São Paulo, October 2016.

ECONOMIC ANALYSIS OF INVESTMENT FOR THE CATTLE RANCHING EXPANSION

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1. INTRODUCTION

Historically, the evolution of national cattle ranching has always followed territorial occupation, expanding production and promoting economic development of several Brazilian regions. It is estimated that from 2010 to 2013, the area allocated to pastures occupied 19% to 23% of the entire national territory, which represents between 164 to 198 million hectares, depending on the source considered.

Agroicone estimates point to a reduction in pasture areas by 4.1 million hectare in Brazil between 1996 and 2013. While pasture areas in some regions of the country have increased, especially in the agricultural frontier regions (such as in the North region) and hitherto covered by native vegetation, in most of the country there has been significant reduction in pasturelands. This occurred due to improvements of technologies adopted in the beef production chain, which has allowed an increase in production in a smaller area (Martha Jr, G.B. et al, 2012; Amaral, G. et al, 2012). According to Martha Jr, G.B. et al (2012), between 1996 and 2006, an estimated area of 73 million hectares in the north of the Amazon ceased to be deforested (for cattle ranching expansion) due to the increase in the productivity of beef.

In 2014, according to Brazilian Association of Beef Exporters - ABIEC (2015), the production of beef reached 10.1 million carcass-equivalent tons (TEC), out of which 2.1 million (20%) was for exports. In the period between the years 1996 and 2013, production per hectare (in @[1] produced per hectare) increased 76%, from 2.2 to 3.8 @/ha/year (Nassar et al. 2014[2]), with gains of 37% in the stocking rate and improvements in performance indexes.

Additionally, it is important to highlight the reduction of clandestine slaughtering and of the informal beef market throughout time (Harfuch, L. et al (2016), Bankuti, F.I. e Azevedo, P.F., 2004; Jesus Jr, C. et al 2008 (BNDES); IBGE, 2016). According to ABIEC (2015), it is estimated that the informal market currently accounts for 22%[3] of all cattle slaughtered in the country. In the year 2000, for example, this ratio was about 40%.

1 1 @ is equivalent to 15 kg.

2 Study developed in partnership with Agroconsult Consultoria e Projetos, under coordination of Maurício Palma Nogueira (coordinator of the livestock sector division).

3 According to CEPEA, clandestine slaughtering of cattle (without proof of sanitary inspection) in Brazil represents approximately 10% of the total. The rest can be considered as informal slaughtering.

However, the advance of pasture areas over areas hitherto covered by native vegetation brought about the debate on the relationship between beef industry and deforestation (Sampaio, 2015). Non-governmental organizations (NGOs), consumers, retailers and the Public Prosecution Service have been pushing the sector to implement measures against irregularities, especially illegal deforestation, with focus on the Amazon, slave labor, and illegal appropriation of land, among others.

In the study "Long-term vision for the Brazilian cattle industry: implementation of the Forest Code and reduction of deforestation[4]", the 2035 baseline scenario indicates that pasture areas will need to be reduced by 18 million hectares compared to 2010, accompanied by an increase of beef production by 44%. That is, the beef industry should increase its production per hectare by 58% in 25 years.

4 This study will be available at www.inputbrasil.org.br

Considering the importance of beef cattle in Brazil and recent commitments to sustainability and reduction of deforestation, this study aims to present economic analysis of the intensification of cattle ranching, from the farmer's point of view, comparing various combinations of technologies and possibilities for expansion of the agricultural frontier, in order to answer the following questions:

- **Is the intensification of already cleared pastures economically feasible? In which conditions (size of the property, technology migration, biome)?**
- **Is the intensification of pastures in already cleared areas more advantageous than clearing new native vegetation areas? In which conditions?**
- **What is the implication of land appreciation in the profitability of cattle ranching?**
- **Is it possible to envisage a future for cattle ranching without the expansion over native vegetation areas? What is necessary for this vision to become a reality?**

Thus, this study is divided as follows: methodology, analysis of results for each biome and final remarks.

2. INVESTMENT ANALYSIS FOR CATTLE RANCHING INTENSIFICATION AND COMPARISON WITH EXPANSION OVER AGRICULTURAL FRONTIER

2.1. METHODOLOGY

To evaluate the economic feasibility of the expansion of cattle ranching, databases with costs and investments, cash flows and production intensification analysis throughout 20 years were constructed for hypothetical and representative farms in three different biomes. Furthermore, scenarios were created for the evaluation of intensification in own land versus production expansion over the agricultural frontier, resulting in the profitability (relative NPV) of cattle ranching in the property and the profitability from land appreciation.

In comparison to other studies done (IIS, 2015, CSR/UFMG, 2015), the present study considers a much wider level of scenarios and technological levels, in three different biomes, both for cattle ranching intensification and expansion over native vegetation areas, besides from considering land appreciation. However, it is not the purpose of this study to exhaust all possible combinations of technological migrations, considering small productivity gains with minimal necessary investments possible. There are higher technological levels possible that were not considered in this study.

Thus, the following hypothetical scenarios were considered:

SCENARIO 1
Cattle ranching intensification, considering only the production area of a hypothetical property.

SCENARIO 2
Cattle ranching intensification in the production area of the property and cattle ranching expansion over own vegetation area (over Legal Reserve surplus).

SCENARIO 3
Cattle ranching intensification in the production area of the property and cattle ranching expansion over purchased native vegetation area (expansion over remanining vegetation in purchased property).

SCENARIO 4
Cattle ranching expansion over purchased vegetation area.

For the analysis of cattle ranching expansion over native vegetation (**scenarios 2, 3 and 4**), two hypothetical cases were considered: (i) The producer has Legal Reserve surplus and decides to clear area to implement cattle ranching (**scenario 2**); (ii)The producer will purchase a farm in native vegetation area and clear area for cattle (**scenarios 3 and 4**).

The aim is to evaluate the economic feasibility in each hypothetical case of expansion over the agricultural frontier, comparing to the scenarios that exclusively consider cattle ranching intensification.

For these scenarios, hypothetical complete cycle farms (breeding, raising and fattening) were evaluated in the Amazon, Cerrado and Atlantic Forest biomes, considering two sizes of productions areas (where the total area of the property varies according to environmental laws):

- **"LARGE"** property with 3 thousand hectares of production area;
- **"SMALL"** property with 300 hectares of production area.

The property sizes were chosen hypothetically considering the reality observed in the field, as well as the INCRA classification of small or family farms (from 1-4 fiscal modules or maximum of 420 hectares) and large farms (over 15 fiscal modules, each module reaching up to 105 ha depending on the state). In Brazil, according to the Agricultural Census 2006 (IBGE, 2009), properties with more than 1000 hectares represent 45% of production areas in the country (approximately 150 million hectares). These opposite extremes in the property sizes were considered also due to the fact that the complete production cycle requires minimum production scale.

The productivity levels (production in live weight per hectares per year) adopted were (considering that 1@=15 kg of live weight):

- **EXTRACTIVIST: productivity of 0-3@/ha/year**
  (annual production of up to 45 kg/ha of live weight);
- **LOW: productivity of 3-6@/ha/year**
  (annual production of 45 to 90 kg/ha of live weight);
- **MEDIUM: 6-12@/ha/year**
  (annual production of 90 to 180 kg/ha of live weight);
- **GROWING[5]: 12-18@/ha/ano**
  (annual production of 180 to 270 kg/ha of live weight).

According to Harfuch, L. et al (2016), the Brazilian Land Use Model for Brazilian Agriculture (BLUM) shows that in 2010, 44% of pasture areas were classified in the extractivist technology level, 50% in the low level and 6% in the medium technology level. **Table 1** summarizes the simulated scenarios for the hypothetical cases of beef cattle farms.

Several sources of data on investments, costs and revenues[6] were combined, such as:

- For the Cerrado biome, the cost of deforestation adopted was of R$3,018 per hectare, revenue of R$3,296[7] per hectare (IMEA, 2015) and the price of land with vegetation of R$2,200/ha (FNP, 2015 adapted to the Bodoquena-MS / Rondonópolis-MT).
- For the Amazon biome, revenues from deforestation are equal to costs (Rettmann, 2013) and R$1,767 per hectare the price of land with vegetation (FNP, 2015 adapted to the Colíder / Alta Floresta-MT).

5 It is worth highlighting that the technology considered as "growing" in this study does not limit productivity to as much as 18@/ha/year, since it is below the productivity potential that the farm can achieve. The considered technology was based on the production on pasture with supplementary feeding.

6 The investments for transition between technology levels were estimated based on Nassar et al. (2014), developed in partnership with Agroconsult (livestock division, coordinated by Maurício Palma Nogueira), the data being adapted to the objectives of the analysis, and a model elaborated based on investment project. Other sources of data were also considered in the model (like FNP, IMEA e ICV).

7 Based on IMEA (2015), the price of timber was considered to be R$ 299.60 per m3 and average productivity of 11 m^3/ha.

TABLE 1. Simulated scenarios for economic analysis of cattle ranching intensification in the Amazon, Cerrado and Atlantic Forest biomes.

AMAZON / CERRADO / ATLANTIC FOREST PROPERTIES WITH 300 AND 3,000 HA	**INTENSIFICATION**		**EXPANSION**	
SCENARIO 1 (intensification with use of 100% of productive area)	Low to medium technology	3-6@/ha to 6-12@/ha	-	
	Low to growing technology	3-6@/ha to 12-18@/ha	-	
	Medium to growing technology	6-12@/ha to 12-18@/ha	-	
SCENARIO 2 (intensification of initial area + expansion in own area, representing 50% of final productive area)	Low to medium technology	3-6@/ha to 6-12@/ha	Extractivist	0-3@/ha
			Low	3-6@/ha
			Medium	6-12@/ha
			Growing	12-18@/ha
	Low to growing technology	3-6@/ha to 12-18@/ha	Extractivist	0-3@/ha
			Low	3-6@/ha
			Medium	6-12@/ha
			Growing	12-18@/ha
	Medium to growing technology	6-12@/ha to 12-18@/ha	Extractivist	0-3@/ha
			Low	3-6@/ha
			Medium	6-12@/ha
			Growing	12-18@/ha
SCENARIO 3 (intensification of initial area + expansion in acquired area representing 50% of final productive area)	Low to medium technology (initial productive area = 50% of final area)	3-6@/ha to 6-12@/ha	Extractivist	0-3@/ha
			Low	3-6@/ha
			Medium	6-12@/ha
			Growing	12-18@/ha
	Low to growing technology	3-6@/ha to 12-18@/ha	Extractivist	0-3@/ha
			Low	3-6@/ha
			Medium	6-12@/ha
			Growing	12-18@/ha
	Medium to growing technology	6-12@/ha to 12-18@/ha	Extractivist	0-3@/ha
			Low	3-6@/ha
			Medium	6-12@/ha
			Growing	12-18@/ha
SCENARIO 4 (expansion in acquired area representing 100% of productive area)	Low technology	3-6@/ha	-	
	Medium technology	6-12@/ha	-	
	Growing technology	12-18@/ha	-	

- On average, necessary investments for technological migration considered for each technology level were (in R$/ha, 2014 values)[8]:

	LOW	MEDIUM	GROWING
EXTRACTIVIST	1.280	2.931	n.d.
LOW		1.650	3.265
MEDIUM			1.890

Source: based on Nassar et al. (2014)

8 The investments in technological migration include the property's infrastructure (buildings, improvements, machinery and equipment), correction of pastures and purchase of animals. It does not include depreciation and reinvestments, which are considered in the operational costs.

It is noteworthy that, for the Atlantic Forest biome, only production intensification was evaluated, considering that area expansion in this region is limited due to the deforestation restriction in the biome (Law nº 11.428 of December 22nd, 2006).

The financial rates used in the analysis were 5.85% p.a. for the inflation rate and 8.5% p.a. for the interest rate (average considered for 20 year period), resulting in a real interest rate of 2.5% p.a..

The main business revenue was the sale of animals after the end of the production cycle. To do this, the price of the @ (considering that 1@=15 kg of live weight) was multiplied by the productivity in sold @ (R$/@ x @/ha = R$/ha). Thus, the higher the productivity of the property, the higher the resulting revenue.

For each production intensification project, in which there is at least a 50% increase in the average productivity of the property, a time horizon of 20 years was considered. The investments were distributed in four years, and costs and revenues also proportional to the productivity gains in the property throughout the same period. **Table 2** summarizes the values adopted in the analysis.

TABLE 2. Values adopted for economic analysis of investment projects

CONSIDERED VALUES	AMAZON	CERRADO	ATLANTIC FOREST
Base Year	2014	2014	2014
Price of low support pasture (R$/ha)	3,567	7,000	14,700
Price of medium support pasture (R$/ha)	4,950	8,417	15,700
Price of crescent support pasture (R$/ha)	6,333	9,833	16,700
Price of agricultural land (R$/ha)	7,067	17,667	21,100
Price of @ fed cattle (R$/@)	113	116	124
Real interest rate	2.5%	2.5%	2.5%
% Production area (discounting Legal Reserve)	20%	80% / 65%	80%
% Legal Reserve area	80%	20% / 35%	20%

Note: Pasture prices (FNP, 2015) in the Amazon refers to Colíder/Alta Floresta-MT. For Cerrado, refers to Bodoquena-MS and Rondonópolis-MT; and for Atlantic Forest, land prices refer to Araçatuba-SP region. Fed cattle prices based on FNP (2015).

3. RESULTS OF THE INVESTMENT ANALYSIS: HYPOTHETICAL CASES OF BEEF CATTLE FARMS

3.1. RESULTS FOR THE CERRADO

The results from all simulated scenarios for the Cerrado biome, detailing the IRR, NPV, payback per hectare and per year, can be found in **Annex 1** (property with 3 thousand ha of production area) and **Annex 2** (property with 300 ha of production area).

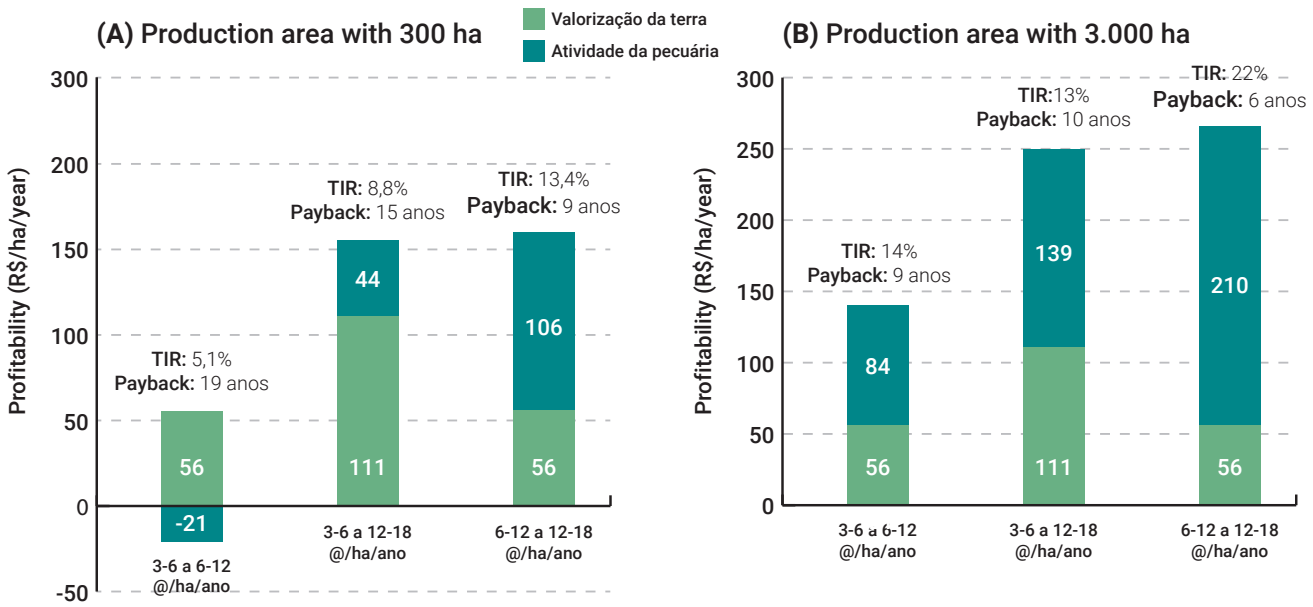
Considering **SCENARIO 1** (cattle ranching intensification using production area of the property), both for a property with 300 hectares and 3 thousand hectares of productive area, the highest profitability (relative NPV) of the project is in the level of greater intensification of cattle ranching, with a higher IRR (at constant 2014 prices) and lower discounted payback. The same behavior is observed for beef cattle profitability, that is, the more intensive the production per hectare, the higher the profitability.

According to **Figure 1**, all production intensification projects for complete cycle production and large farms are economically feasible, and the IRR is above the MARR considered (8.5%). However, the lower the initial productivity level of the farm (as in the cases of properties of up to 6@/ha/year of live weight gain), the lower the IRR[9] and the higher the payback period, which can reach up to 9 years.

Economic feasibility is more evident and capital return is higher, both in small and large farms, in the projects that start from an average productivity of 6 to 12@/ha/year, increasing until up to 18@/ha/year. In this case, considering the costs, investments and revenues from 2014, the IRR can reach up to 22%, with a 5-year payback. It is important to note that the small properties (300 ha) are only economically feasible compared to the MARR in the level with higher intensification of the activity (12-18@/ha/year).

9 For this analysis, the IRR was calculated using production costs and constant 2014 prices in R$. For the discounted payback calculation, the annual inflation rate (5.85%) was used to calculate the cumulative annual profitability at Present Value with a MARR of 8.5%.

FIGURE 1. Profitability (relative NPV) of the Cerrado project
(Scenario 1: production intensification)



Source: results of the study.

Furthermore, the smaller farms can use other, more profitable production systems (such as breeding and fattening), which are not considered in this analysis.

The financial result of the investment project for cattle ranching intensification also includes the patrimonial gain from land appreciation since the higher the productivity, the higher the price of land, according to FNP data (the prices of land with low support and crescent support pastures were differentiated), as shown in **Table 2**. By excluding the patrimonial gain from the investment in the improvement of the productivity of the land, considering only the return on investment of cattle ranching, the IRR in the large farms reduced by two percentage points in each scenario. On the other hand, in the small farms, the impact of land appreciation is more relevant in the total return of the project. Respectively for each productivity level, as shown in **Figure 1**, the IRR of the projects would be 0% in the first case, 5% in the second and 12% for the increase of productivity from 12@/ha/year to up to 18@/ha/year.

Considering **SCENARIO 2** (productivity gains in 1,500 ha of the property's production area, besides from cattle ranching expansion over own vegetation area and considering that the property has a native vegetation surplus that can be legally converted into production area in 1,500 ha), it is noted that cattle ranching expansion over vegetation, combined with intensification in already productive areas, show smaller returns for cattle ranching than those analyzed in **scenario 1**, exhibiting negative results in some cases, but surpassing previous results related to land appreciation.

The project with the worse economic return in **scenario 2** is related to production intensification from low (3-6@/ha/year) to medium (6-12@/ha/year) technology and expansion over native vegetation area with medium production (6-12@/ha/year) (**Figure 2**). The IRR is lower than the MARR and the payback of 19 years. Still regarding **scenario 2**, the project with the best economic return is related to production intensification migrating from medium (6-12@/ha/year) to growing (12-18@/ha/year) and using extractivist production in the expansion area (up to 3@/ha/year). In this case, the IRR was of 13.1% and the payback of 10 years. However, the best profitability (relative NPV) occurred in the growing (12-18@/ha/year) technology level in the expansion area.

For **SCENARIO 3** (intensification in production area and expansion in purchased area) the two projects with highest economic return, but with IRR below the MARR considered (8.5%), were those with production intensification from low (3-6@/ha/year) and medium (6-12@/ha/year) to growing (12-18@/ha/year), associated to expansion in purchased area using, respectively, growing and low production technology (**scenario 3 in Figure 2**). That is, implementing a production intensification project (in 1,500ha) combined with the purchase of new area for cattle ranching expansion (in the additional 1,500 ha) has low or null economic feasibility in this simulated scenario.

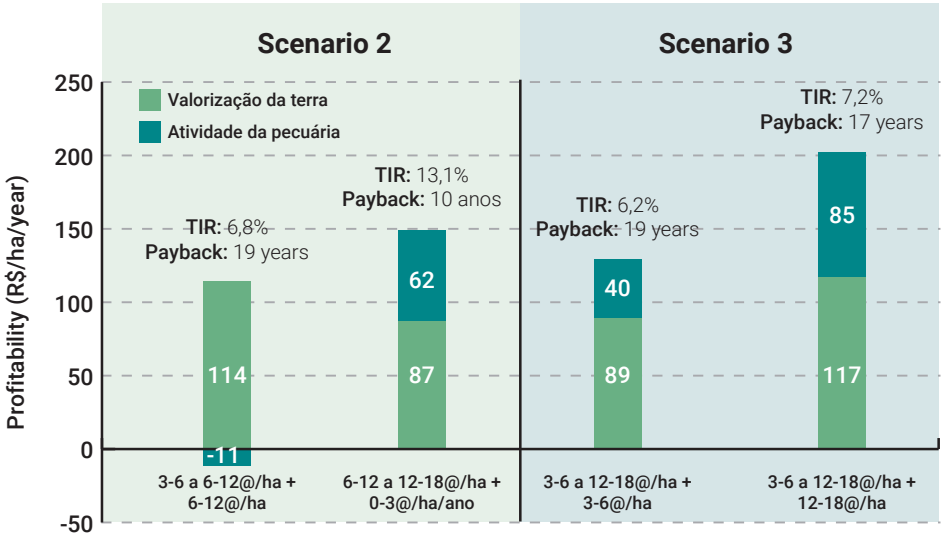
In both simulated **scenarios, 2 and 3,** the other combinations of increased productivity followed by expansion over vegetation area in the Cerrado showed similar results to those in **Figure 2**, with minimum payback of 10 to 19 years and of 17 to 19 years, respectively, considering large farms.

In the analysis of the small farms, no combination of cattle ranching intensification and production expansion showed to be economically feasible in the simulated **scenarios 2 and 3**, with negative project results in almost all cases, even incorporating land appreciation.

In **SCENARIO 4**, considering only the implementation of cattle ranching over purchased native vegetation area, with different production technologies, it was possible to observe profitability behavior as in the previous scenarios. That is, cattle ranching intensification leading to increasing returns on investments made for large properties (exclusively due to land appreciation), not being economically feasible in small properties, as shown in **Figure 3**.

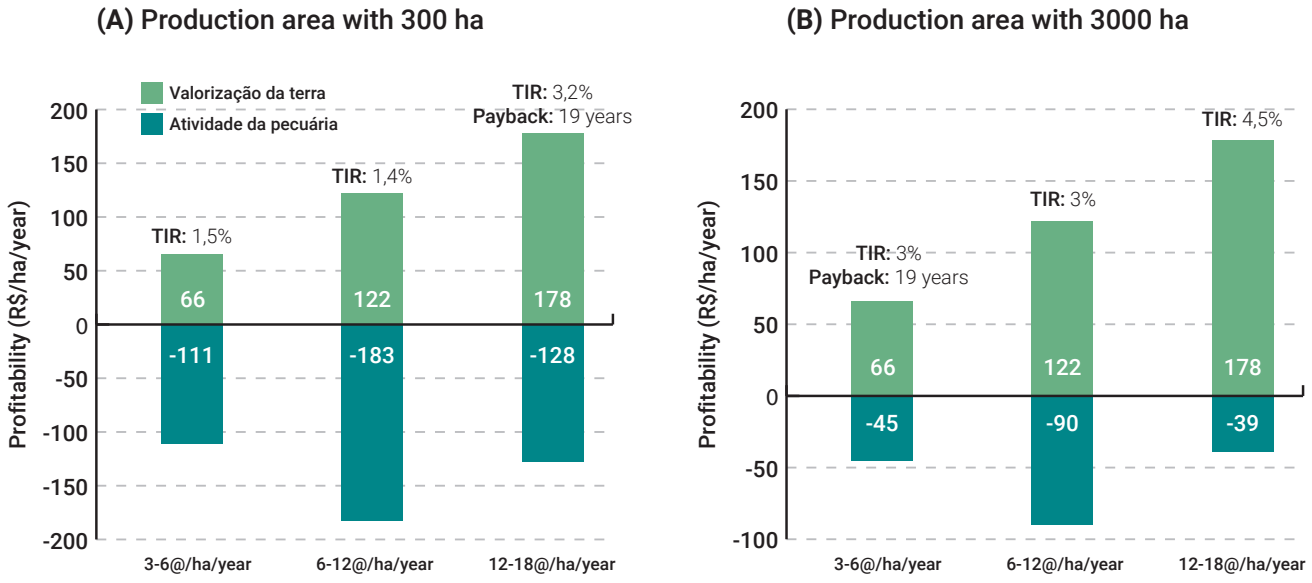
In the case of the Cerrado, among all simulated scenarios, the highest IRR and lowest payback are related to **scenario 1** of intensification migrating from medium (6-12 @/ha/year) to growing (12-18@/ha/year) technology. However, the results of all scenarios show feasibility of adopting an intensive cattle ranching in contrast to those that use low technology (up to 6@/ha).

FIGURE 2. Profitability (NPV) of the Cerrado Project
(Scenarios 2 and 3: properties with 3 thousand ha of production area)



Source: results of the study

FIGURE 3. Profitability (NPV) of the Cerrado Project
(Scenario 4: expansion over acquired native vegetation)



Source: results of the study

In general, the projects for production expansion in a large farm showed that land appreciation associated with expansion over vegetation areas have higher weight in the return of the investment project, compared to the profitability of the cattle ranching itself, regardless of productivity. On the other hand, in the intensification projects for the same area size, cattle ranching has a greater impact on the return of the project than the appreciation of the land, being crescent with the productivity levels considered.

3.2. RESULTS FOR THE AMAZON

The same scenarios were simulated for the Amazon biome (detailed in **Annexes 3 and 4**), where the results were different from those of the Cerrado, regarding the initial profitability of cattle ranching (especially due to the differences in fed cattle prices) and land appreciation, with greater price differences for land with pastures according to the technology adopted.

Regarding **SCENARIO 1** (considering only cattle ranching intensification without expansion of production area), in large properties, the highest profitability (relative NPV) of the project occurs when passing from low (3-6@/ha/year) to growing (12-18@/ha/year) technology, which is contrary to the Cerrado, where the most profitable would be to increase initial productivity from medium (6-12@/ha/year) to growing (12-18@/ha/year). However, the highest economic return (highest IRR) occurs in the migration from medium to growing technology. In this scenario, the IRR of projects varies from 14% to 20% in 20 years, with payback from 11 years to 6 years, respectively. Even disregarding land appreciation, technology migration is profitable for all productivity levels evaluated, where the IRR varies from 8.4% to 17.6%[10]. That is, land appreciation from productivity improvements contributes to the return of the projects by 2.4 to 6.1 percentage points.

10 The IRR of investment projects for sustainable intensification of cattle production within the "Novo Campo" Program of the Centro de Vida Institute (IIS, 2015), implemented in Alta Floresta-MT, showed several similar values to those presented in this study (approximately 17% for a 20-years project).

In the case of small properties, the profitability of intensification, from initial productivity of 3-6@/ha/year reaching 6-12@/ha/year or up to 18@/ha/year, is negative, with payback of 19 years, where the return on investment occurs due to land appreciation from technological improvements in the property.

In the results from **SCENARIO 2**, which combines production intensification and cattle ranching expansion over native vegetation inside the property (over Legal Reserve surplus), for the small farms, only the migration from medium (6-12@/ha/year) to growing (12-18@/ha/ano) technology with 10-year payback were economically feasible. In all other cases, positive returns were exclusively due to land appreciation, and profitability of cattle ranching was negative for those properties.

For the same scenario, in the case of large properties, the project with highest profitability per ha per year is the intensification of productivity from low (3-6@/ha/year) to growing (12-18@/ha/year), with expansion in own areas with growing (12-18@/ha) technology, when the value reaches R$ 530.59 per ha/year. However, the IRR is of 11.1% and the payback of 19 years, which is lower than in the case of intensification with medium (6-12@/ha/year) initial productivity migrating to growing (up to 18@/ha/year) and expanding over vegetation with extractivist technology (up to 3@/ha/year). The IRR in this last case reaches 13.4%, with a 13-year payback.

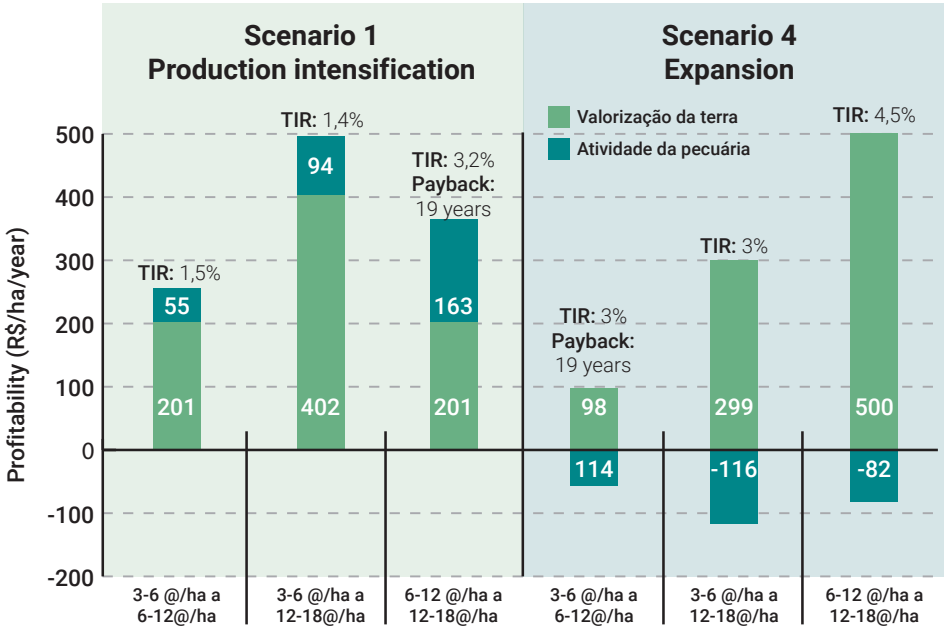
The results from **SCENARIO 3** were very similar to those from **scenario 2**, since the only difference is the purchase of vegetation area for cattle ranching expansion, besides from production intensification in the property. The financial results, however, were worse than in **scenario 2**, and there was no case where the IRR was higher than the

MARR, considering the total return on investment of the project (with land appreciation and production intensification). Still, the profitability per ha per year of some projects were continuously upward, reaching R$444.62, which is completely explained by land appreciation.

Similarly, in **SCENARIO 4**, which considers only production expansion over purchased vegetation area, no scenario was economically feasible (IRR of 3% to 5%), where the positive profitability is only due to land appreciation. **Figure 4** shows the results of **scenarios 1 and 4** for a large property.

In the case of cattle ranching in the Amazon, although the total profitability of the project is positive, **scenarios 2, 3 and 4** for a small property showed to be unfeasible. This is due to economies of scale, which favors production in large properties for the complete production cycle. Thus, properties with up to 300 ha need to achieve growing productivity level (above 12@/ha/year) for the cattle ranching to become profitable.

FIGURE 4. Profitability (NPV) of Project in the Amazon
(Scenarios 1 and 4) – property with production area of 3 thousand ha



Source: results of the study

In general, it was possible to observe that the projects with the best profitability (relative NPV) are those that achieve a productivity superior to 12@/ha, including for those with expansion over native vegetation areas. When comparing production intensification with expansion over the agricultural frontier for a large farm, the profitability per ha and per year is similar in both cases, reaching almost R$500. However, the difference between them is the composition of the return of the project and the IRR, which is much lower in the case of expansion over native vegetation (both owned and acquired) relative to production intensification in the case of a property that already has the activity, both in the Amazon and in the Cerrado biomes.

3.3. RESULTS FOR THE ATLANTIC FOREST

The Atlantic Forest scenario is limited to production intensification instead of area expansion, since according to Law nº 11.428 of December 22nd, 2006, there are legal restrictions regarding deforestation in rural areas in this biome, differently from the other biomes regulated by the Brazilian Forest Code. Thus, only the analysis related to production intensification in already used areas are presented (**scenario 1**), and the results detailed in **Annex 5**.

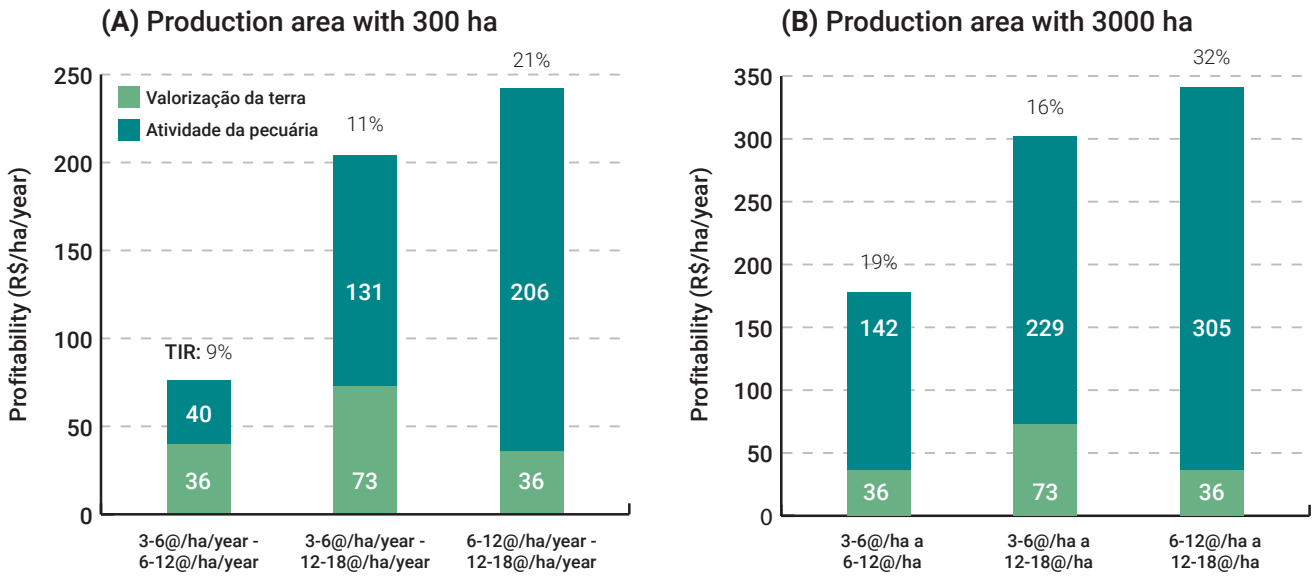
In this case, the projects with greater profitability (relative NPV), both for large and small properties, are those where there is more technological migration, that is, when there is a transition from medium (6-12@/ha/year) to growing (12-18@/ha/year) technology, resulting in an IRR of 31.6% and 20.9%, respectively. With this migration, it is possible to gain R$341.46 per ha in the large property and R$241.63 in the small property.

It is important to highlight that the return on investment is explained mainly by the intensification of cattle ranching, with lower impact from land appreciation in the project NPV, compared to the Cerrado and Amazon biomes. The payback is also shorter in this biome, being from 4 to 7 years in the case of properties with 3 thousand ha of production area and of 6 to 12 years in the properties with 300 ha of pastures (**Figure 5**).

For both hypothetical properties sizes, for any productivity level, the return of cattle ranching is superior to land appreciation for all intensification projects. This result is different from the Amazon and Cerrado biomes, especially due to the differences in logistics and infrastructure surrounding the properties. Additionally, the variations in the prices of land with pasture are lower in the Atlantic Forest relative to other biomes, resulting in lower impact on the return of the investment project.

Differently from the Cerrado and Amazon biomes, all small farms showed to be economically feasible for production intensification, especially in cases where technological migration reaches 12 to 18@/ha/year. Considering the profile of the

FIGURE 5. Profitability (NPV) of cattle intensification projects in the Atlantic Forest (NPV 20 years).



Source: results of the study

properties in this region, there are few properties with area above 2,500 ha. Additionally, other activities can have better economic return for farms with smaller production scale, such as raising and fattening or breeding, which were not addressed in this study.

Compared to other regions, the intensification projects in this biome are the ones with the highest returns on investment for all levels of productivity considered, reaching up to 32%. This result is mainly explained due to the greater proximity of this region to beef consumer centers and better access to inputs for intensification[11].

11 Even altering the price of cattle, the impact result is too small compared to the relative IRR and NPV.

4. FINAL REMARKS

The intensification scenarios for cattle ranching in complete cycle farms (breeding, raising and fattening) presented sought to evaluate the profitability of projects for productivity improvement in a 20-year period, considering hypothetical properties of two opposite extreme sizes(300 and 3 thousand ha of cattle ranching area). Furthermore, scenarios for expansion over native vegetation in the Amazon and Cerrado biomes, both over own (Legal Reserve surplus) and purchased vegetation, were analyzed.

Due to economies of scale in cattle ranching, larger properties are able to achieve better economic returns through intensification, compared to smaller properties. For small producers, especially low-tech, it is important to seek alternatives regarding the production activity, such as raising and fattening or breeding, which were not addressed in this study. Only the Atlantic Forest biome showed economic feasibility for cattle ranching intensification in properties with up to 300 ha, due to the greater return per ha of the beef industry in the region compared to the other analyzed biomes.

Economic viability was greater in the cattle ranching intensification projects in already cleared areas compared to the projects that include expansion over native vegetation, both own (Legal Reserve surplus) and purchased, for different levels of productivity. Both the Internal Rate of Return (IRR) and the return on investment period (payback) are better when techniques to improve cattle ranching are applied (as in the case of the complete cycle evaluated in this study). Additionally, under the patrimonial point of view, the differentiation of pasture land prices by support capacity also generates economic return on investment when migrating production technology.

The results from the scenarios that consider expansion over purchased native vegetation show that the return on investment is determined, exclusively, by real estate appreciation, due to the low prices of land with vegetation compared to those with pastures. It is important to highlight that, according to Ichihara (2013), based on investment project analysis, real estate appreciation upon cattle ranching expansion in the Amazon region is a decisive factor in the producer's decision process, being economically preferable to expand in new vegetation areas rather than through pasture recovery techniques.

Thus, note that it is possible to envisage cattle ranching with environmental conservation, especially in the agricultural expansion frontier region, where there is also wide availability of pasture areas with considerable potential for the intensification process to take place. It could allow this activity to free areas for other uses, such as grains and planted forests, besides from contributing to Brazil's mission to achieve the environmental goals proposed during COP21.

However, deforestation is still attractive from the real estate appreciation perspective, requiring command and control policies in order to contain deforestation, in addition to private policies such as cattle purchase restrictions from illegal deforestation areas; as well as to support conservation, granting special conditions for producers who conserve remaining green areas in their rural properties (Legal Reserve surplus) and that develop sustainable production systems (FGV EESP/GV AGRO, 2016).

Moreover, two important factors should be considered in order to boost production intensification without expansion over new areas of native vegetation. The first is

the investment in recovery and renovation of pastures within properties, especially those in agricultural frontier regions, considering the need to produce more without advancing pasture areas. In this sense, according to Dias-Filho (2011), the renovation of pastures plays an important role in the achievement of such goal, through the use of technologies to develop new forage and of strategies to recover and manage pastures.

In this sense, what is found is the existence of several technologies and management practices that are already available for producers, however the greatest challenge is dissemination, large scale adoption, technical assistance to the producer and necessity of capital injections.

The investment in animal genetics, for example, is a factor that induces sustainable intensification, not only to improve the quality of the carcass, but also so that the production process from breeding until fattening is faster and, therefore, with lower demand for additional area (and consequently reduction in deforestation and GHG).

Furthermore, for low productivity producers (up to 3@/ha/year and 3-6@/ha/year in some of the simulated scenarios), crop-livestock integration is a solution to improve the profitability of the property, diversification of activities and lower economic risk and can be used by small and large establishments (Balbinot Jr. et al., 2009). In the case of adoption for corn, for example, the beef cattle production cost can be smaller since such product would be used as an input for the supplementation of the herd.

The second factor is the necessity of rural extension and technical assistance, essential in order to implement sustainable intensification projects in the properties. This is one of the gaps faced by producers, who often need to better understand the investments (and returns) and the necessary techniques, which can make them less reticent to the process. According to case studies and pilot projects (IIS/ICV, 2015, GTPS, 2014) these are some of the main barriers to be overcome to ensure that cattle ranching intensification is widespread in Brazil.

Lastly, the results of the intensification analysis presented in this study are similar to those from the implemented pilot projects in the Amazon and Cerrado regions. Generally, incentive policies for the adoption of Good Agricultural Practices (GAP), differentiated prices for quality of the carcass and greater inclusion of cattle ranchers in the formal beef market are important factors for the improvement of the profitability of the activity and for the reduction of pasture expansion over native vegetation areas.

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ANNEX 1 – RESULTS OF SIMULATED SCENARIOS FOR THE CERRADO BIOME AND PRODUCTION AREA OF 3,000 HA

SIMULATED SCENARIOS	INTENSIFICATION	EXPANSION	RELATIVE NPV 20 YEARS (R$/ha/year)	IRR Constant prices	PAYBACK
SCENARIO 1 (intensification with use of 100% of production area)	Low to medium technology	-	140	14,0%	9 years and 2 months
	Low to growing technology	-	250	12,9%	10 years and 1 month
	Medium to growing technology	-	265	22,5%	5 years and 5 months
SCENARIO 2 (intensification of initial area + expansion in own area, representing 50% of final production area)	Low to medium technology	Extractivist	78	7,7%	19 years and 0 months
		Low	99	7,9%	17 years and 0 months
		Medium	103	6,8%	19 years and 0 months
		Growing	156	7,7%	17 years and 2 months
	Low to growing technology	Extractivist	133	8,9%	16 years and 1 month
		Low	154	8,9%	14 years and 4 months
		Medium	158	7,8%	17 years and 2 months
		Growing	212	8,4%	16 years and 0 months
	Medium to growing technology	Extractivist	148	13,1%	10 years and 3 months
		Low	170	12,2%	10 years and 4 months
		Medium	174	10,0%	13 years and 1 month
		Growing	227	10,2%	12 years and 4 months
SCENARIO 3 (intensification of initial area + expansion in acquired area representing 50% of final production area)	Low to medium technology (initial production area = 50% of final area)	Extractivist	52	4,5%	19 years and 1 month
		Low	73	5,0%	19 years and 1 month
		Medium	77	4,7%	19 years and 1 month
		Growing	131	5,7%	19 years and 1 month
	Low to growing technology	Extractivist	108	5,9%	19 years and 1 month
		Low	129	6,2%	19 years and 0 months
		Medium	133	5,8%	19 years and 1 month
		Growing	186	6,5%	19 years and 0 months
	Medium to growing technology	Extractivist	123	7,4%	19 years and 0 months
		Low	144	7,6%	17 years and 1 month
		Medium	148	6,8%	19 years and 0 months
		Growing	201	7,5%	17 years and 2 months
SCENARIO 4 (expansion in acquired area representing 100% of production area)	Low technology	-	21	3,0%	19 years and 2 months
	Medium technology	-	32	3,1%	19 years and 2 months
	Growing technology	-	138	4,5%	19 years and 1 month

Source: results of the study

ANNEX 2 – RESULTS OF THE SIMULATED SCENARIOS FOR THE CERRADO BIOME AND PRODUCTION AREA OF 300 HA

SIMULATED SCENARIOS	INTENSIFICATION	EXPANSION	RELATIVE NPV 20 YEARS (R$/ha/year)	IRR Constant prices	PAYBACK
SCENARIO 1 (intensification with use of 100% of production area)	Low to medium technology	-	35	5.2%	19 years and 1 month
	Low to growing technology	-	155	8.8%	15 years and 0 months
	Medium to growing technology	-	161	13.4%	9 years and 1 month
SCENARIO 2 (intensification of initial area + expansion in own area, representing 50% of final production area)	Low to medium technology	Extractivist	-67	-1.5%	-
		Low	-72	-1.2%	-
		Medium	-95	-1.3%	-
		Growing	-37	1.3%	-
	Low to growing technology	Extractivist	-6	2.2%	-
		Low	-11	2.1%	-
		Medium	-35	1.4%	-
		Growing	24	3.1%	19 years and 2 months
	Medium to growing technology	Extractivist	4	2.8%	19 years and 2 months
		Low	-1	2.5%	-
		Medium	-24	1.5%	-
		Growing	34	3.6%	19 years and 2 months
SCENARIO 3 (intensification of initial area + expansion in acquired area representing 50% of final production area)	Low to medium technology (initial production area = 50% of final area)	Extractivist	-92	-1.0%	-
		Low	-97	-0.8%	-
		Medium	-121	-0.9%	-
		Growing	-62	1.0%	-
	Low to growing technology	Extractivist	-32	1.5%	-
		Low	-37	1.5%	-
		Medium	-60	1.0%	-
		Growing	-2	2.5%	-
	Medium to growing technology	Extractivist	-21	1.7%	-
		Low	-26	1.6%	-
		Medium	-50	1.1%	-
		Growing	9	2.7%	19 years and 2 months
SCENARIO 4 (expansion in acquired area representing 100% of production area)	Low technology	-	-45	1.5%	-
	Medium technology	-	-61	1.4%	-
	Growing technology	-	50	3.2%	19 years and 2 months

Source: results of the study

ANNEX 3 – RESULTS OF THE SCENARIOS SIMULATED FOR THE AMAZON BIOME AND PRODUCTION AREA OF 3,000 HA

SIMULATED SCENARIOS	INTENSIFICATION	EXPANSION	RELATIVE NPV 20 YEARS (R$/ha/year)	IRR Constant prices	PAYBACK
SCENARIO 1 (intensification with use of 100% of production area)	Low to medium technology	-	256	14.8%	11 years and 2 months
	Low to growing technology	-	496	14.4%	11 years and 4 months
	Medium to growing technology	-	364	20.0%	6 years and 5 months
SCENARIO 2 (intensification of initial area + expansion in own area, representing 50% of final production area)	Low to medium technology	Extractivist	206	10.3%	19 years and 0 months
		Low	223	10.0%	19 years and 0 months
		Medium	292	9.7%	19 years and 0 months
		Growing	410	10.5%	19 years and 0 months
	Low to growing technology	Extractivist	326	11.4%	19 years and 0 months
		Low	344	11.0%	18 years and 1 month
		Medium	413	10.6%	19 years and 0 months
		Growing	531	11.1%	19 years and 0 months
	Medium to growing technology	Extractivist	267	13.4%	13 years and 3 months
		Low	285	12.6%	13 years and 1 month
		Medium	354	11.5%	17 years and 1 month
		Growing	472	12.0%	16 years and 1 month
SCENARIO 3 (intensification of initial area + expansion in acquired area representing 50% of final production area)	Low to medium technology (initial production area = 50% of final area)	Extractivist	124	4.5%	19 years and 2 months
		Low	141	4.6%	19 years and 1 month
		Medium	210	5.2%	19 years and 1 month
		Growing	328	6.2%	19 years and 1 month
	Low to growing technology	Extractivist	244	5.8%	19 years and 1 month
		Low	262	5.9%	19 years and 1 month
		Medium	331	6.2%	19 years and 1 month
		Growing	449	7.0%	19 years and 1 month
	Medium to growing technology	Extractivist	185	5.5%	19 years and 1 month
		Low	203	5.6%	19 years and 1 month
		Medium	272	6.0%	19 years and 1 month
		Growing	390	6.9%	19 years and 1 month
SCENARIO 4 (expansion in acquired area representing 100% of production area)	Low technology	-	41	2.9%	19 years and 2 months
	Medium technology	-	182	3.9%	19 years and 2 months
	Growing technology	-	418	5.2%	19 years and 1 month

Source: results of the study

ANNEX 4 – RESULTS OF THE SCENARIOS SIMULATED FOR THE AMAZON BIOME AND PRODUCTION AREA OF 300 HA

SIMULATED SCENARIOS	INTENSIFICATION	EXPANSION	RELATIVE NPV 20 YEARS (R$/ha/year)	IRR Constant prices	PAYBACK
SCENARIO 1 (intensification with use of 100% of production area)	Low to medium technology	-	150	8.7%	19 years and 1 month
	Low to growing technology	-	394	11.3%	19 years and 0 months
	Medium to growing technology	-	270	14.7%	10 years and 5 months
SCENARIO 2 (intensification of initial area + expansion in own area, representing 50% of final production area)	Low to medium technology	Extractivist	60	4.5%	19 years and 2 months
		Low	51	4.0%	19 years and 2 months
		Medium	92	4.5%	19 years and 2 months
		Growing	214	6.3%	19 years and 1 month
	Low to growing technology	Extractivist	184	7.0%	19 years and 1 month
		Low	176	6.5%	19 years and 1 month
		Medium	216	6.4%	19 years and 1 month
		Growing	338	7.6%	19 years and 1 month
	Medium to growing technology	Extractivist	120	6.6%	19 years and 1 month
		Low	112	5.9%	19 years and 1 month
		Medium	152	5.9%	19 years and 1 month
		Growing	275	7.5%	19 years and 1 month
SCENARIO 3 (intensification of initial area + expansion in acquired area representing 50% of final production area)	Low to medium technology (initial production area = 50% of final area)	Extractivist	-22	2.2%	-
		Low	-31	2.0%	-
		Medium	10	2.6%	19 years and 2 months
		Growing	132	3.9%	19 years and 2 months
	Low to growing technology	Extractivist	102	3.8%	19 years and 2 months
		Low	94	3.7%	19 years and 2 months
		Medium	134	4.0%	19 years and 2 months
		Growing	256	5.0%	19 years and 1 month
	Medium to growing technology	Extractivist	38	3.1%	19 years and 2 months
		Low	30	2.9%	19 years and 2 months
		Medium	71	3.4%	19 years and 2 months
		Growing	193	4.6%	19 years and 2 months
SCENARIO 4 (expansion in acquired area representing 100% of production area)	Low technology	-	-25	2.3%	-
	Medium technology	-	88	3.2%	19 years and 2 months
	Growing technology	-	327	4.6%	19 years and 2 months

Source: results of the study

ANNEX 5 – RESULTS OF THE SIMULATED SCENARIOS FOR THE ATLANTIC FOREST BIOME AND PRODUCTION AREA OF 3,000 HA

SIMULATED SCENARIOS	INTENSIFICATION	EXPANSION	RELATIVE NPV 20 YEARS (R$/ha/year)	IRR Constant prices	PAYBACK
SCENARIO 1 (intensification with use of 100% of production area)	Low to medium technology	-	179	19.0%	6 years and 4 months
	Low to growing technology	-	302	16.4%	7 years and 5 months
	Medium to growing technology	-	341	31.6%	4 years and 3 months

Source: results of the study

ANNEX 6 – RESULTS OF SCENARIOS SIMULATED FOR THE ATLANTIC FOREST BIOME AND PRODUCTION AREA OF 300 HA

SIMULATED SCENARIOS	INTENSIFICATION	EXPANSION	RELATIVE NPV 20 YEARS (R$/ha/year)	IRR Constant prices	PAYBACK
SCENARIO 1 (intensification with use of 100% of production area)	Low to medium technology	-	77	9.2%	12 years and 4 months
	Low to growing technology	-	203	11.4%	10 years and 4 months
	Medium to growing technology	-	242	20.9%	5 years and 7 months

Source: results of the study

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ABOUT INPUT

The Land Use Initiative (INPUT - Iniciativa para o Uso da Terra) brings together Agroicone with Climate Policy Initiative (CPI) in Brazil. It counts on a dedicated team of leading economists, lawyers, mathematicians, geographers and agronomists who work at the forefront of how to increase environmental protection and food production.

INPUT engages stakeholders in Brazil's public and private sectors and maps the challenges for a better management of its natural resources. Also, it mobilizes agents of the productive chains in order to promote compliance with the new Forest Code. In addition, the project aims at analyzing and influencing the creation of a next generation of low-carbon economy policies in Brazil.

In this project, Agroicone is responsible for generating information about the alternatives to native vegetation restoration, as well as the areas of compensation for Legal Reserves and engaging the private sector in discussing the challenges of regulation and create industry solutions that enable large-scale adaptation.

For more information on the project, visit: www.inputbrasil.org