FINANCING FOREST RESTORATION WITH ECONOMIC EXPLORATION OF THE LEGAL RESERVE

FEBRABAN - Brazilian Federation of Banks
FGVCes - Center for Sustainability Studies at Getulio Vargas Foundation

April 2018

Prepared for

FGV EAESP
CENTRO DE ESTUDOS EM SUSTENTABILIDADE

FEBRABAN 50
BRAZILIAN FEDERATION OF BANKS

Conducted by

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ACKNOWLEDGEMENTS

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Itaú Unibanco, Rabobank, Santander, Sicredi and Votorantim.

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ARL – Legal Reserve Area
APP – Permanent Preservation Area
CAR – Rural Environmental Registry
CRA – Environmental Reserve Quotas
FEBRABAN – Brazilian Federation of Banks
GEE – Greenhouse Gases
FGVces – Sustainability Study Center of Fundação Getulio Vargas
NCF – New Forest Code
NDC – Nationally Determined Contribution
PIB – Gross Domestic Product
PRA – Environmental Regularization Program
RL – Legal Reserve
SFN – National Financial System

Presentation

The Brazilian Federation of Banks (FEBRABAN) and the Center for Sustainability Studies at Getulio Vargas Foundation (FGVces) have established a partnership that is now in its fourth cycle of activities to analyze the possible ways to leverage the transition towards a Green Economy in Brazil by using resources brokered by the National Financial System (SFN).

Throughout the year of 2017, four studies were conducted, three of which are a sequel to the studies started in the previous year. The first of them analyzes the financial feasibility of adopting photovoltaic systems in Brazil to determine the scalability of financing such projects. The second study intends to evaluate the economic-financial feasibility of financing models for the restoration of Legal Reserve Areas (ARL) where economic exploration is possible. The third study addresses the management of climate risk by banks and companies, by evaluating the possible impact of the adoption of carbon pricing systems in Brazil on financial institutions, in particular in the relevant economic sectors of bank financing portfolios[1]. Finally, the fourth study tried to analyze the implications and risks for financial institutions of deforestation on the livestock, soybean, wood products and palm oil supply chains.

This report presents the second study, with the objective to analyze the economic-financial feasibility of selected financing models for reforestation activities in Brazil by taking into account the economic use of the Legal Reserve area as well as the main rural property activities. The study scope includes the states of São Paulo, Paraná and Mato Grosso for livestock, sugarcane and soybean production processes.

To achieve the proposed objective, economic-financial models have been established to evaluate the impact of reforestation on the cash flow of selected production processes by considering their respective profitability. In addition, field visits were made to evaluate together with rural producers, the applicability and economic-financial feasibility of the suggested reforestation models.

[1] Reports produced by Informa Economics IEG | FNP that has operated for more than 25 years in Agribusiness consultancy in Brazil.

The results of such models were discussed throughout 2017 with the Working group (GT) organized in FEBRABAN under this project, with FEBRABAN's Social Responsibility and Sustainability Committee (CRSS) and other stakeholders involved with the topic.

The research included: i) a bibliographic review, in particular reports on the environmental adequacy of rural properties, the legal framework and available financial instruments; ii) interviews with national and international members of the reforestation market; iii) a financial modeling exercise based on *Agrianual* and *Agripecuária* data to identify the most adequate financial product to the client's profile and also viable to financial institutions; iv) field visits to obtain primary data; v) discussions with members of FEBRABAN participating in the Working group (GT) established for this project and in the Social Responsibility and Sustainability Committee (CRSS); and vi) internal discussions by the FGVces team.

This report is organized as follows: the first chapter gives an introduction to the topic and its specific objectives. The second chapter presents the methodological approach of this report. The third chapter presents the context related to the New Forest Code (Law no. 12,651, of May 25, 2012), the Permanent Preservation Area and the Legal Reserve. The fourth chapter presents the criteria for the selection of priority areas to be financed and the selected areas. The fifth chapter discusses the suggested productive systems for Legal Reserve areas to be potentially financed. The sixth chapter presents the economic-financial financing feasibility models for productive systems that are proposed for exploration in the Legal Reserve and their impacts on the profitability and cash flow of rural properties. The seventh chapter discusses the tests for the applicability of productive systems selected for Legal Reserve exploration for cases analyzed in the field. The eighth chapter presents the analyses of the results obtained. The ninth chapter makes propositions to expand the performance of the financial sector in the financing of the activities referred to above. The tenth chapter gives the final conclusions of this stage of work.

1. Introduction and objective

On May 25, 2012 the New Forest Code (NCF) was established by the law no. 12,651. This law established new criteria for the use and occupation of land in Brazil, which affected the farming industry and consequently impacted the Brazilian economy, as the agribusiness sector in 2016 accounted for 23.6% of GDP[2] and 46.6% of Brazilian exports.[3] Farming activities occupy approximately 30% of the national territory.[4]

The NCF created the Rural Environmental Registry (CAR) and the Environmental Regularization Program (PRA). In addition, this served as a basis for reforestation projects by establishing that forests and other forms of native vegetation are assets of common interest to all of the country's inhabitants, who exercise their property rights within the limits established by the law.

As a part of the Paris Agreement[5], Brazil established its targets for its Nationally Determined Contribution (NDC). One of these was to restore and reforest 12 million hectares of forest by 2030. The estimated native vegetation deficit based on NCF rules amounts to 19 million hectares.[6]

Both NDC and NCF implementation mechanisms, in particular PRA, generate a required allocation of funds to finance the vegetation to be restored. The estimated amount for the target established by NDC is about R$ 52 billion by 2030.[7]

Reforestation costs are not negligible and may be specially increased for small and medium producers.[8] The economic exploration of the Legal Reserve, as permitted by the NCF, may contribute to improve the property cash flow.

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[2] (CEPEA, 2016)

[3] (MAPA, 2016)

[4] (IBGE, 2006)

[5] The Paris Agreement was accepted by 195 countries in December 2015, at the 21st Conference of the Parties to the UNFCCC (United Nations Framework Convention on Climate Change). Its objective is to limit global warming by no more than 2 °C, and making efforts to prevent it from exceeding 1.5 °C by the end of this century through the use of legally binding contributions of all parties of the convention. The Agreement was ratified by the Brazilian government in September 2016 when the country, based on the year of 2005, committed to reduce its greenhouse gas emissions (GEE) by 37% by 2025 and 43% by 2030.

[6] (IMAFLORA, 2017)

[7] (Kishinami & Watanabe Jr, 2016)

[8] (Soares-Filho, 2013)

By considering the challenges of reforestation and the environmental liabilities associated with the APP and RL areas to be reforested in Brazil, it is essential to find conditions to make a greater allocation of private funds for that purpose feasible. Bank financing may be a major factor of such conditions.

Currently, there are an estimated 11 million hectares of environmental liabilities of the Legal Reserve Area (ARL) in the country and 8 million hectares in the Permanent Preservation Area (APP). Considering the average reforestation cost of R$ 20,000.00/ha for the former and R$ 7,000.00 for the latter, there is a potential financing market of R$ 138 billion (considering 50% reforestation of the total area).[9]

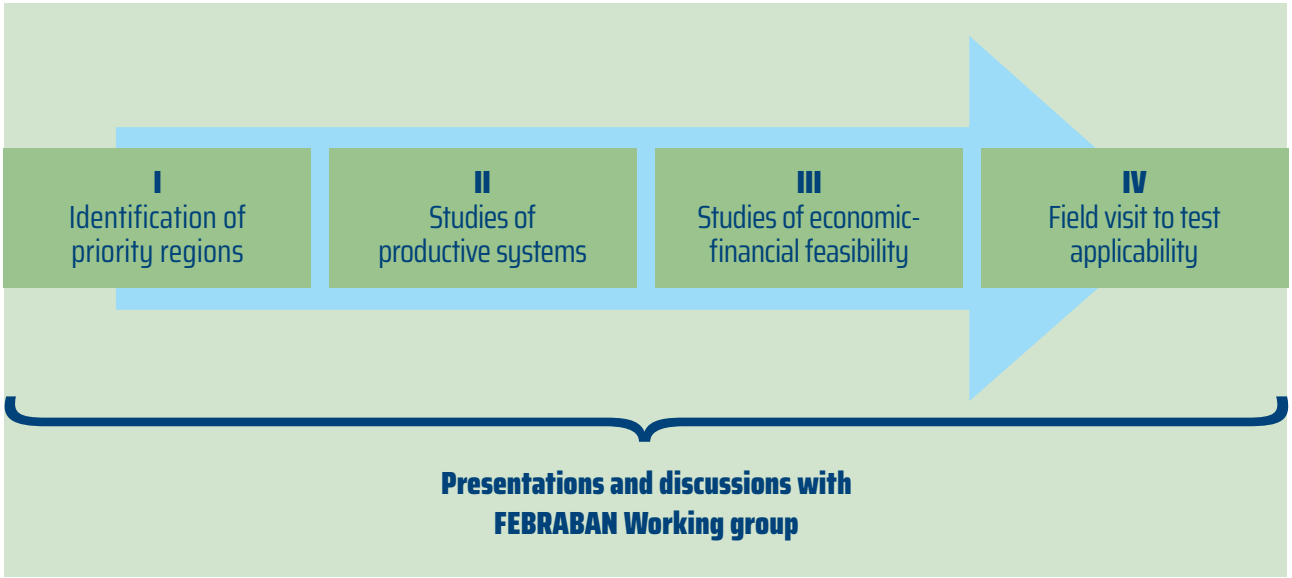
In this context, this study has two specific objectives: (i) to identify and evaluate financing models for the reforestation of Legal Reserve areas (where there is a possibility of economic exploration), by considering the integrated management of properties, as well as models to reduce the credit risk of operations; and (ii) to identify potential activities, regions and clients for National Financial System (SFN) to engage in reforestation financing based on data on productive activities of livestock, sugarcane and soybean in the states of São Paulo, Paraná and Mato Grosso over the years of 2016 and 2017.

[9] RL recomposition cost is higher than that of APP, as the economic exploration requires plantation intensification and area management. In APPs there is no possibility of economic use and the natural regeneration resource is used more frequently.

2. Methodological approach

This chapter aims to describe the activities performed and the method adopted for the execution of this study. The study's activities have been divided into four stages:

Figure 1. Activities performed throughout the study



Source: Elaborated by authors.

- ✓ **Activity I –** Mapping of regions with a higher financing potential for reforestation (APP and RL) in three States (SP, MT and PR) and identification of municipalities for this study;
- ✓ **Activity II –** Study of productive systems for RL areas with a financing potential and selection of potentially feasible systems;
- ✓ **Activity III –** Economic feasibility models of productive systems selected in activity II;[10]
- ✓ **Activity IV –** Field visit to test the applicability of productive systems selected in activity II and evaluate the financing potential for such arrangements.

[10] (GVCes, 2017)

Activity I. Selection of priority regions

Considered States

The states considered for this study were São Paulo, Paraná and Mato Grosso, to maintain comparability with the results of the study carried out by FEBRABAN and FGVces in 2016.[11] São Paulo was selected for its history of deforestation and its respective environmental deficit in the Atlantic Forest (there is 13.7% of native vegetation),[12] as well as for its importance to the national economy.[13] The state of Paraná was selected because of the extent of its environmental deficit in the Atlantic Forest biome (as is the case with São Paulo) and the importance of its agricultural production for the national scene.[14] In Paraná, only 11.7% of original native vegetation (Atlantic Forest) remains. In addition, deforestation began advancing once again in the state in the period of 2015 and 2016, increasing by 74% in relation to the period of 2014 and 2015.[15]

Mato Grosso was selected for having accounted in 2016 for 15% of Brazilian farming activities.[16] In addition, Mato Grosso is the state with the highest cumulative deforestation rate, equivalent to approximately 36% of total deforestation in the Brazilian Amazon region.[17] The Savanna region has also been intensively deforested in the state and the study considered reforestation only in that biome.[18]

Selection of priority municipalities

In all three selected states, the following surveys and spatial analyses were performed per municipality:

✓ Total APP surface area;
✓ Compliant and non-compliant APP surface areas: total and per municipality;
✓ Total ARL surface area;

[11] (GVCes, 2017)
[12] (SOS MATA ATLÂNTICA; INPE, 2017)
[13] (Victor, Cavalli, Guillaumon, & Filho, 2005)
[14] (Governo do Estado do Paraná, 2017)
[15] (SOS Mata Atlântica, 2017)
[16] (Mapa, 2016)
[17] (Teixeira, Almeida, & Bertella, 2014)
[18] (MMA; IBAMA, 2011)

✓ Compliant and non-compliant ARL surface areas: total and per municipality;
✓ Pasture and agricultural surface area;
✓ Settlement areas, Conservation Units and Indigenous Lands;
✓ Economic production per crop: temporary and permanent crops and silviculture.

This information is provided at state level, and the selection of municipalities was predominantly based on a non-compliance ARL survey, as these areas are subject to restoration and economic forest management, according to the Forest Code.

Based on the characteristics of each state, such as size and number of municipalities, and to represent to the best possible extent the deficit areas of the Legal Reserve, two parameters have been jointly adopted:

✓ Highest non-compliant ARL in relation to total ARL;
✓ Highest non-compliant ARL in absolute terms.

Figure 2 shows both criteria used for the selection of municipalities in each state. It is possible to note that there is some difference among the states, both in absolute and relative deficit areas.[19]

Figure 2. Criteria for selection of priority municipalities for states of MT, PR and SP, respectively

MT	PR	SP
• RL deficit above 50% of total RL surface area • RL deficit with a surface area above 100,000 ha	• RL deficit above 50% of total RL surface area • RL deficit with a surface area above 7,000 ha	• RL deficit above 30% of total RL surface area • RL deficit with a surface area above 4,000 ha

Source: Elaborated by authors.

Chapter 4 shows the results of municipalities selected for each state.

[19] Deficitareas refer to an area that is not in compliance with the NCF. For absolute deficit, the number of total hectares is considered, while for relative deficit the quantity of total deficit is estimated and divided by total ARL.

Activity II . Selection of productive systems in RL areas for financing purposes

The possible forestry and agroforestry productive systems for ARL restoration are countless. In this respect, it is important to stress that there is no sole model that could be considered the best or most adequate model for a certain property or region. The aptitude and edaphoclimatic conditions of the region, the existence of pre-established or potential production chains for its organization, estimates of productivity, costs and revenues are some of the variables to be considered in order to define the species that will compose the productive systems. In addition, in the preparation of such systems, it is important to consider the legal assumptions that are explicitly or implicitly present in the NCF provisions, to ensure that their use and economic exploration will comply with the law. Sources for this selection of productive systems included the use of primary data from projects with agroforestry characteristics existing in regions covered by the study, as well as secondary data generated by research institutions.

Chapter 5 details how the selection of productive systems for Legal Reserve areas was made.

Activity III. Economic-financial feasibility models of the productive systems selected in activity II

The economic-financial modeling that was carried out, which was similar to the one that was carried out in the first version of this study, aims to analyze the payment capacity of credit borrowers based on computer simulations according to the client's profile, main productive activity and productive systems for RL reforestation as well as location.

All models are a simplification of reality. As such, results should be seen as indications rather than future forecasts. In addition, as they are models that consider the regions and their specific characteristics, such as the regional climate, results cannot be generalized.

To refine and increase the robustness of the model, the Monte Carlo method was applied, where probability distributions for certain selected assumptions (interest rate, revenues from culture) are used to calculate the results' probability distributions.

Activity IV. Field visit to test the applicability of the productive systems selected and the financing potential for such arrangements

Visits to five rural properties were made with the objective of testing the applicability of productive systems for ARL economic exploration. The properties are located in the three selected states (São Paulo, Mato Grosso and Paraná).

On-site visits were made to collect primary data, which were later processed and analyzed for the organization and proposal of the possible productive systems in the Legal Reserve area. Such proposed productive systems considered edaphoclimatic capacities, took into account the size and growth rate of these species, increase and maintenance of biodiversity in the system, in addition to the existence, or creation potential, of a market as well as legal aspects, especially those related to federal and state bodies.

3. Context of the new Forest Code: APP and ARL

The Legal Reserve Area (ARL) is the percentage of area comprising the native vegetation coverage to be maintained by all rural properties, which is 20% in the states of São Paulo and Paraná, regardless of original vegetation in the region, which may be phytophysiognomies of Savanna and Atlantic Forest biomes. On the other hand, in the state of Mato Grosso, by finding itself within the geographic delimitations of the Legal Amazon territory, these percentages are 80% or 50% for properties located in forest regions, 35% for those located in Savanna areas and 20% for those located in the Pantanal biome.[20]

If the property does not have the minimum native vegetation percentage to compose the required ARL, as established by Law 12,651/2012, one or more of the following alternatives should be adopted:

I - Compensation of the total or partial area of Legal Reserve (RL), which can be made through the acquisition of an Environmental Reserve Quote (CRA); lease of area under environmental right of way regime, or Legal Reserve with native vegetation established or in regeneration or restoration conditions, whether that area is in a real estate owned by the same person or third parties; or donation to the public power or area located in the public-domain Conservation Unit depending on land regularization.

II - Restoration of native vegetation in the same property, which can be made through the adoption of different techniques, such as: induction, follow-up and/or natural regeneration, or plantation of native species by using seeds, plants or other sources of propagating material that can also be intercalated with exotic native or fruitful species in agroforestry systems, provided that the use of exotic species shall not exceed 50% of total area to be recovered.

[20] Legal Reserve delimitations are established by Art.12 of Federal Law 12,651/2012.

By legal definition, ARL has the function of ensuring the sustainable economic use of natural resources of the rural property, helping the preservation and rehabilitation of ecological processes and promoting the preservation of biodiversity, as well as the cover and protection of wild fauna and native flora.[21] ARL definition in the new Forest Code considers the area's multifunctionality by recognizing its importance as a source of natural resources to be economically explored by a management based on sustainability precepts while providing several ecosystemic services.

Another important matter is the acceptance of inclusion of Permanent Preservation Areas (APPs) in the calculation of ARL percentage of the real estate. It should be pointed out that it is possible, provided that there is no conversion of new areas for alternative use of soil in the rural property and, in such a case, the APP protection regime does not change,[22] in particular for those areas defined by the presence of water bodies. That is, if forest management is accepted in the ARLs, that type of activity is not allowed in hydric APPs considered as RL.

By considering the multifunctional aspect of ARL as an area intended for environmental preservation and provision of natural resources, in situations where there is ARL deficit in the rural property and where the alternative to achieve the minimum percentage required by law is restoration, it is possible to develop forestry and agroforestry projects to promote the exploration of wood and/or non-wood products through a sustainable management, by generating revenues at several harvest cycles.

Given the existing ARL deficit (11 million hectares), the possibility of economic exploration of ARL is a way to achieve targets to replace existing environmental deficits, and would stimulate the development of a forest economy in the country.

[21] Definition of Legal Reserve according to item III of Art. 3 of Federal Law 12,651/2012.

[22] Legal provision included in Art. 15 of Law 12,651/2012.

Brazil is a power in the forestry sector, with a highly-productive silviculture activity that is the result of half a century of investments in technological research and development. However, that silviculture has practical limitations to be replicated on a large scale in projects focused on ARL reforestation, as it is based on only a few species, most of which are exotic and planted under a monoculture system, the main product of which is timber, pulp and paper.

At ARL reforestation, legal provisions point to the need to implement biodiversity systems predominantly constituted of native species , and the exploration component of which may be wood and non-wood forest products, such as fruits, seeds, nuts, honey, fungi, essential oils, strata, resins, tannins, cork, herbal products and ornamental plants, among others. In commercial exploration of non-wood forest products, the country has also stood up as a major world exporter of cashew nuts, mate herb and *açaí* in particular.

Thus, by considering the importance of promoting the implementation of the Environmental Regularization Program (PRA), it is essential to associate the regional knowledge of traditional farmers and extractors that control the handling of non-wood forest products to apply it to the development of new or adapted specific economic models to be implemented in ARL.

4. Identification of priority municipalities for reforestation financing

For the states of São Paulo, Mato Grosso and Paraná, they tried to identify the municipalities with greater potential to get reforestation financing through the analysis of their Legal Reserve deficits (ARL in compliance or non-compliance with the Forest Code) and main agricultural productive activities. Analysis was made according to public geospatial databases. In addition, to contribute to the financing subject, other information related to municipalities of referenced states was collected, such as: identification of Permanent Preservation Areas (APPs) in compliance or non-compliance with the Forest Code, profile of rural properties (number of small, medium and large properties), rural settlements, silviculture and details of temporary and permanent crops.

It is important to point out that, because of the expressive set of geospatial data used in the diagnosis of priority areas, it was necessary to resort to different data sources for each state. Supplement 1 provides all generated maps and their respective details, their data sources and a brief description.

Such analysis allowed for the identification of current demands to work on the environmental deficits and implement their PRAs. That way, to identify the potential priority bank financing markets for environmental regularization of rural properties, the municipalities with greater deficit of ARL were identified.

The sections below provide the spatial information of each state followed by the selection of municipalities with high potential for the development of economic exploration projects of Legal Reserve areas.

Mato Grosso

The state of Mato Grosso has approximately 90.3 million hectares, 25% of which are occupied by pastures, 14% by agricultural areas, 4.4% by rural settlements and less than 1% by silviculture. The main economic activity in the state is cattle ranching, which occupies 23 million hectares. Agricultural activity is predominantly concentrated in the center portion of the state, where the cattle-ranching activity is more expressive in the southern and northern regions of the state.

Another important issue refers to the environmental deficit areas, both for APP and ARL. APP and ARL areas occupy respectively 2.6% and 28.6% of total Mato Grosso territory. It is noted that 84.4% of ARL areas in the state, according to the Forest Code, are in compliance with the law (Table 1). However, because of Mato Grosso's territorial dimensions, the non-compliant area (15.6%) occupies more than 4.03 million hectares with the possibility of forest restoration for economic purposes, and may contribute to the increase of the rural producer's income and the achievement of targets established in the Brazilian NDCs.

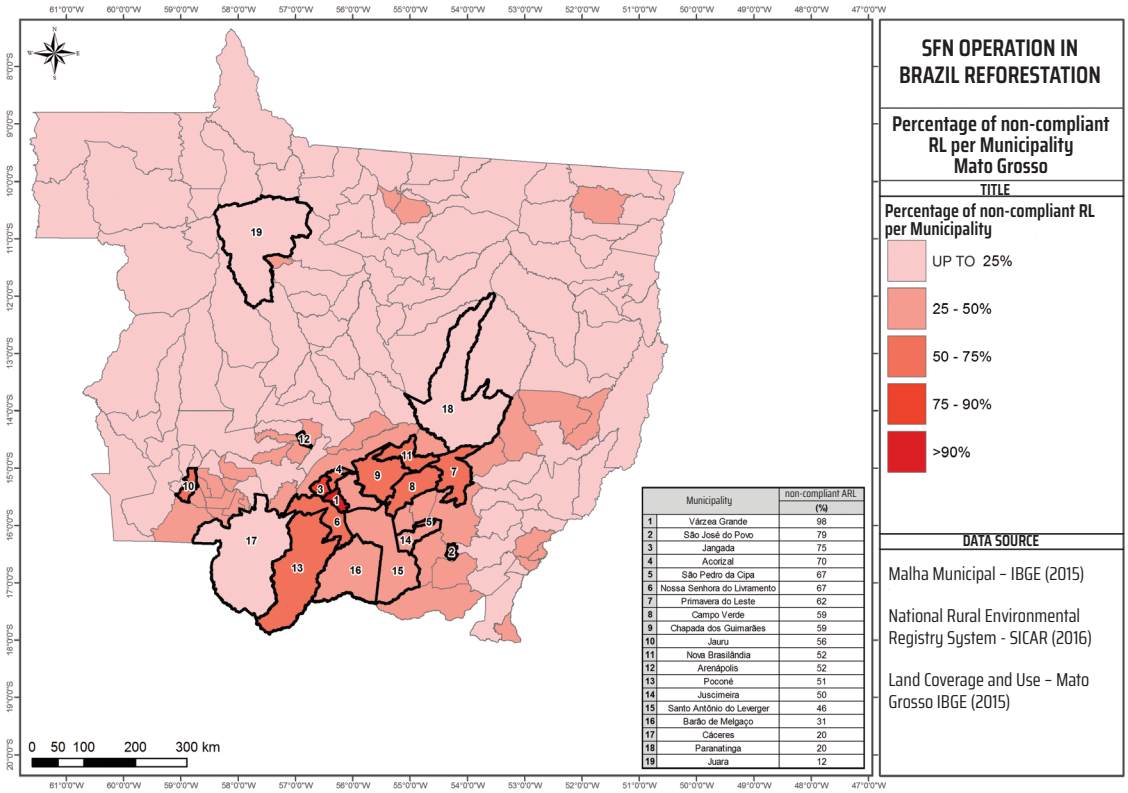
By considering the APP deficit of 33.1%, the total environmental deficit amounts to 48.7% in relation to the sum of APP and ARL areas that should exist in Mato Grosso, or 4.8 million hectares (4.03 million hectares of ARL and 0.77 million hectares of APP), corresponding to 5.3% of the total surface area of the state (Table 1).

It should be stressed that areas with APP deficit in the state of Mato Grosso are more scattered along the state territory, different from what occurs with non-compliant ARL areas.

For that state, municipalities with ARL deficits above 50% in relation to total ARL (non-compliant ARL/total ARL) were selected, in addition to municipalities with more than 100,000 hectares of non-compliant ARL.

According to the adopted methodology, 19 priority municipalities in MT were selected, which are highlighted in the map and table below (Figure 3 and Table 1).

Figure 3. Municipalities with largest absolute and relative non-compliant RL areas in the state of MT



Source: Elaborated by authors.

Table 1. Municipalities with largest absolute and relative non-compliant RL areas in the state of MT

	Municipalities	Non-compliant ARL (%)
1	Várzea Grande	98
2	São José do Povo	79
3	Jangada	75
4	Acorizal	70
5	São Pedro da Cipa	67
6	Nossa Senhora do Livramento	67
7	Primavera do Leste	62
8	Campo Verde	59
9	Chapada dos Guimarães	59
10	Jauru	56

	Municipalities	Non-compliant ARL (%)
11	Nova Brasilândia	52
12	Arenápolis	52
13	Poconé	51
14	Juscimeira	50
15	Santo Antônio do Leverger	46
16	Barão de Melgaço	31
17	Cáceres	20
18	Paranatinga	20
19	Juara	12

Source: Elaborated by authors.

Cattle ranching is the predominant activity in those municipalities by occupying 40% of the total surface area of 14.5 million hectares, corresponding to 16% of the total surface area of the state of Mato Grosso amounting to 90.3 million hectares. Agricultural activity and silviculture occupy respectively 10% and 0.5% of the total area of priority municipalities. This profile matches the rest of the state as cattle ranching occupies 25% of the total area of Mato Grosso, agriculture occupies 13.6% and silviculture occupies only 0.3%. The southern portion of the state of Mato Grosso concentrates the municipalities with higher percentages of ARL that are not in compliance with the law.

The total ARL of priority municipalities has 4.4 million hectares, 1.4 million hectares of which are non-compliant, corresponding to 32% of the total ARL of priority municipalities and 30% of non-compliant ARL in the state.

With respect to the APP, the 19 municipalities account for 416,500 hectares of total APP, 61% of which are in compliance and 31% in non-compliance with the Forest Code.

Settlements represent only 2% of the total surface area of the state and 4% of total surface area of the priority municipalities.

Finally, the small rural properties (up to four fiscal modules) account for 85% of the total 17,457 rural properties in 19 selected municipalities. Medium and large properties account for only 9% and 7%, respectively. A summary of all information is provided in Table 2.

Table 2. Summary of information on the state of Mato Grosso

	Mato Grosso	Nineteen municipalities with higher reforestation financing potential
General characteristics	Total surface area: 90.3 Mha Total RL area: 25.8 Mha Total APP surface area: 2.3 Mha	Total surface area: 14.5 Mha Total RL area: 4.4 Mha Total APP surface area: 416,500 ha
Non-compliant RL	4 Mha	1.4 Mha
Non-compliant APP	771,900 ha	163,400 ha
Productive Activity	Cattle raising 25.4%; agriculture 13.6%; silviculture 0.32%	Cattle raising 40%; agriculture 10%; silviculture 0.45%
Size of properties	84% small; 9% medium and 7% large	85% of small properties in municipalities with higher potential
Settlements	2%	4%

Source: Elaborated by authors.

São Paulo

The state of SP has 24.8 million hectares, 25% of which are occupied by pastures, 51% by agricultural areas, 1% by rural settlements and 4.4% by silviculture. The main economic activity is agricultural production comprising 12.7 million hectares, where sugarcane is the main temporary crop planted in 5.6 million hectares, followed by soybean and corn. With respect to permanent crops, orange accounts for the largest planted area with approximately 413,000 hectares.[23]

[23] (IBGE, 2015)

APP and ARL areas occupy respectively 12.2% and 7% of the total São Paulo territory, provided that total APP area is 57% larger than the total ARL area due to the large extension of hydrographic network, especially in the Atlantic Forest Biome and more specifically in regions of the Dense Ombrophilous Forest in the east of the state.

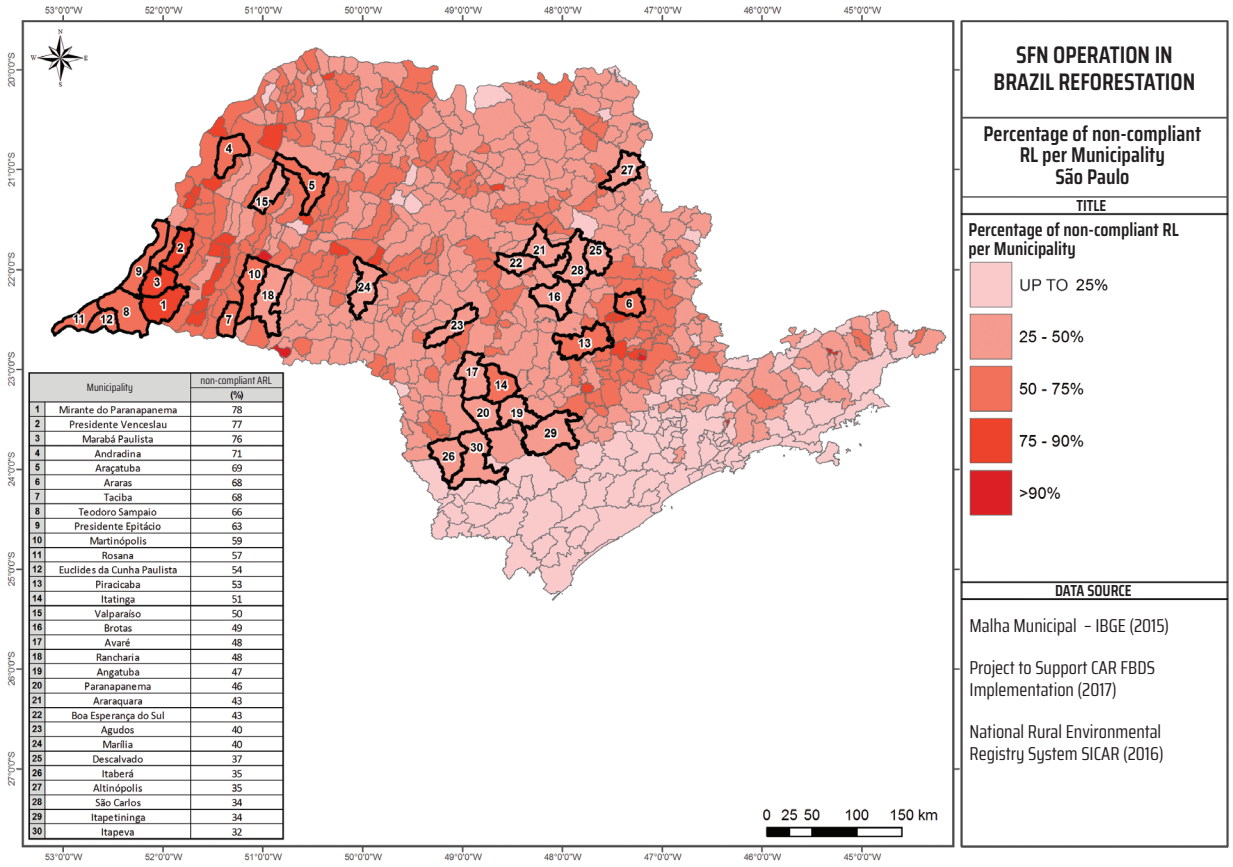
In the western part of the state, there is a high cattle ranching activity with a great concentration of pastures, while agricultural areas are predominantly concentrated in the mid-northern part of the state.

Differently from the state of MT, the São Paulo region presents, relatively, a high environmental deficit for both parameters analyzed, APP and ARL. It is noted that 38% of areas intended for the Legal Reserve in the state, according to the Forest Code assumptions, are not in compliance with the law; more than half the APPs need to be restored (51.5%) (Table 2). In absolute terms, the state of São Paulo has 656,200 hectares of areas with potential to promote reforestation for economic purposes, that is, ARL that are not in compliance with the Forest Code. With respect to the APP, the state of São Paulo has 1.57 million hectares of APP non-compliant with the law. According to the spatial distribution of such areas, São Paulo's western region comprises the municipalities with higher percentages of non-compliant ARL and APP related to the total ARL and APP. The sum of APP and ARL environmental deficit areas amounts to approximately 9% of total São Paulo area.

For that state, municipalities with ARL deficit above 30% in relation to total ARL (non-compliant ARL/total ARL) were selected, in addition to municipalities with more than 4,000 hectares of non-compliant ARL.

According to the adopted methodology, 30 priority municipalities have been selected in São Paulo, which have potential to develop reforestation projects for economic exploration, as highlighted in the map and table below (Figure 4 and Table 3).

Figure 4. Municipalities with largest absolute and relative non-compliant RL areas in the State of SP



	Municipality	non-compliant ARL (%)
1	Mirante do Paranapanema	78
2	Presidente Venceslau	77
3	Marabá Paulista	76
4	Andradina	71
5	Araçatuba	69
6	Araras	68
7	Taciba	68
8	Teodoro Sampaio	66
9	Presidente Epitácio	63
10	Martinópolis	59
11	Rosana	57
12	Euclides da Cunha Paulista	54
13	Piracicaba	53
14	Itatinga	51
15	Valparaíso	50
16	Brotas	49
17	Avaré	48
18	Rancharia	48
19	Angatuba	47
20	Paranapanema	46
21	Araraquara	43
22	Boa Esperança do Sul	43
23	Agudos	40
24	Marília	40
25	Descalvado	37
26	Itaberá	35
27	Altinópolis	35
28	São Carlos	34
29	Itapetininga	34
30	Itapeva	32

Source: Elaborated by authors.

Table 3. Municipalities with largest absolute and relative non-compliant RL areas in the state of SP

	Municipalities	Non-compliant ARL (%)
1	Mirante do Paranapanema	78
2	Presidente Venceslau	77
3	Marabá Paulista	76
4	Andradina	71
5	Araçatuba	69
6	Araras	68
7	Taciba	68
8	Teodoro Sampaio	66
9	Presidente Epitácio	63
10	Martinópolis	59

	Municipalities	Non-compliant ARL (%)
11	Rosana	57
12	Euclides da Cunha Paulista	54
13	Piracicaba	53
14	Itatinga	51
15	Valparaíso	50
16	Brotas	49
17	Avaré	48
18	Rancharia	48
19	Angatuba	47
20	Paranapanema	46
21	Araraquara	43
22	Boa Esperança do Sul	43
23	Agudos	40
24	Marília	40
25	Descalvado	37
26	Itaberá	35
27	Altinópolis	35
28	São Carlos	34
29	Itapetininga	34
30	Itapeva	32

Source: Elaborated by authors.

The predominant activity in these municipalities is agriculture, which accounts for 52.5% of the total area of 3.2 million hectares (Table 2). Cattle ranching and silviculture activities account respectively for 31.7% and 7.1% of the total area of priority municipalities. This profile matches the rest of the state as agriculture occupies 51.3% of the total area of SP, cattle ranching occupies 24.7% and silviculture occupies only 4.4%.

Total ARL of priority municipalities has 334,300 hectares, 167,200 hectares of which are non-compliant, corresponding to 50% of total ARL of priority municipalities and 25.5% of non-compliant ARL in the state.

With respect to the APP, the 30 municipalities account for 269,200 hectares of total APP, 42.4% of which are in compliance and 57.6% in non-compliance with the Forest Code. Settlements represent only 1% of the total surface area of the state and 3.5% of total surface area of priority municipalities.

Finally, the small rural properties (up to four fiscal modules) account for 82% of the total surface area of 22,643 rural properties in 30 selected municipalities. Medium and large properties account for only 11% and 7%, respectively. The main information is shown in Table 4.

Table 4. Summary of information on the state of São Paulo

	São Paulo	Thirty municipalities with higher reforestation financing potential
General characteristics	Total surface area: 24.8 Mha Total RL area: 1.7 Mha Total APP surface area: 3.0 Mha	Total surface area: 3.2 Mha Total RL area: 334,400 ha Total APP surface area: 269,200 ha
Non-compliant RL	656,200 ha	167,200 ha
Non-compliant APP	1.6 Mha	155,000 ha
Productive Activity	Agriculture 51.3%; cattle ranching 24.7%; silviculture 4.4%	Agriculture 52.5%; cattle ranching 31.7%; silviculture 7.1%
Size of properties	85% small; 11% medium and 4% large	82.2% of small properties
Settlements	1%	3.5%

Source: Elaborated by authors.

Paraná

The state of PR has approximately 20 million hectares, 16.6% of which are occupied by pastures, almost 50% by agricultural lands, 1.9% by rural settlements, and 8.2% by silviculture, mainly eucalyptus and pine. The main economic activity is agricultural production, where 10 million hectares are especially intended for the plantation of soybean (5.2 million ha), corn (2.4 million ha) and wheat (1.3 million ha).[24] In the north of the state there is also a high cattle-ranching and agricultural activity.

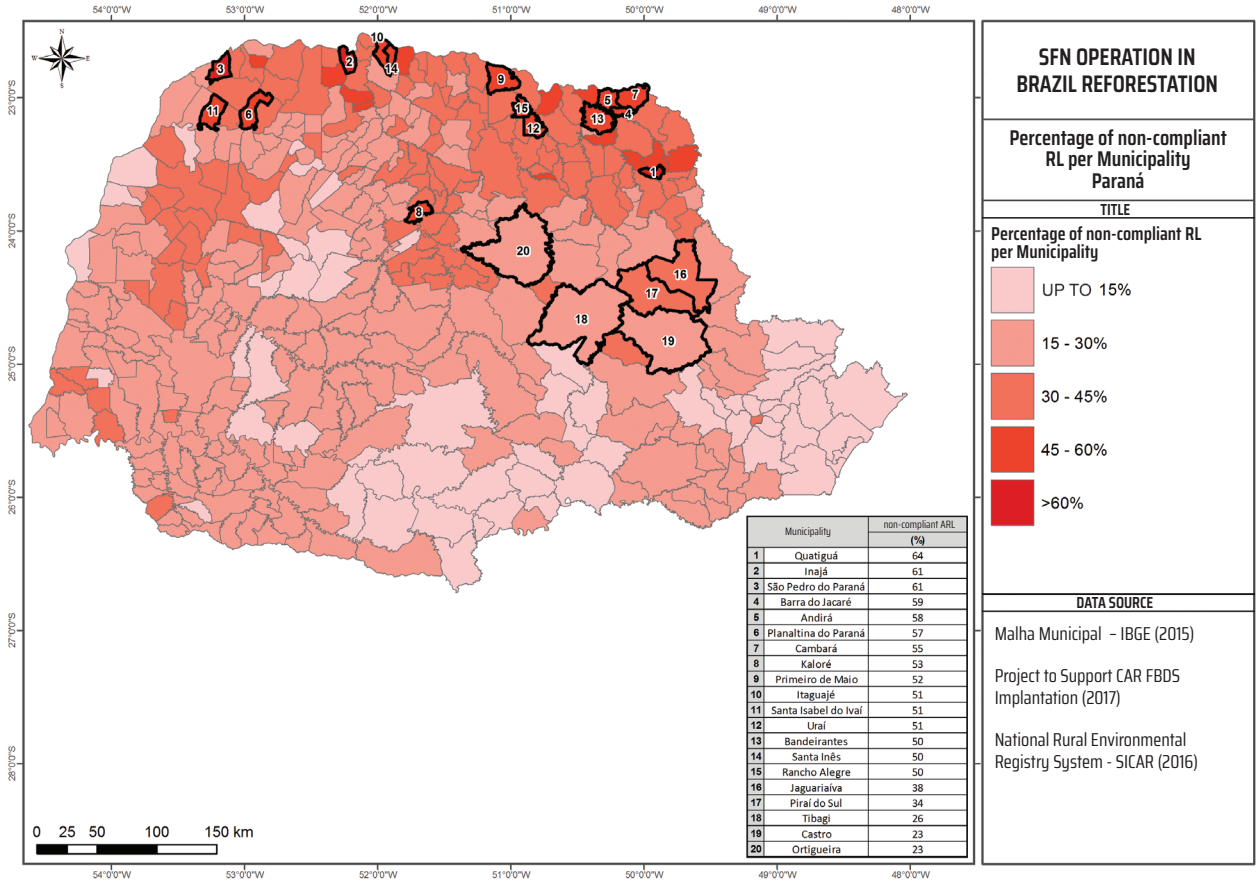
[24] (IBGE, 2015)

APP and ARL areas occupy respectively 11.7% and 10.1% of the total Parana territory. With respect to the environmental deficit areas, it is noted that 20.9% of areas intended for Legal Reserve in the state, according to the Forest Code assumptions, are not in compliance with the law, which corresponds to 420,300 hectares (area with possibility to promote reforestation for economic purposes). With respect to the APP deficit, the area intended for its restoration amounts to 723,100 hectares, equivalent to 31% of total APP in the state (Table 3). According to a previous mapping, the northern region of the state of PR comprises the municipalities with highest percentages of non-compliant ARL and APP in relation to total ARL and APP.

In the state of PR, municipalities with ARL deficit above 50% in relation to total ARL (non-compliant ARL/total ARL) were selected, in addition to municipalities with more than 7,000 hectares of non-compliant ARL.

According to the adopted methodology, 20 priority municipalities in PR were selected, which are highlighted in the map and table below (Figure 5 and Table 5).

Figure 5. Municipalities with largest absolute and relative non-compliant RL areas in the state of PR



	Municipality	non-compliant ARL (%)
1	Quatiguá	64
2	Inajá	61
3	São Pedro do Paraná	61
4	Barra do Jacaré	59
5	Andirá	58
6	Planaltina do Paraná	57
7	Cambará	55
8	Kaloré	53
9	Primeiro de Maio	52
10	Itaguajé	51
11	Santa Isabel do Ivaí	51
12	Uraí	51
13	Bandeirantes	50
14	Santa Inês	50
15	Rancho Alegre	50
16	Jaguariaíva	38
17	Piraí do Sul	34
18	Tibagi	26
19	Castro	23
20	Ortigueira	23

Source: Elaborated by authors.

Table 5. Municipalities with the largest absolute and relative non-compliant RL areas in the state of PR

	Municipalities	Non-compliant ARL (%)
1	Quatiguá	64
2	Inajá	61
3	São Pedro do Paraná	61
4	Barra do Jacaré	59
5	Andirá	58
6	Planaltina do Paraná	57
7	Cambará	55
8	Kaloré	53
9	Primeiro de Maio	52
10	Itaguajé	51
11	Santa Isabel do Ivaí	51
12	Uraí	51
13	Bandeirantes	50
14	Santa Inês	50
15	Rancho Alegre	50
16	Jaguariaíva	38
17	Piraí do Sul	34
18	Tibagi	26
19	Castro	23
20	Ortigueira	23

Source: Elaborated by authors.

The predominant activity in these municipalities is agriculture, which accounts for 54% of the total area of 1.5 million hectares (Table 3). Cattle ranching and silviculture activities account both for 17% of the total area of priority municipalities. This profile matches the rest of the state as agriculture occupies 50% of the total area of PR, cattle ranching occupies 17% and silviculture occupies only 8%.

Total ARL of priority municipalities have 179,000 hectares, 54,800 hectares of which are non-compliant, corresponding to 31% of total ARL of priority municipalities and 13% of non-compliant ARL in the state.

With respect to the APP, the 20 selected municipalities account for 173,000 hectares of total APP, 65% of which are in compliance and 35% in non-compliance with the Forest Code. Settlements represent only 2% of the total surface area of the state and of total surface area of priority municipalities.

Finally, the small rural properties (up to four fiscal modules) account for 88% of the total surface area of 16,547 rural properties in 20 selected municipalities. Medium and large properties account for only 8% and 4%, respectively. Information is highlighted in Table 6.

Table 6. Summary of information on the state of Paraná

	Paraná	Twenty municipalities with higher reforestation financing potential
General characteristics	Total surface area: 19.9 Mha Total RL area: 2 Mha Total APP surface area: 2.3 Mha	Total surface area: 1.4 Mha (20 municipalities) Total RL area: 176,000 ha Total APP surface area: 172,600 ha
Non-compliant RL	420,000 ha	54,800 ha
Non-compliant APP	723,100 ha	61,000 ha
Productive Activity	Cattle ranching 17%; agriculture 50%; silviculture 8%	Agriculture 54%; cattle ranching 17%; silviculture 17%
Size of properties	90% small; 7% medium and 3% large	88% of small properties in municipalities with higher potential
Settlements	2%	2%

Source: Elaborated by authors.

5. Selection of Productive systems for RL area reforestation financing

There are many productive systems that can be used for reforestation. However, in terms of ARL, the most important one is to prepare the arrangements that particularly meet the limits and requirements provided in regulations related to the implementation of Environmental Regularization Programs.

Productive systems used in this study were selected by considering this context and intended to obtain solutions and recommendations for a potential financing in Legal Reserve areas with economic exploration. More details on assumptions adopted for operating income, general costs (including labor, input and implantation prices), productivity (average annual increase) and product prices are described in Supplement 2.

Sustainable Forest Management

Proposed models have been conceived to obtain economic returns through sustainable forest management. To do that, it is necessary to explore the natural vegetation respecting the target products inventories, both wood and non-wood products, and the ecosystem as a whole to ensure economic, social and environmental benefits with the promotion of ecosystemic services, as provided in the Forest Code.

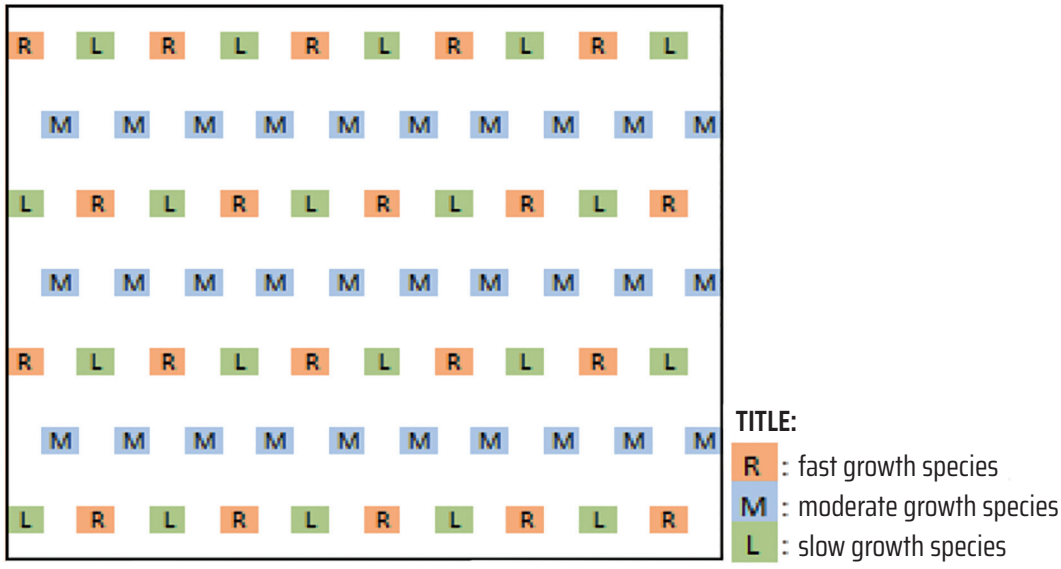
Separation of species in groups established by growth pace

With respect to models that consider the management of wood products, it is necessary to join together the use of different species in a design that allows exploration in successive cutting or clearing cycles. As such, the species were separated into groups based on growth pace (speed). We have then silviculture groups with the same exploration time, which allows for a better volumetric projection at different cycles of exploration of such groups, as described below:

- ✓ **Fast cycle:** species that produce a great volume of wood in short periods of time, where clearing is expected to take place from 3 to 14 years;
- ✓ **Moderate cycle:** species that will make wood available for clearing between 14 and 25 years;
- ✓ **Slow cycle:** species for which clearing will only be possible after 30 years.

In productive systems designs for economic exploration of ARL, models containing species of fast, moderate and slow cutting cycle were separated. The inclusion of different native trees is essential, as it ensures the use of a greater number of species of Brazilian's wide biodiversity, thus meeting the ARL objective that is to restore the native vegetation by promoting the biodiversity maintenance. Figure 6 provides an example of productive arrangement with species of different growth paces. Figure 6 shows an example of productive systems with species of different growth pace.

Figure 6. Example of productive arrangement



Source: Elaborated by authors.

Revenue phases and perpetuity

Fast-growing wood species generate revenues over shorter periods; however their products have a lower market price. On the other hand, slow growth species groups have, in general, higher prices. The formation of long-term economic productive forest systems is still unusual in Brazil, but it is very applied to forest management in mild weather countries where there are production cycles expected for more than one century. This is a condition to be adopted, especially for ARL (green saving concept) where forest management is focused on economic exploration by future generations.

However, to anticipate the revenues of those forest production systems, it is important to consider the integration of wood production with other non-wood forest products (PFNMs). PFNMs continuously generate revenues from the start of their production, in annual cycles, which contributes to the payment of costs of wood activity that, in the long term, is often higher than revenues obtained from wood. In this context, Agroforestry Systems (SAFs) also have a great potential for ARL restoration, especially at the start of the system establishment, where there is the production of short-cycle agricultural species.

In this study, several productive systems are considered, from systems that only produce wood to systems that only explore non-wood products.

Description of proposed models

Taking into consideration that at this stage of the study the approach focuses on restoration models specifically for the Legal Reserve, possible productive systems of forest or agroforests have been prepared with strict observance of possibilities and limitations established by the applicable law, both at federal and state level, in São Paulo, Paraná and Mato Grosso. It is emphasized that all models focus on economic returns, whether in the form of revenues from the sale of wood products – in this case, wood was considered to be traded standing – and non-wood products. Harvest cycles were established according to selected species.

For the selection of exotic species, the following elements were considered: species adaptability to soil and weather conditions in the region, preexistence of a supply chain, available infrastructure, in addition to regional aptitude for culture. This information is still more important in the case of non-wood forest products. For example, the heart of palm crop requires hot weather and a high quantity of rain and therefore the Ombrophilous Forest region is adequate for its cultivation, provided that the plantation should be prevented in areas subject to the occurrence of frosts, as the heart of palm does not tolerate that weather condition. Agroforestry systems, in addition to being an alternative for restoration in small properties, are strongly recommended for anticipating revenues from agricultural or non-wood forest products in our biodiversity.

In Supplement 2 it is possible to find a description of eventual plantation models.

Annex I describes the productive systems selected for São Paulo, Paraná and Mato Grosso, respectively.

For each state, six to seven different restoration alternatives have been proposed according to the higher regional aptitude for the plant. Among the proposed alternatives, two alternatives of each state were selected to go through the economic-financial return simulations, taking into account its simple payback period and demand for the product.

Table 7. Examples of ARL economic exploration models

RL restoration	50% native +
Example of studied models in SP	50% Pupunha
	50% eucalyptus citriodora
	50% eucalyptus process
	50% African mahogany
	50% rubber tree
	50% juçara
Example of studied models in PR	25% juçara + 25% banana
	25% araucaria + 25% mate herb
	50% eucalyptus citriodora
	50% eucalyptus process
	50% African mahogany
	50% pecan nut
Example of studied models in MT	50% Australian cedar
	50% teak
	50% African mahogany
	50% rubber tree
	50% eucalyptus citriodora
	50% SAF

Source: Elaborated by authors.

6. Models of economic-financial feasibility to finance productive systems selected for legal reserve exploration

This chapter intends to detail the economic-financial feasibility studies on bank financing for reforestation through productive systems selected for Legal Reserve exploration and their impacts on profitability and on cash flow of rural properties.

Applied Methodology

Financial Modeling

The objective of economic-financial modeling is to understand if the reforestation costs and their financing are compatible with rural property returns obtained both from its main activity (agriculture or cattle ranching in the case of this study) and the economic exploration in the Legal Reserve Area (ARL).

Two types of analysis were made in order to understand the producer's payment capacity: i) if the producer's accrued annual cash flow is positive or negative along the projected period; and ii) which is the estimated impact of ARL cultivation and exploration financing on the producer's payment capacity; that analysis was made through the calculation of the percentage of financing cost of reforestation (financial cost plus amortization) on the property profitability. The concept of profitability used here is according to the *Agrianual* calculation, which refers to the rural producer's profit after traditional operating and financial expenses of his main activity.

Equation 1. Formula of ARL cultivation and exploration financing impact on the producer's profitability

$$\text{IMPACT} = \frac{\text{(financial expense + payment of principal)}}{\text{profitability}}$$

Source: Elaborated by authors.

Projected cash flows consider a time horizon of 45 years for working capital and investment financing. That is because although the term specified by the PRA allows for reforestation to be made in 20 years, restoration models with economic exploration have a time horizon of 25 years, as species are cleared in the short, medium and long term. Therefore, in the case where the last restoration lot is made in the 20th year, the modeling time horizon shall reach 45 years to incorporate the 25 years for restoration of that last lot.

To construct the economic-financial models, the main productive activity prevailing in the region, the state where the property is located, the client's profile and the models of economic exploration in the RL were identified, as shown in Table 8.

Table 8. Variables considered in economic-financial modeling

Type of restoration	RL with economic exploration
Type of client	Owner: medium and large Rural producer: medium and large
Productive activity	Sugarcane, grains/soybean and livestock
Location	States of SP, PR and MT
Economic exploration in RL	For each state, different selected species
Types of financing	Working Capital (Pronamp) and investment (environmental ABC)

Source: Elaborated by authors.

All scenarios were based on the economic exploration of RL according to limits established by the Forest Code.

Every model, for being a simplified representation of the reality, has limitations, such as:

- ✓ The model only considers the option of working with working capital financing or investment financing, although the producers may use both of them at the same time;
- ✓ For the main productive activity's profitability (sugarcane, grains/soybean or livestock) secondary data of the 2016 *Agrianual* was used in the base model, which provides only constant or stationary information to the variable "price of agricultural commodities", which is dynamic. To deal with that limitation, that was one of variables used in the Monte Carlo simulations, the results of which are shown along this chapter.
- ✓ Revenues and productivity have been considered constant, which may be considered conservative for a medium and long-term projection.

Model Variables

Considered regions

Considered regions included São Paulo, Mato Grosso and Paraná (as shown in chapter 2), with emphasis on the priority municipalities.

Considered productive activities

The following productive activities were selected: cultivation of sugarcane, soybean and cattle-ranching activity. Agroindustry in the country is extremely relevant for Brazilian GDP – taking into account that the sector accounts for 23.6% of GDP[25] and is responsible for 46.6% of the country's exports.[26] In 2016, the farming sector occupied a leading position in the Brazilian economy by helping to overcome the difficulties of the current Brazilian scenario.[27] Soybean was selected for the fact that Brazil ranks second in soybean production worldwide.[28] Cattle ranching, in turn, was selected because Brazil has one of the greatest commercial cattle herds in the world.[29]

[25] (Cepea, 2016b; IBGE, 2017)
[26] (Cepea, 2016a; MDIC, 2017)
[27] (CNA, 2016)
[28] (EMBRAPA, 2017)
[29] (UFMG, 2014)

Sugarcane, on the other hand, was selected for being the main agricultural product in the state of São Paulo.[30]

To calculate the operating profitability of such activities, data from the 2016 *Agrianual* survey[31] was used.

Types of clients considered

The analysis considered medium and large rural producers. INCRA's classification was used for the fiscal modules.

Types of financial products considered

For each of these clients, the economic-financial model considered different financial products existing in working capital and investment financing with a potential use for reforestation with economic exploration.

In case of working capital financing, there is a division of reforestation into 10 lots, each of which is planted every two years while financing is renewed every year.

In case of investment financing, it uses lots of five-year term each. In this case, plantation is made in stages, where a lot is planted every five years.

For working capital, the use of Pronamp was considered, while the use of ABC Program (Low-Carbon Agriculture) was considered for investment.

[30] (Instituto de Economia Agrícola, 2017)

[31] Yearbook prepared by Informa Economics IEG | FNP Consultancy, which is an integral part of Informa PLC Business Intelligence Division. The yearbook provides a database of restricted access, containing information on commodities costs and revenues. For use in this study, access to the database was obtained and therefore data are not available for public consultation.

Types of cultures for ARL restoration: productive systems

In chapter 5 the main selected productive systems were described, which are detailed in Annex I. For the simulations, two cases were selected per region, according to the greater potential for market demand. Table 9 shows the productive systems selected for each region.

Table 9. Summary of productive systems selected for each region

RL restoration	50% native +	Simple Payback
SP-Case 1	50% pupunha	16
SP-Case 2	50% eucalyptus citriodora	15
PR-Case 1	25% juçara + 25% banana	4
PR-Case 2	25% araucaria + 25% mate herb	11
MT-Case 1	50% Australian cedar	14
MT-Case 2	50% teak	14

Source: Elaborated by authors.

Simulations

Table 10 provides the number of simulations (economic-financial modeling) made for each productive activity.

Table 10. Lists of simulations performed

Productive Activity	States	Clients	Financial Products	Simulations
Soybean	São Paulo, Paraná and Mato Grosso	Large and medium producer	PRONAMP Working Capital, ABC Investment Program	24
Sugar cane	São Paulo and Paraná	Large and medium producer	PRONAMP Working Capital, ABC Investment Program	16
Cattle ranching (extensive and semi-intensive)	São Paulo, Paraná and Mato Grosso	Large and medium producer	PRONAMP Working Capital, ABC Investment Program	48

Source: Elaborated by authors.

Model assumptions

Assumptions adopted for economic-financial modeling have been classified as: i) operational and ii) financial.

Operational Assumptions

For the purpose of comparison with the 2016 study, the same assumptions to determine the total area and productive areas have been adopted for medium and large producers in the three states. i) medium producer is that with 4 to 15 fiscal modules; ii) large producer is that with more than 15 fiscal modules. As the fiscal module areas vary among states, Table 11 considers the total area of the considered property.

Table 11. Average productive area considered

Size of property	Total surface area (ha)	Productive Area (ha)
SP – Large	857	600
SP – Medium	300	210
PR - Large	857	600
PR - Medium	300	210
MT - Large	2143	1178
MT - Medium	750	412

Source: Elaborated by authors.

With respect to the productive area for large and medium producers, the same assumptions of the previous year were adopted. For the states of Paraná and São Paulo 70% of total area was assumed as productive area, given that 20% belong to RL (APP area included in that percentage) and 10% are used for activities unrelated to plantation, such as infrastructure and road, among others. For the state of Mato Grosso, 10% of the area intended for activities unfavorable to plantation was maintained, however the RL area must be equal to 35% in that state.

For the APP and RL restoration costs, average values applied to that type of activities in different regions of the study were used, based on minimum technical specifications. In this analysis, the most conservative scenario of restoration techniques in terms of percentage proposed by the National Plan for the Recovery of Native Vegetation – 2014 Planaveg - was used (this scenario also appears in the 2017 Planaveg, but not as the most conservative scenario),[32] as shown in Table 12.

Table 12. % of ARL used for each reforestation method

Reforestation method	%
Natural regeneration	40
Full restoration	30
High Density	15
Enrichment	15

Source: Planaveg33

Average cost per hectare, taking into account the different Planaveg scenarios, amounts to R$ 6,986.00 for the state of São Paulo, R$ 7,040.00 for the state of Paraná and R$ 8,340.00 for Mato Grosso (Table 13) for APP. For ARL, amounts corresponds to R$ 32,460.00 for São Paulo, R$ 15,287.00 for Paraná and R$ 22,227.00 for Mato Grosso. Such amounts consider the use of own labor without considering area fencing. Fencing costs were estimated in R$ 7,500.00 per km without considering the required labor (including labor costs, that amount increases to R$ 9,660.00 per km), corresponding to R$ 2,500.00 per hectare (like in the study of previous year). Fencing was only used for cattle ranching activities.

Table 13. Average cost of APP restoration

APP Restoration	Total R$/ha	Total w/o maintenance R$/ha
São Paulo	6,986.00	5,082.00
Paraná	7,040.00	5,117.00
Mato Grosso	8,340.00	6,160.00

Source: Elaborated by authors.

[32] (MMA, 2017)

[33] (MMA, 2014)

Table 14. Average cost of ARL restoration

ARL restoration (examples)	Total R$/ha
São Paulo	32,460.00
Paraná	15,287.00
Mato Grosso	22,227.00

Source: Elaborated by authors.

In compliance with the law, it was considered that restoration is made in stages. For investment financing cases, 20% of the areas recovered was planted every five years, starting in year zero and ending in year 20 for the RL area. In the case of working capital financing, 10% of restoration was made every two years for the RL area. For APP areas, in both cases there was a division of the total area into five lots that were restored every four years by following, for each lot, the disbursement profile of the previous year, which may be seen in Table 15. A period of three years was considered, with implantation in years 1, 2 and 3.

Table 15. APP restoration profile

Year	%
1	45
2	35
3	20

Source: Elaborated by authors.

The adopted model has a time horizon of 45 years.

The property area to be restored in shown in table below (Table 16), based on results indicated in the Imaflora study[34]

[34] (Imaflora, 2017)

Table 16. APP and ARL areas to be restored (% of property)

Property	APP area to be restored* (%)	RL area to be restored (%)
SP – Large	5	6
SP – Medium	5	7
PR - Large	11	3
PR - Medium	9	6
MT - Large	1	4
MT - Medium	1	12

* About the total surface area of the property.

Source: Elaborated by authors based on 2017 Imaflora data.

Profitability of the analyzed cultures was based on the 2016 Agrianual[35] survey, in constant currency, which is shown in Table 17.

Table 17. Profitability of cultivated lands

Culture/State (R$/ha/year)	Year 1
Sugar cane (SP)	3,606
Sugar cane (PR)	3,224
MT Soybean - Conventional	906
PR Soybean - Conventional	1,655
SP Soybean - Conventional	1,015

Source: *Agrianual*, 2015

On the other hand, cattle-ranching profitability was estimated on the basis of the 2016 *Agripecuária*[36] data, which is shown in Table 18.

[35] Report produced by Informa Economics IEG | FNP.

[36] Yearbook prepared by Informa Economics IEG | FNP Consultancy, which is an integral part of Informa PLC Business Intelligence Division. The yearbook provides a database of restricted access, containing information on costs and revenues of Brazilian Farming activities. For use in this study, access to the database was obtained and therefore data are not available for public consultation.

Table 18. Cattle-ranching profitability

Culture/State (R$/ha/year)	Year 1
Extensive (SP)	582
Extensive (PR)	547
Extensive (MT)	335
Semiextensive (SP)	870
Semiextensive (PR)	846
Semiextensive (MT)	405

Source: *Agripecuária*, 2016

Financial Assumptions

All simulations were made by using existing products for rural credit or BNDES funding. Financing interest rates established in the 2017/18 Agricultural and Livestock Plan were adopted, which are show in Table 19.

Table 19. Financing rates established in 2017 Plano Safra (Agriculture and Livestock Plan)

	Working Capital: large producer	Working Capital: medium producer	Investment: ABC Program
Interest Rates	8.5% per year	7.5% per year	7.5% per year

Source: Elaborated by authors.

Figure 7. Summary of cash flow in terms of assumptions/variables referred to above

Cash flow	Formula	Assumption described on page:
(+) Revenues	(productive area: crop profitability) + RL area to be restored * RL revenues	Page 30;33;32
(-) Restoration cost	(APP area to be restored: APP cost) + (RL cost + RL area to be restored)	Page 32;31;31;32
(-) Financing costs	(interest + installments)	Page 33

Source: Elaborated by authors.

Simulations based on the Monte Carlo Method

The method used for simulations is deterministic. To expand the base case analysis, the Monte Carlo method was used. Starting from the cash flow model described above, some variables were chosen to run by a sensitivity analysis, thus creating thousands of possible scenarios for some of the adopted assumptions based on distributions of selected probabilities (a distribution of normal or uniform probability was generally adopted), and also generating thousands of possible results for the projected cash flows.

Sensitivity analyses were made for the variables related to ARL and APP costs, property profitability for the main productive activity, ARL revenues and interest rates for all selected activities. To select the maximum and minimum amounts, historical series of soybean, sugarcane and *boi gordo* (cattle) prices were analyzed. 100,000 simulations were run for each of the productive activities by varying separately the costs of restoration of ARL and APP, interest rates, crop profitability and ARL revenues. Such factors could be simultaneously varied, however it would be more complex to identify the factor that generated the highest impact on the payment capacity of the credit borrower. For that reason, factors were isolated and analyzed separately.

Results

This section intends to present the results from the base cases and from the Monte Carlo simulation.

Base cases

According to the assumptions adopted, in 46.6% of the cases an impact below 7% was verified and in 71.6% of cases, an impact below 10% on the payment capacity of financing reforestation.

The annual cash flow is negative for 2.1% of cattle-ranching simulations. In general, the impact is generally higher for investment financing in relation to working capital in 24 years. When analyzed in the period of 45 years, there is no significant change between both modalities.

For the case of São Paulo, it is noted that cash flow is positive in all simulations and the base case with the lowest impact is that using eucalyptus citriodora. However, the dissemination of this restoration model requires more in-depth analysis of the product demand and its market characteristics.

For the state of Paraná, restoration by araucaria and mate herb showed to be more attractive as compared to juçara heart of palm and banana, with impact levels twice smaller in some results. In addition, working capital financing resulted in an impact lower than in the investment financing case.

In the case of Mato Grosso, sugarcane was not simulated because it is not a typical crop in the state (sugarcane production in that state is very low). Among the restoration options using teak or Australian cedar, it was noted that there is no significant difference between the resulting impacts of both of them, being teak more attractive.

The table below shows the modeling results for simulations that cause impact on the debtor's payment capacity lower than 7%. The first column shows the type of culture used in the area (ex. soybean/sugarcane). The second column shows the restoration model considering that at least 50% of its area should be composed of native species. The following column shows the state where the project is located. It is followed by the financing type (working capital/investment) and the result of the model cash flow, which may be positive if all years are positive, or negative if in at least one projected year there is a negative cash flow. The last two columns show the impact – as measured by financial expenses and payment of the principal divided by the producer's profitability in 24 years and 45 years. In this case, the smaller the better. There is first the percentage for the 45 years of model and then for the first 24 years, with the purpose to allow the comparison with the result of study published in the previous year.

Table 20. Modeling results for base cases presenting an impact lower than 7% on the borrower's payment capacity

Culture	Restoration Model 50% native +	State	Type	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Sugar cane	50% eucalyptus citriodora	SP	Working Capital	Positive	2.2	3.4
Sugar cane	50% eucalyptus citriodora	SP	Investment	Positive	2.7	6.7
Sugar cane	25% araucaria + 25% mate herb	PR	Working Capital	Positive	2.3	4.1
Sugar cane	25% juçara + 25% banana	PR	Working Capital	Positive	3.8	5.2
Soybean	50% eucalyptus citriodora	SP	Working Capital	Positive	4.0	6.6
Soybean	25% araucaria + 25% mate herb	PR	Working Capital	Positive	2.1	3.6
Soybean	25% juçara + 25% banana	PR	Working Capital	Positive	4.2	5.9
Soybean	50% teak	MT	Working Capital	Positive	3.0	4.7
Soybean	50% cedar	MT	Working Capital	Positive	3.3	5.0

Source: Elaborated by authors.

Monte Carlo Method

To expand the analysis and minimize the deterministic aspect of the base-case results, Monte Carlo simulations were run. Some of the results of the simulation by the Monte Carlo Method are shown below, for which @RISK® software, version 7.0, was used. 100,000 simulations were run by using a normal or uniform statistical distribution. Varied parameters included ARL revenues, ARL restoration cost, interest rates, APP restoration cost and profitability of main culture.

In the case of the Monte Carlo simulations, there was not the same level of details of the base cases, given that when a great interval is analyzed, different realities may be covered. Three cases were studied. The first was sugarcane in São Paulo, the second was soybean in São Paulo and the third was extensive cattle ranching in Mato Grosso, by considering the medium producers.

Table 21 shows the interval used in the Monte Carlo simulations. The first line shows all data used for the model in the base case and the second line shows the spectrum of values adopted in Monte Carlo models. The first column shows the profitability of crops considered in the study. In the Monte Carlo simulations, values were based on the analysis of the crops' price history and not only the value for the year of 2016/2017. The second column shows the restoration costs for both APP and RL (the same cost interval was adopted for all three cases). The third column shows the interest rate (the same interest rate interval was used for the three cases).

Table 21. Interval used in Monte Carlo simulations

Affected indicator	Profitability (R$/ha/year)	Restoration Cost (R$/ha)	Interest Rate
Base case	Soybean: R$ 1,600 Sugar cane: R$ 3,506 Livestock: R$ 335	APP Restoration: R$ 9,400 + Fencing: R$ 2,500 RL Restoration: R$ 19,000	Medium Producer; Cost financing: 7.5% Medium Producer; Investment: 7.5%

Affected indicator	Profitability (R$/ha/year)	Restoration Cost (R$/ha)	Interest Rate
Monte Carlo assumption	Soybean: between R$ 464 and R$ 1,538 Sugar cane: Between R$ 456 and R$ 1,355 Livestock: Between R$ 62.5 and R$ 287.5	Restoration: Between R$ 5,750 - R$ 19,250 + Fencing: Between R$ 615 - R$ 2,685	Between 3% and 17.55%

Source: Elaborated by authors.

In general, it is possible to conclude that the impact results were more sensitive to the main activity's profitability and RL cost and less sensitive to interest rates and revenues from RL exploration. In addition, it was noted that the lower the profitability, the higher the sensitivity to the RL cost. Annex III shows the detailed results.

Figure 8 shows the results of some simulations by the Monte Carlo method in the case of working capital financing for the 45 year model (all results the Monte Carlo simulation method are shown in Annex III). The axis (4.4 in the first case) represents the result of the base case. The grey part of the horzintal bar graph shows the result of the minimum value achieved in the Monte Carlo simulation, while the blue part of the bar graph refers to maximum values. The numbers on the sides are the maximum and minimum values.

Figure 8. Result of simulation by Monte Carlo method for soybean-raising costs in 45 years

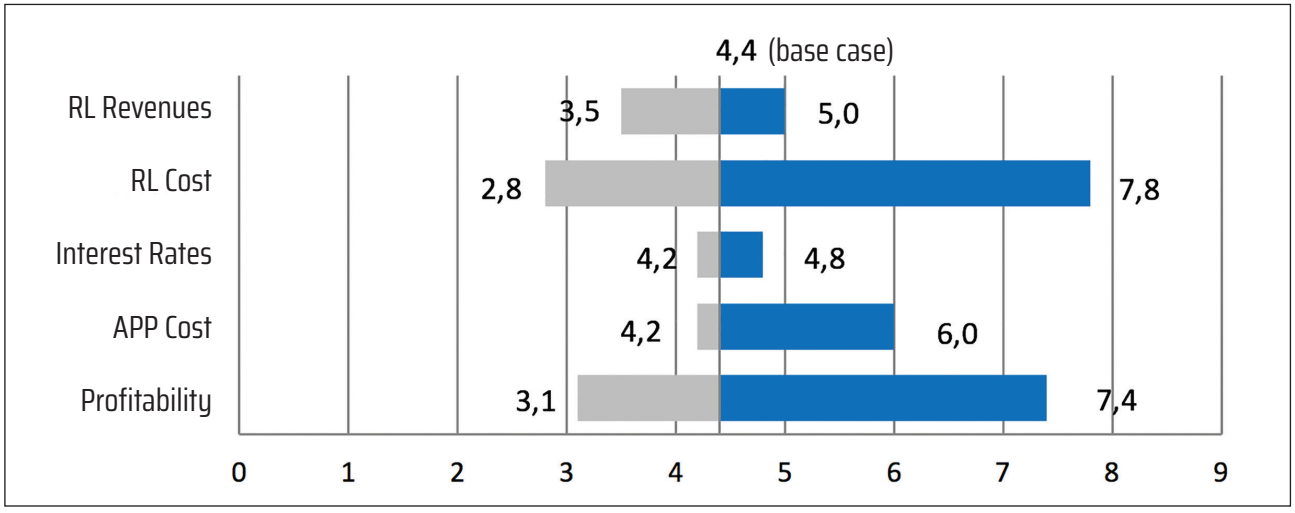


Figure 9. Sugar cane costs in 45 years – Cost of financing/profitability (%)

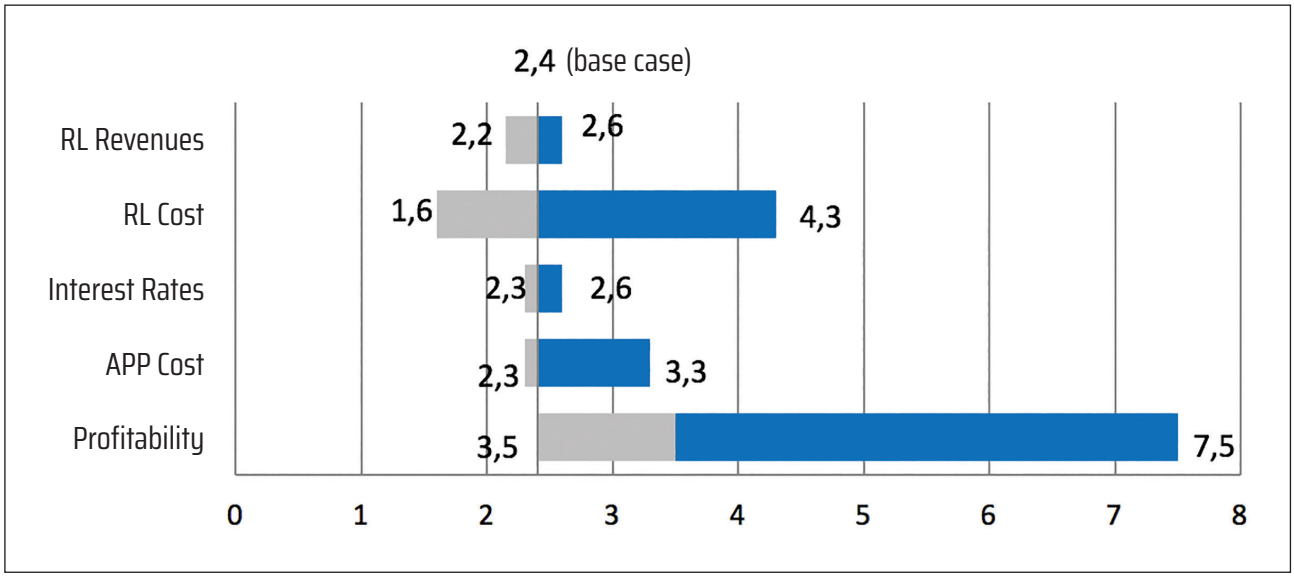
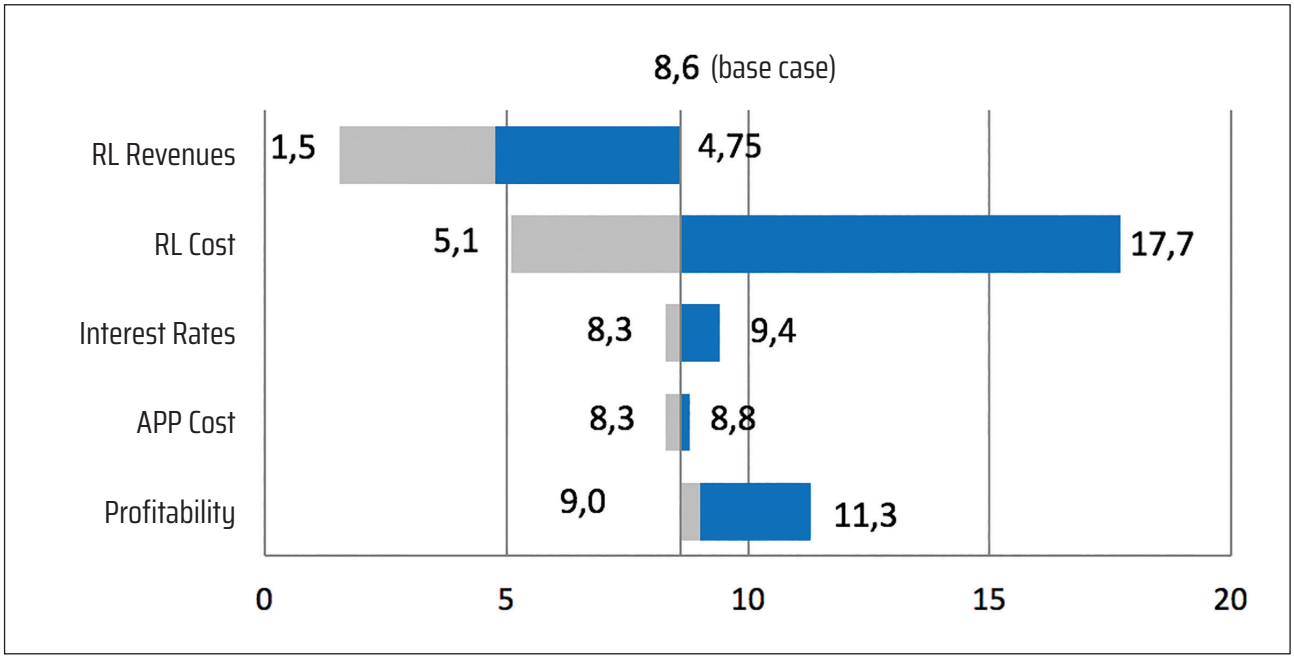


Figure 10. Livestock costs in 45 years – Cost of financing/profitability (%)



Source: Elaborated by authors.

Analysis of the Monte Carlo simulations

Five variables were analyzed in the simulation using the Monte Carlo method:

- ✓ RL Revenues
- ✓ ARL Cost
- ✓ Interest Rates
- ✓ APP Cost
- ✓ Profitability of cultivated land

For the soybean simulations, the impact in the case of working capital financing remained at up to 14% (for the case of 24 years and for the lower profitability considered) and for investment up to 25% (for the case of 24 years and for the lower profitability considered). Parameters that gave more rise to a variability in the results were the RL cost and the profitability of the main culture as opposed to interest rates (in the case of working capital) and ARL revenues (in the case of investment), which were the less sensible indicators both for 24-year and 45-year simulations.

For the sugarcane simulations, both in the case of working capital and investment, the indicator that showed the highest sensitivity was profitability. Results for that case ranged between 5.6% and 14% for 24-year simulations, and between 3.5% and 7.5% for 45-year simulations in the case of working capital, and between 10.8% and 25.4% for 24-year simulations and between 4.3% and 9.2% for 45-year simulations for investment. On the other hand, the parameters that represented the least impact were the ARL revenues and interest rates.

For extensive cattle-ranching simulations, the RL cost was the most expressive indicator due to the lower profitability (the higher the profitability, the lower the sensitivity to RL cost). Results for this case ranged between 10.5% and 39.6% for 24-year simulations, and between 5.1% and 17.7% for 45-year simulations in the case of working capital, and between 15.7% and 62.1% for 24-year simulations and between 6.4% and 22.0% for 45-year simulations for investment. On the other hand, the parameters that represented the least impact were the RL revenues and interest rates.

7. Test for applicability of productive systems financing: case studies

The case studies had two objectives. The first was to determine whether the secondary data used and the obtained results were adequate, and the second was to check on site the producers' challenges, by determining whether the approach adopted by them led to positive results for the property and whether the adopted model can be replicated.

This chapter intends to provide a brief presentation of the case studies and their results. Supplement 3 provides more details on each case study. As requested by the rural producers that accepted to participate in this study, the identification of properties was maintained confidential.

Methodological Procedures

The case study consisted of on-site visits followed by primary data processing. After that primary data processing, it was possible to analyze possible reforestation methods with Legal Reserve exploration.

Table 22 provides information on the rural properties or projects selected by the technical team, which comprised the case studies of this project.

Table 22. Properties included as case studies

Case	Municipality	Macro-region	Main Activity	Flagship species
1	Bocaina - SP	Bauru - São Paulo Midwest	Sugar cane	Macadamia
2	Lapa - PR	Curitiba Mesoregion	Livestock	Pine nuts + mate herb
3	Jacupiranga – SP	MT Northeast	Livestock and ILP*	Native nutritional species
4	Novo São Joaquim - MT	MT Northeast	Livestock and apiculture	Acacia
5	Barra do Garça - MT	Marília – São Paulo Midwest	Silviculture	Hardwoods

* Crop-livestock integration

Source: Elaborated by authors.

With regard to land use and land use change and in order to analyze the environmental conditions of the properties under study, geospatial data on such places was requested from the owners. In the case of that information being unavailable, the SiCAR was used through the property's CAR registration number. After data collection and processing, thematic maps were prepared.

In the areas visited, a diagnosis was made based on the thematic maps produced. The information gathered in the field included: the identification of the current land use; the characterization of vegetation cover; the existence of factors that would cause limitation and/or barriers to the development of the project´s activities.

For each case study, different productive systems were proposed, taking into account some basic conditions recognized during the field visits and the analysis of its discounted cash flow.

In the cash flow analysis, the costs directly involved in the introduction, maintenance, handling and collection of the production systems of the proposed economic models of the Legal Reserve were considered. The considered revenues included those generated by the sale of products supplied by the system over time.

Result of case studies

First of all, a comparison was made between simulations made with data from the case studies and secondary data.

Tables 23 and 24 show the comparison of the impacts on the index "financial expenses+principal payment/profitability" between the primary and secondary data from Case 2 in a farm located in Paraná. The first table shows the impact on case study 2, which uses mate herb and Araucaria as one of the possible restoration models. The second table shows the results of the impact on a model that also uses mate herb with araucaria, but instead based on secondary data.

It is possible to find similarities between the results of both tables, validating the simulation process from secondary data.

The case study 2 highlights the index "financial expense+principal payment/profitability" that is more attractive than in the case of model using secondary data, although both cases indicate a medium/low impact on the producer's payment capacity in a time horizon of 45 years.

Table 23. Impact on financial expenses/profitability index for restoration model of case 2 with primary data

Restoration Model	Property	Culture	Type	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Mate herb with Araucaria (case 2)	150 ha	Sugar cane	Working Capital	Positive	7.1	11.4
Mate herb with Araucaria (case 2)	150 ha	Sugar cane	Investment	Positive	8.5	19.3

Source: Elaborated by authors.

Table 24. Impact on financial expenses/profitability index for restoration model using mate herb with araucaria and secondary data

Restoration Model	Property	Culture	Type	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Mate herb with Araucaria (secondary data)	300 ha	Sugar cane	Working Capital	Positive	8.2	15.8
Mate herb with Araucaria (secondary data)	300 ha	Sugar cane	Investment	Positive	9.9	28.3

Source: Elaborated by authors.

In general, the results of the case studies were positive and profitable.

In the case studies, innovative ideas of some producers that were particularly successful or that can present good results when supported by technical assistance were seen. Analyses of secondary data and field visits show that feasibility increases when a value chain is developed in the region around the forest economic exploration (example: Case 1 - macadamia in Jaú). Reproducing these clusters around a given forestry activity in the identified regions may help to increase the demand for this type of financing. It is important to point out that such ideas can be replicated in other locations if there is product demand and if the place has a similar phytophysiognomy.

However, although the business models are profitable, there are obstacles that must be overcome for a better dissemination of the process. One of the difficulties to obtaining financing is the long-term profile inherent to forest projects. Another difficulty involves the existence of collateral.

In addition, a successful restoration requires specific knowledge on the matter and continuous monitoring. Technical assistance to the rural producer is an indispensable factor, both for the selection of productive systems and for crop management.

Legal uncertainty caused by legal concerns on the constitutionality of the Forest Code and the postponements of the CAR (Rural Environmental Registry) implementation date is another factor that may decrease the financing attractiveness and increase its transaction costs.

Challenges to be faced for the escalation of the business model

The business models presented in this study faces the following challenges:

- ✓ The long-term time horizon (45 years), especially in terms of credit granting from financial institutions. Such periods are unusual for financial institutions and require an adequate funding that is not currently fully available.
- ✓ Legal uncertainty related to the Forest Code and environmental laws, which is aggravated by factors such as the deferment of the CAR deadline.
- ✓ Many producers are not used to exploring the RL economically, especially those who have no experience with forestry activities.
- ✓ There is a lack of proficiency and technical assistance for the development of reforestation techniques, which creates an additional barrier for the producer, as reforestation with economic exploration is complex from a technical and operational standpoint.
- ✓ There is a lack of tree seedlings and a qualified supply chain.
- ✓ The lack of additional incentives, such as payment for environmental services, makes the execution of the proposed business model difficult. It is necessary to consider that, even in models where the impact on the producer is small and can be absorbed by the generation of revenues and cash flow of the property, compliance with the law means a loss in the property's profitability.
- ✓ A successful reforestation requires the increase of productivity of rural properties or the adoption of measures that compensate the producer's profitability loss.
- ✓ A high indebtedness level of the rural producer makes credit granting by financial institutions difficult.
- ✓ Existing financial instruments have some operational difficulties that represent obstacles for financing (example: Environmental ABC).
- ✓ There is a lack of financial mechanisms for forest restoration.

8. Proposed discussions and final considerations

The analyses showed that there are feasible models for reforestation financing. The best results were found for soybean and sugarcane producers and working capital financing with feasible productive systems in all three evaluated states.

Comparing the results with studies conducted in 2016 showed that the additional revenues obtained from the economic exploration of the Legal Reserve makes the business model more attractive for potential financing. In addition, analyses of secondary data and field visits showed that feasibility increases when a value chain is developed in the region around the forest economic exploration (example: Macadamia in Jaú). Reproducing these clusters around a certain forestry activity in regions identified as of priority may help to increase the demand for financing of the activity.

However, even showing results with a low impact on the borrower's payment capacity, a large-scale financing model of this activity has not shown itself in general to be attractive for banks and clients at this time, except in specific cases. That fact partially derives from the case that part of the property profitability is still compromised by the high restoration costs especially in the short term and by its profitability nature only in the long term. Taking into account that profitability is a key-factor for bank financing feasibility, the increased productivity of the main activity or the adoption of measures leading to positive economic results for the rural property as a whole is essential for financing feasibility.

Also, during the field visit, a low specific technical knowledge in the forest area was noted, which would demand a greater technical assistance during plantation and in the maintenance period. This technical assistance, however, has very often shown itself to be inexistent or unreliable and plantation monitoring has shown itself to be insufficient to ensure good performance should the producer opt for performing that activity.

All of the aspects described above in addition to the current legal uncertainty with regard to the Forest Code reduces the attractiveness of the models both for producers and financers.

In order to face the challenges set out above, the following discussions have been proposed. The recommendations aim to emphasize ways in which FEBRABAN and financial institutions may promote discussions with governments, associations and rural producers to propose improvements.

Proposed improvements in existing financial mechanisms and the creation of alternatives with the Ministries of Finance, Agriculture (MAPA) and Environment (MMA)

- ✓ With regard to the Rural Credit Manual (MCR), the possibility of financing restoration as a working capital item rather than only in the form of investment is proposed. In addition, the creation of an option to increase the credit limit for the producer that has already completed restoration or is in the process of regularization (without increasing the total amount of funds allocated to rural credit) is proposed.

- ✓ With regard to the Low-Carbon Agriculture Program (ABC) and items applicable to reforestation, integrated operations are proposed, including credit facilities for reforestation associated with financing practices that increase productivity/profitability of the main activity. Moreover, it is proposed the operationalization of a complementary model, without the National Treasury equalization, which could be requested, in addition to rural producers (current beneficiaries), by companies or cooperatives operating in the supply chain of such a sector.

- ✓ Discussions with fund managers that could be used to reduce financing risks and costs are also proposed, including access to collateral mechanisms through international or national development funds and multilateral institutions – such as, for example, the World Bank.

- ✓ In addition, discussions with ministries on challenges and possible ways toward the effective implementation of the Forest Code and high-quality availability of information related to its performance and instruments (e.g., Rural Environmental Registry and Environmental Regularization Programs) are also proposed.

- ✓ Finally, the implementation of mechanisms that correctly price and pay for the environmental services provided by the rural producer may be supported, which would contribute to the advance of ARL economic exploration. Policies that recognize and compensate positive externalities should be considered to stimulate and promote reforestation with and without the economic use of the Legal Reserve.

Additionally, the importance of promoting technical assistance programs should be emphasized. Financial institutions, through FEBRABAN, may promote that discussion at a governmental level (MMA, MAPA and Embrapa). It is also suggested that FEBRABAN will contribute to disseminate information associated with ARL economic exploration, by aligning the results of this study with bank representatives and rural producers, class associations and organizations operating in the area.

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Annexes

Annex I – Productive systems for ARL restoration in all three states

Table 25. Productive systems for ARL restoration in São Paulo

RL restoration (SP)	50% native +	Simple Payback (years)
Case 1	50% native	21
Case 2	50% eucalyptus process*	14
Case 3	50% eucalyptus citriodora	15
Case 4	50% African mahogany	15
Case 5	50% rubber tree	--
Case 6	50% Pupunha	16
Case 7	50% Juçara	9

* Eucalyptus undergoes an industrial process for the manufacture of wood products, such as pulp and paper especially, but also for reconstituted wood panels.

Source: Elaborated by authors.

Table 26. Productive systems for ARL restoration in Paraná

RL restoration (PR)	50% native +	Simple Payback (years)
Case 1	50% native	35
Case 2	50% eucalyptus process	21
Case 3	50% eucalyptus citriodora	14
Case 4	50% Australian cedar	14
Case 5	50% pecan nut	14
Case 6	25% juçara + 25% banana	4
Case 7	25% araucaria + 25% mate herb	11

Source: Elaborated by authors.

Table 27. Productive systems for ARL restoration in Mato Grosso

RL restoration (MT)	50% native +	Simple Payback (years)
Case 1	50% native	21
Case 2	50% Australian cedar	14
Case 3	50% eucalyptus citriodora	14
Case 4	50% African mahogany	15
Case 5	50% teak	14
Case 6	50% Agro-Forestry Systems (SAF)	7

Source: Elaborated by authors.

Annex II – Results of economic-financial simulations

SÃO PAULO

50% native and 50% eucalyptus citriodora

Working Capital:

Table 28. Result for São Paulo considering working capital financing and productive system 50% native and 50% eucalyptus citreodora

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	4.0	6.6
Medium	Soybean	Positive	4.4	7.3
Large	Sugar cane	Positive	2.2	3.4
Medium	Sugar cane	Positive	2.4	3.7
Large	Extensive Livestock	Positive	7.0	12.7
Large	Semi-extensive Livestock	Positive	5.2	9.1
Medium	Extensive Livestock	Positive	7.4	13.5
Medium	Semi-extensive Livestock	Positive	5.6	9.7

Source: Elaborated by authors.

Investment:

Table 29. Result for São Paulo considering investment financing and productive system 50% native and 50% eucalyptus citreodora

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	4.9	12.7
Medium	Soybean	Positive	5.3	13.8
Large	Sugar cane	Positive	2.7	6.7
Medium	Sugar cane	Positive	3.0	7.4
Large	Extensive Livestock	Positive	8.5	23.5
Large	Semi-extensive Livestock	Positive	6.4	17.1
Medium	Extensive Livestock	Positive	8.9	24.9
Medium	Semi-extensive Livestock	Positive	6.8	18.2

Source: Elaborated by authors.

50% native and 50% heart ofpalm

Working Capital:

Table 30. Result for São Paulo considering working capital finance and productive system - 50% native and 50% pupunha

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	13.1	18.2
Medium	Soybean	Positive	14.7	20.5
Large	Sugar cane	Positive	6.9	9.1
Medium	Sugar cane	Positive	7.8	10.3
Large	Extensive Livestock	Positive	22.1	32.2
Large	Semi-extensive Livestock	Positive	15.8	22.5
Medium	Extensive Livestock	Positive	24.3	35.8
Medium	Semi-extensive Livestock	Positive	17.6	25.1

Source: Elaborated by authors.

Investment:

Table 31. Result for São Paulo considering investment financing and productive system - 50% native and 50% pupunha

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	16.0	34.7
Medium	Soybean	Positive	17.9	38.9
Large	Sugar cane	Positive	8.4	17.9
Medium	Sugar cane	Positive	9.6	20.2
Large	Extensive Livestock	Positive	26.5	60.3
Large	Semi-extensive Livestock	Positive	19.1	42.7
Medium	Extensive Livestock	Positive	29.2	66.4
Medium	Semi-extensive Livestock	Positive	21.3	47.3

Source: Elaborated by authors.

PARANÁ

50% native, 25% araucaria and 25% mate herb

Working Capital:

Table 32. Result for Paraná considering working capital financing and procutive system - 50% native, 25% araucaria and 25% mate herb

Property	Culture	Cash flow	Financial expenses / profitability % (45 years)	Financial expenses / profitability % (24 years)
Large	Soybean	Positive	2.1	3.6
Medium	Soybean	Positive	2.7	4.6
Large	Sugar cane	Positive	2.3	4.1
Medium	Sugar cane	Positive	2.4	4.0
Large	Extensive Livestock	Positive	9.0	16.6
Large	Semi-extensive Livestock	Positive	6.2	11.2
Medium	Extensive Livestock	Positive	8.2	15.8
Medium	Semi-extensive Livestock	Positive	6.0	11.0

Source: Elaborated by authors.

Investment:

Table 33. Result for Paraná considering investment financing and productive system - 50% native, 25% araucaria and 25% mate herb

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	2.6	7.1
Medium	Soybean	Positive	3.4	8.8
Large	Sugar cane	Positive	2.9	8.0
Medium	Sugar cane	Positive	7.9	3.0
Large	Extensive Livestock	Positive	10.6	31.1
Large	Semi-extensive Livestock	Positive	7.4	21.4
Medium	Extensive Livestock	Positive	9.9	28.3
Medium	Semi-extensive Livestock	Positive	3.4	8.8

Source: Elaborated by authors.

50% native, 25% juçara and 25% banana

■ Working Capital:

Table 34. Result for Paraná considering working capital financing and productive system - 50% native, 25% juçara and 25% banana

Property	Culture	Cash flow	Financial expenses / profitability % (45 years)	Financial expenses / profitability % (24 years)
Large	Soybean	Positive	4.2	5.9
Medium	Soybean	Positive	6.0	7.8
Large	Sugar cane	Positive	3.8	5.2
Medium	Sugar cane	Positive	5.4	6.9
Large	Extensive Livestock	Positive	13.0	19.0
Large	Semi-extensive Livestock	Positive	9.3	13.6
Medium	Extensive Livestock	Positive	14.3	19.8
Medium	Semi-extensive Livestock	Positive	11.0	15.0

Source: Elaborated by authors.

Investment:

Table 35. Result for Paraná considering investment financing and productive system - 50% native, 25% juçara and 25% banana

Property	Culture	Cash flow	Financial expenses / profitability % (45 years)	Financial expenses / profitability % (24 years)
Large	Soybean	Positive	5.1	11.2
Medium	Soybean	Positive	7.2	14.1
Large	Sugar cane	Positive	4.2	9.2
Medium	Sugar cane	Positive	6.0	11.8
Large	Extensive Livestock	Positive	15.0	33.5
Large	Semi-extensive Livestock	Positive	10.9	24.7
Medium	Extensive Livestock	Positive	16.8	32.7
Medium	Semi-extensive Livestock	Positive	13.0	25.8

Source: Elaborated by authors.

MATO GROSSO

50% native and 50% teak

■ Working Capital:

Table 36. Result for Mato Grosso considering working capital finance and productive system - 50% native and 50% teak

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	3.0	4.7
Medium	Soybean	Positive	5.6	9.8
Large	Extensive Livestock	Positive	6.2	11.2
Large	Semi-extensive Livestock	Positive	5.6	9.7
Medium	Extensive Livestock	Positive	8.6	17.7
Medium	Semi-extensive Livestock	Positive	8.1	16.2

Source: Elaborated by authors.

Investment:

Table 37. Result for Mato Grosso considering investment financing and productive system - 50% native and 50% teak

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	3.8	9.0
Medium	Soybean	Positive	7.0	16.3
Large	Extensive Livestock	Positive	7.7	19.4
Large	Semi-extensive Livestock	Positive	6.9	17.3
Medium	Extensive Livestock	Positive	10.6	26.7
Medium	Semi-extensive Livestock	Positive	10.0	24.9

Source: Elaborated by authors.

50% native and 50% Australian cedar

■ Working Capital:

Table 38. Result for Mato Grosso considering working capital financing and productive system - 50% native and 50% Australian cedar

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	3.3	5.0
Medium	Soybean	Positive	6.0	9.9
Large	Extensive Livestock	Positive	6.5	11.2
Large	Semi-extensive Livestock	Positive	5.9	9.9
Medium	Extensive Livestock	Positive	8.6	16.7
Medium	Semi-extensive Livestock	Positive	8.2	15.5

Source: Elaborated by authors.

Investment:

Table 39. Result for Mato Grosso considering investment financing and productive system - 50% native and 50% Australian cedar

Property	Culture	Cash flow	Financial expenses/ profitability % (45 years)	Financial expenses/ profitability % (24 years)
Large	Soybean	Positive	4.1	9.5
Medium	Soybean	Positive	7.2	17.0
Large	Extensive Livestock	Positive	7.9	19.8
Large	Semi-extensive Livestock	Positive	7.0	17.7
Medium	Extensive Livestock	Negative	10.5	26.7
Medium	Semi-extensive Livestock	Positive	9.9	25.0

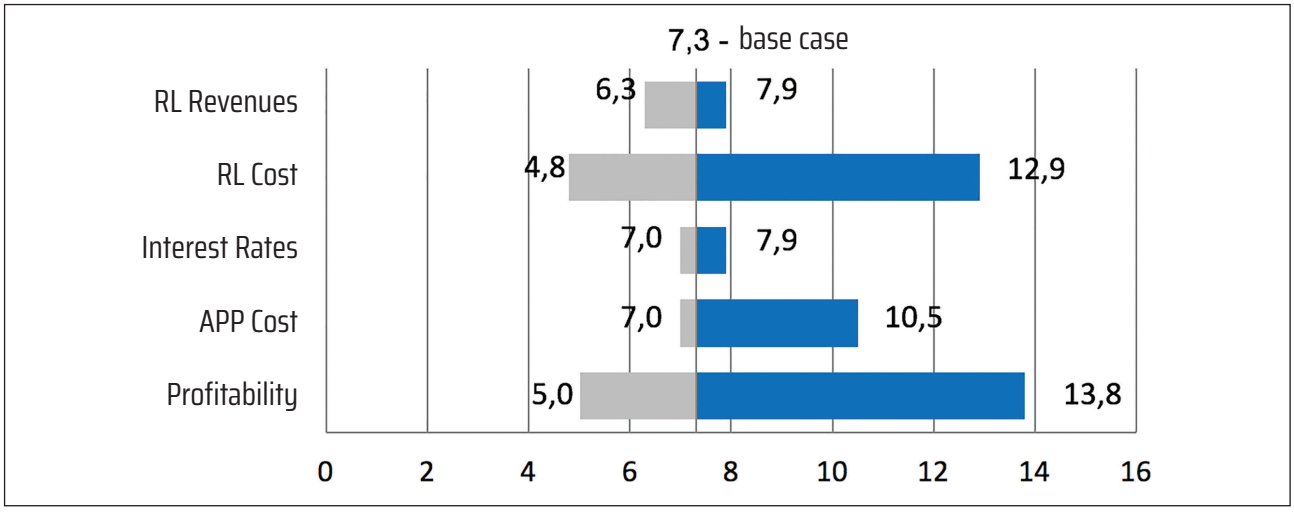
Source: Elaborated by authors.

Annex III – Results of Monte Carlo simulations

SOYBEAN:

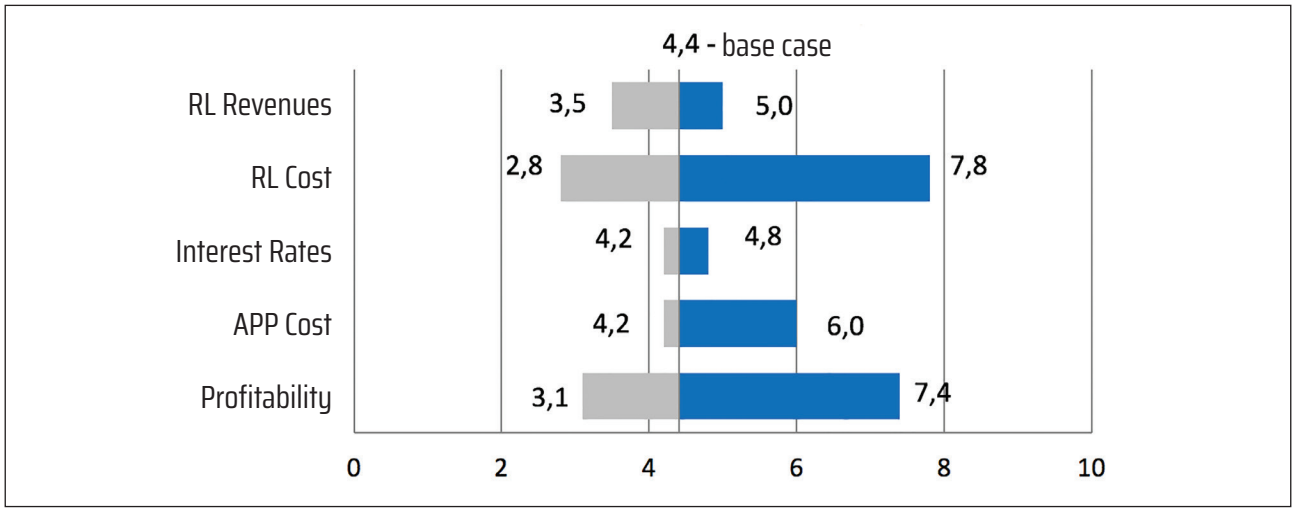
Working Capital:

Figure 11. Result of simulation by Monte Carlo method for soybean in the 24th year



Source: Elaborated by authors.

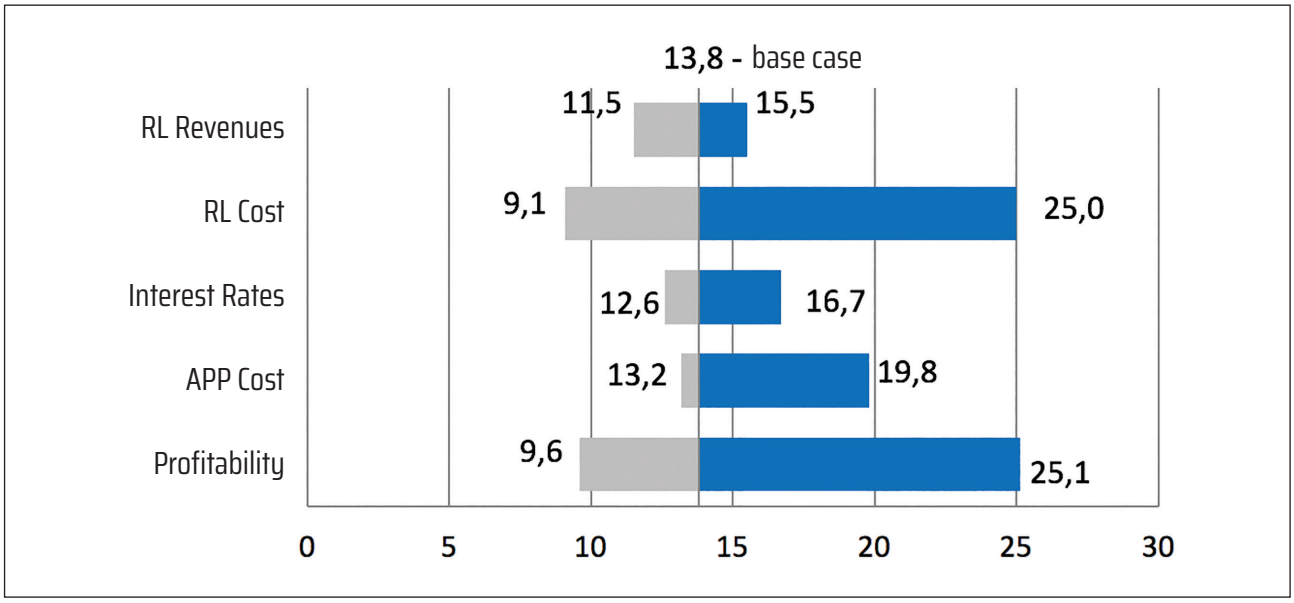
Figure 12. Result of simulation by Monte Carlo method for soybean in the 45th year



Source: Elaborated by authors.

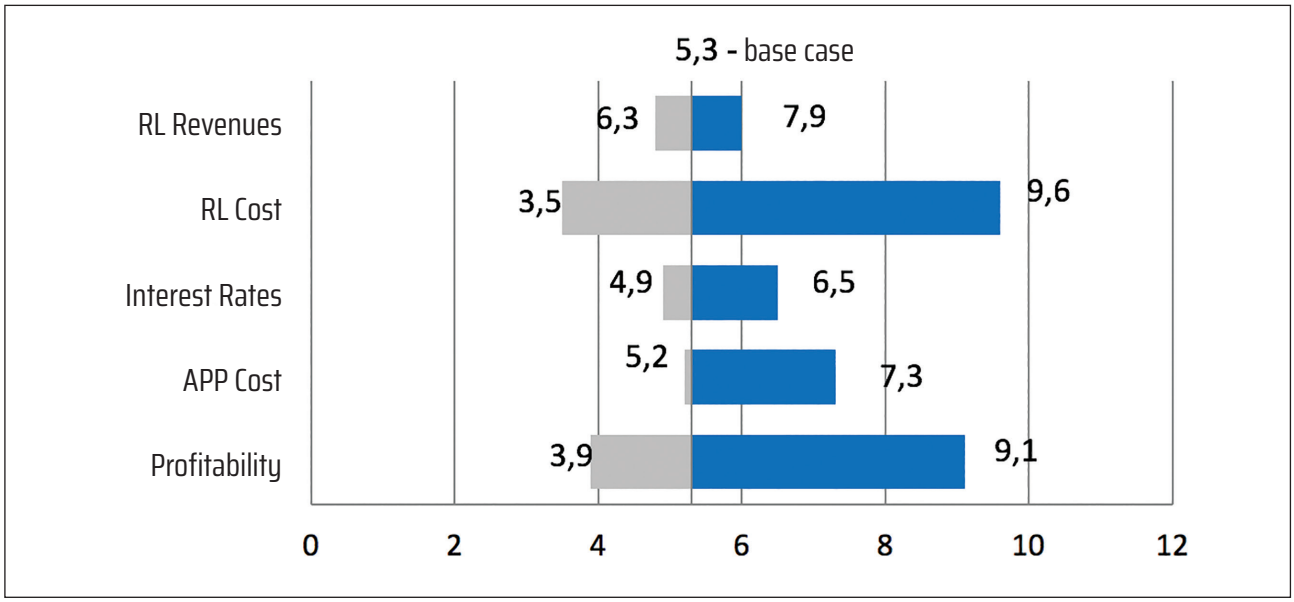
Investment:

Figure 13. Result of simulation by Monte Carlo method for soybean in the 24th year



Source: Elaborated by authors.

Figure 14. Result of simulation by Monte Carlo method for soybean in the 45th year

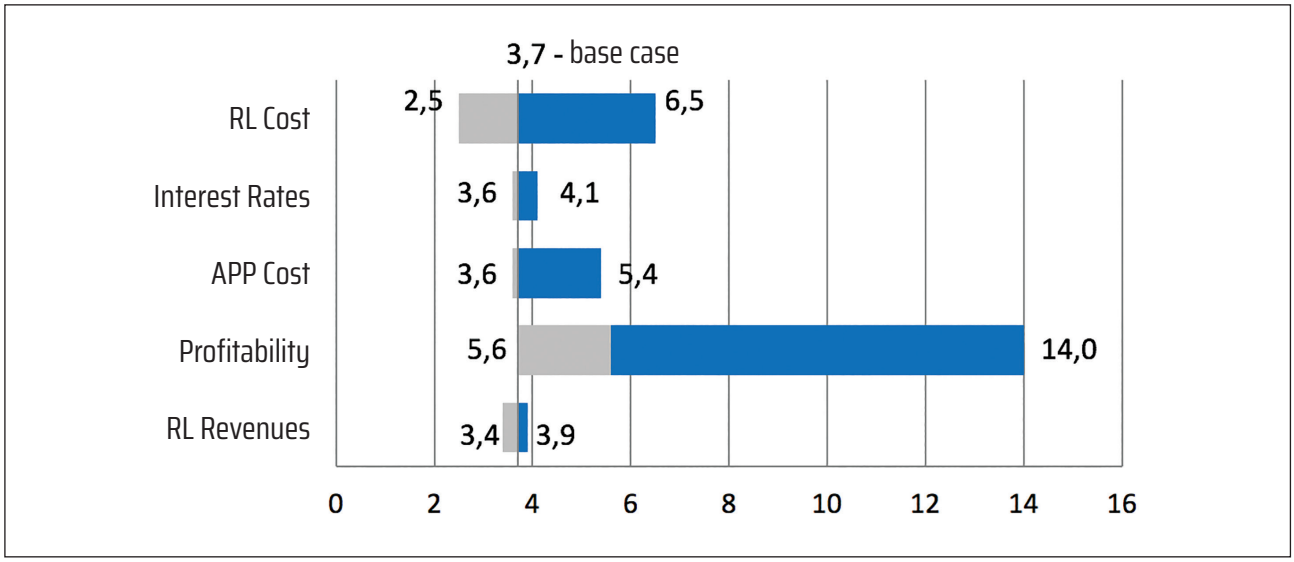


Source: Elaborated by authors.

SUGAR CANE:

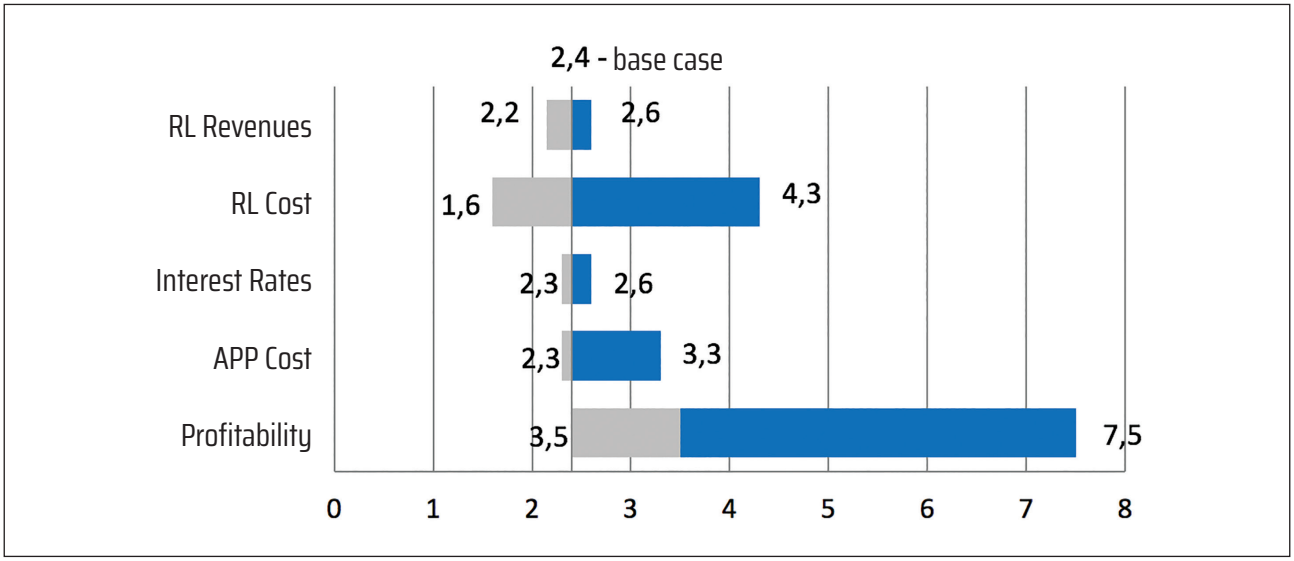
Working Capital:

Figure 15. Result of simulation by Monte Carlo method for sugarcane in the 24th year



Source: Elaborated by authors.

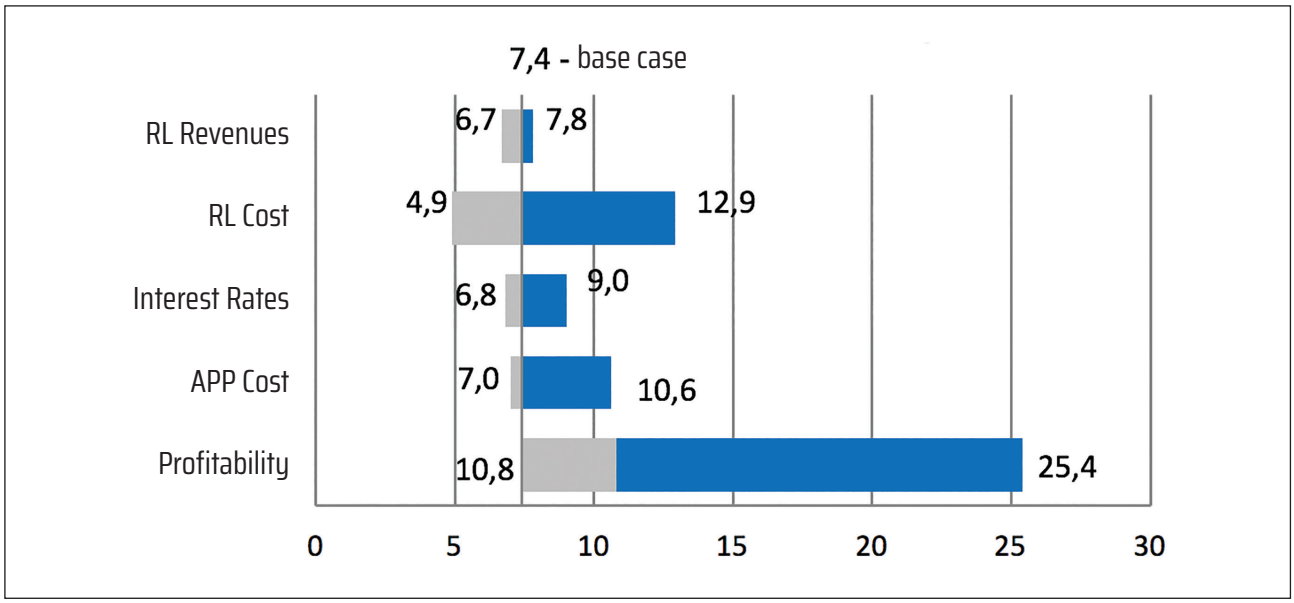
Figure 16. Result of simulation by Monte Carlo method for sugarcane in the 45th year



Source: Elaborated by authors.

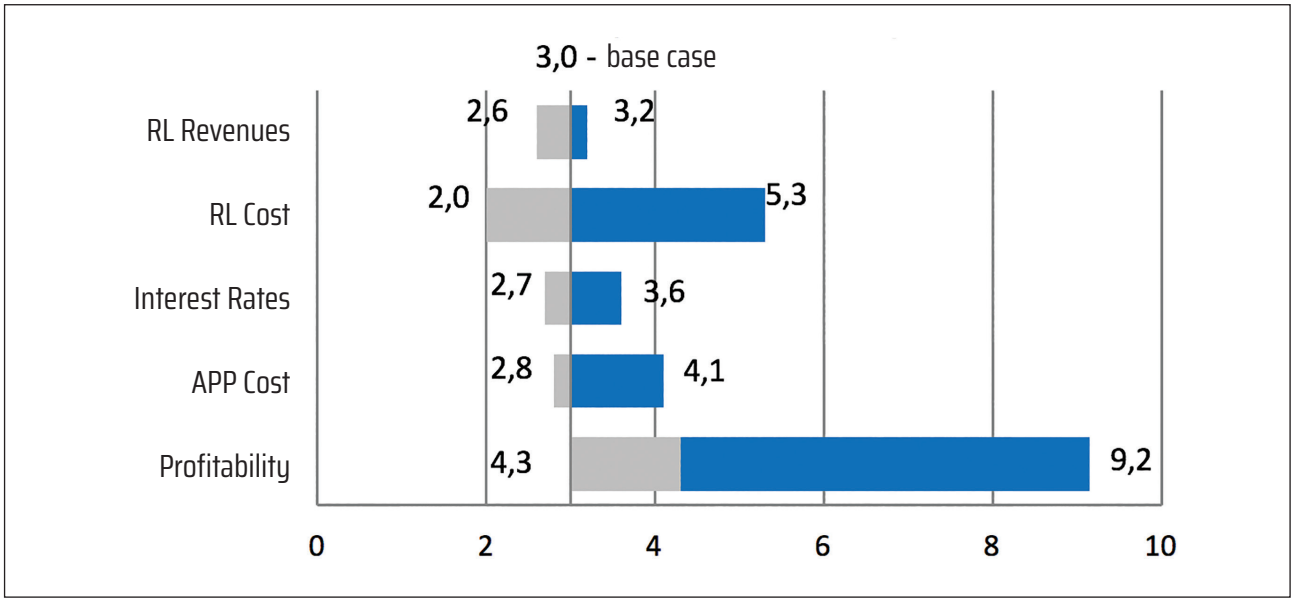
Investment:

Figure 17. Result of simulation by Monte Carlo method for sugarcane in the 24th year



Source: Elaborated by authors.

Figure 18. Result of simulation by Monte Carlo method for sugarcane in the 45th year

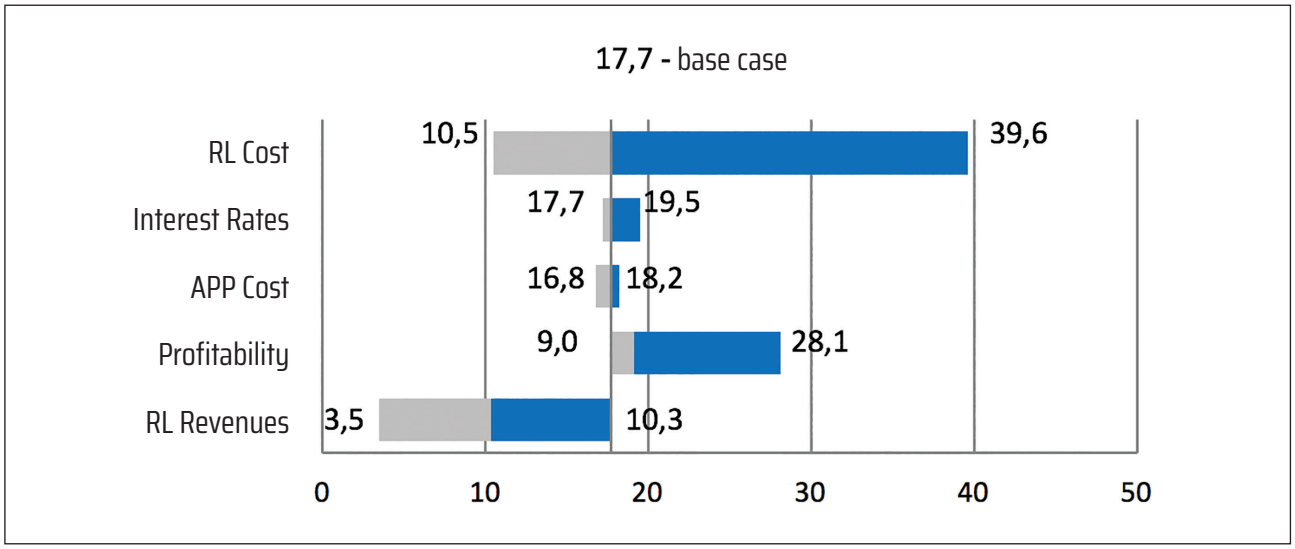


Source: Elaborated by authors.

LIVESTOCK:

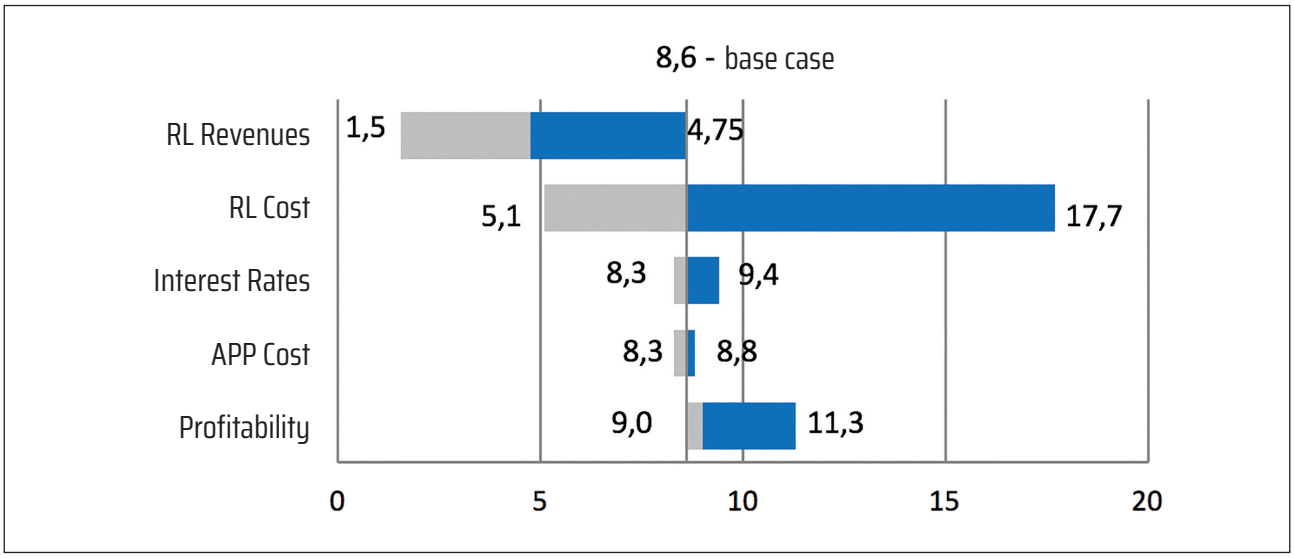
Working Capital:

Figure 19. Result of simulation by Monte Carlo method for livestock in the 24th year



Source: Elaborated by authors.

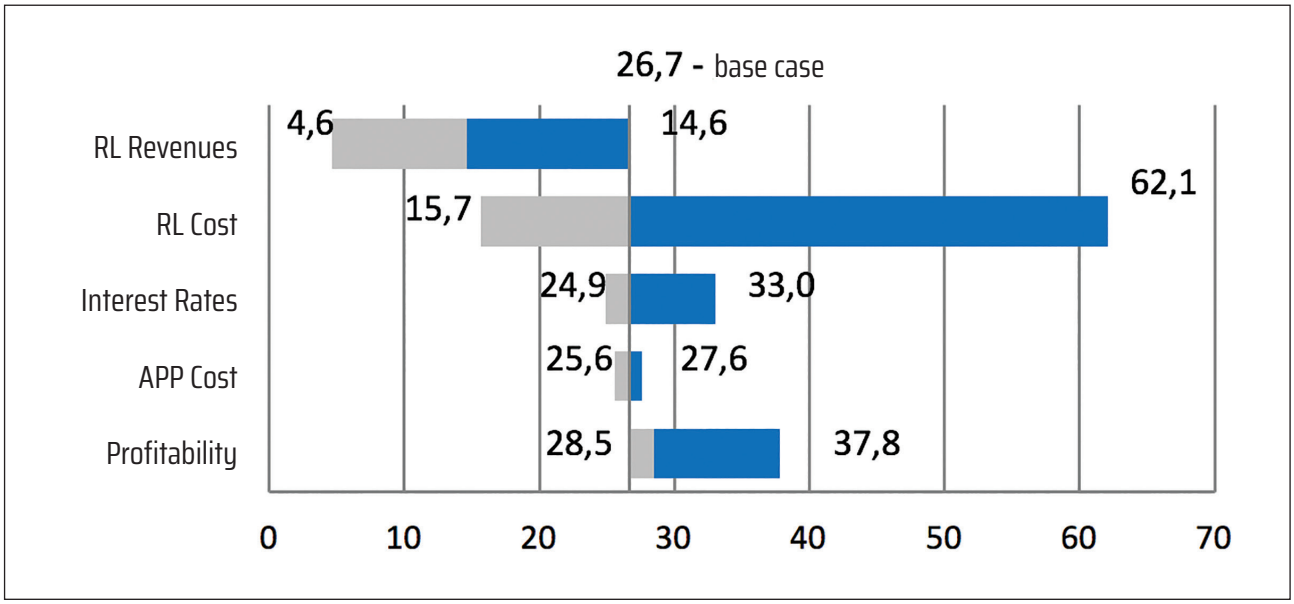
Figure 20. Result of simulation by Monte Carlo method for livestock in the 45th year



Source: Elaborated by authors.

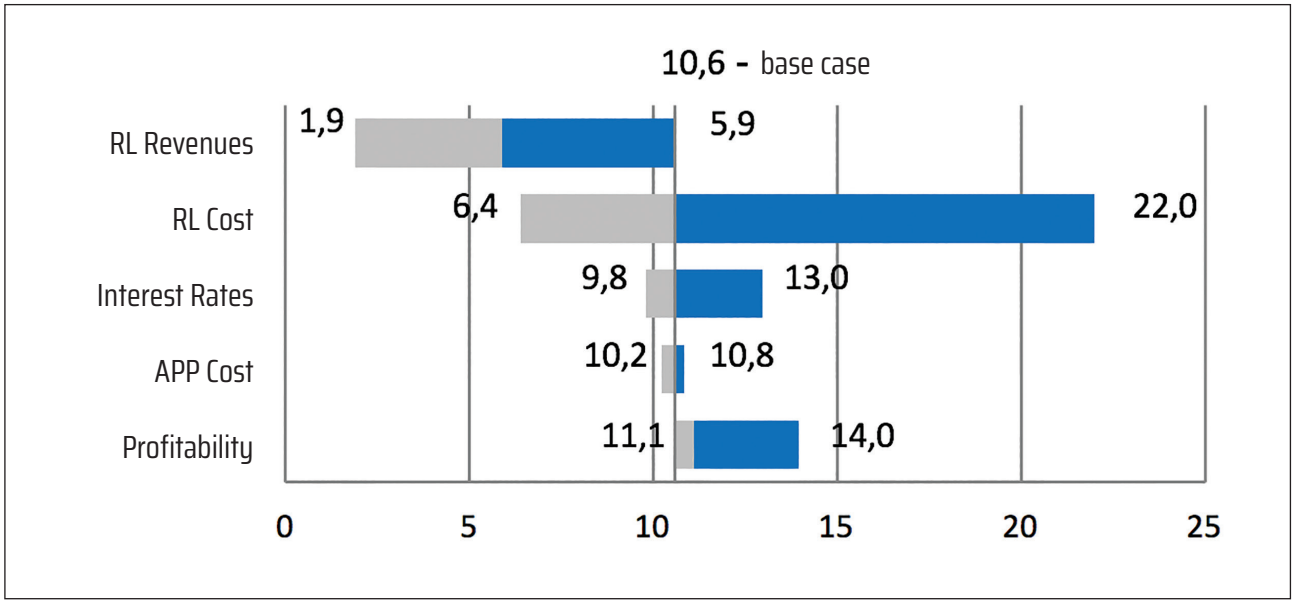
Investment:

Figure 21. Result of simulation by Monte Carlo method for livestock in the 24th year



Source: Elaborated by authors.

Figure 22. Result of simulation by Monte Carlo method for livestock in the 45th year



Source: Elaborated by authors.

Prepared for

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