.1007/s100510170238

IBGE – Instituto Brasileiro de Geografia e Estatística. **Mapa da Cobertura e Uso da Terra do Mato Grosso.** 2016. Retrieved from https://www.ibge.gov.br/geociencias-novoportal/informacoes-ambientais/cobertura-e-uso-da-terra/10867-cobertura-e-uso-da-terra.html

JOAQUIM, M. S.; SOUZA, Á. N.; SOUZA, S. N.; PEREIRA, R. S.; ANGELO, H. Aplicação da teoria das opções reais na análise de investimentos em sistemas agroflorestais. **Cerne**, Lavras, v. 21, n. 3, 439-447, 2015. http://dx.doi.org/10.1590/01047760201521031658

MOREIRA, J. M. M. Á. P.; SIMIONI, F. J.; SANTANA, L. F. Impacto do Custo de Transporte no Risco da Rentabilidade Florestal na Região de Itapeva-SP. **Revista Paranaense de Desenvolvimento**, Curitiba, v. 38, n. 132, 77-89, 2017. http://www.ipardes.pr.gov.br/ojs/index.php/revistaparanaense/article/view/905

NOCE, R.; SILVA, M. L.; SOARES, T. S.; CARVALHO, R. M. M. A. Análise de risco e retorno do setor florestal: produtos da madeira. **Revista Árvore**, Viçosa, v. 29, n. 1, 77-84, 2005. http://dx.doi.org/10.1590/S0100-6762200500010000

NOGUEIRA FILHO, F. P.; BAJAY, M. M.; SOUSA, J. A.; ARAÚJO, J. D. M.; CORREIA, D. Viabilidade econômica da produção de eucalipto no polo moveleiro de Marco – Ceará. **Revista iPecege**, Piracicaba, v. 3, n. 4, 22-34, 2017. https://doi.org 10.22167/r.ipecege.2017.4.22

OLIVEIRA JÚNIOR, O. L.; CARNEVALLI, R. A.; PERES, A. A. C.; REIS, J. C.; MORAES, M. C. M. M.; PEDREIRA, B. C. Análise econômico-financeira de sistemas integrados para a produção de novilhas leiteiras. **Archivos de Zootecnia**, Córdoba, v. 65, n. 250, 203-212, 2016. http://www.uco.es/organiza/servicios/publica/az/php/az.php?idioma_global=0&revista=190&codigo=2452

PALISADE CORPORATION. **Risk Analysis and Simulation Add-In for Microsoft® Excel - Guide to use @Risk**. New York: Palisade Corporation. 2004.

SALTON, J. C.; MERCANTE, F. M.; TOMAZI, M.; ZANATTA, J. A.; CONCENÇO, G.; SILVA, W. M.; RETORE, M. Integrated crop-livestock system in tropical Brazil: Toward a sustainable production system. **Agriculture, Ecosystems & Environment**, São Carlos, v. 190, n. 1, 70-79, 2014. http://dx.doi.org/10.1016/j.agee.2013.09.023

REZENDE, J. L. P.; OLIVEIRA, A. D. **Análise econômica e social de projetos florestais.** 2013. Viçosa: UFV.

SANTOS, S. S.; GRZEBIELUCKAS, C. Silvopastoral system with eucalyptus and beef cattle: an economic feasibility analysis on a farm in Mato Grosso/Brazil. **Revista Custos e @gronegócio online**, Recife, v. 1, n. 3, 317-333, 2014. http://www.custoseagronegocioonline.com.br/numero3v10/Artigo%2014%20silvapastoril%20english.pdf

SILVA, S. C.; OLIVEIRA, A. D.; COELHO JUNIOR, L. M.; REZENDE, J. L. P. Economic viability of cerrado vegetation management under conditions of risk. **Revista Cerne**, Lavras, v. 17, n. 2, 141-149. 2011. http://dx.doi.org/10.1590/S0104-77602011000200001

SOARES, P. R. C.; CARDOSO, M. V.; SCHIRIGATTI, E. L.; ALMEIDA, A. N.; SILVA, J. C. G. L.; TIMOFEICZYK JUNIOR, R., Comportamento sazonal da exportação brasileira de celulose para a china entre 1997 e 2012. **Revista Floresta**, Curitiba, v. 45, n. 2, 251-260, 2015. http://dx.doi.org/10.5380/rf.v45i2.33007

SOARES, A. F.; SILVA, H. J. T. da; SANCHES, A. L. R.; OZAKI, V. A. Análise da dinâmica inflacionária no Brasil e preços de commodities: Uma aplicação do modelo de vetores autorregressivos. **Teoria e Evidência Econômica**, Passo Fundo, v. 22, n. 46, 178-198, 2016. https://doi.org/10.5335/rtee.v22i46.6758

VALERIUS, J.; SILVA, J. C. G. L.; TIMOFEICZYK JUNIOR, R.; STEINER NETO, P. J. Comparative analysis of the us importation seasonality of wooden moldings made out of brazilian and chilean conifers. **Floresta**, v. 52, n. 1, 001-006, 2022. http://dx.doi.org/10.5380/rf.v52i1.62588.

VITALE, V.; MIRANDA, G. de M. Análise comparativa da viabilidade econômica de plantios de Pinus taeda e Eucalyptus dunnii na região centro-sul do Paraná. **Revista Floresta**, Curitiba, v. 40, n. 3, 469-476, 2010.