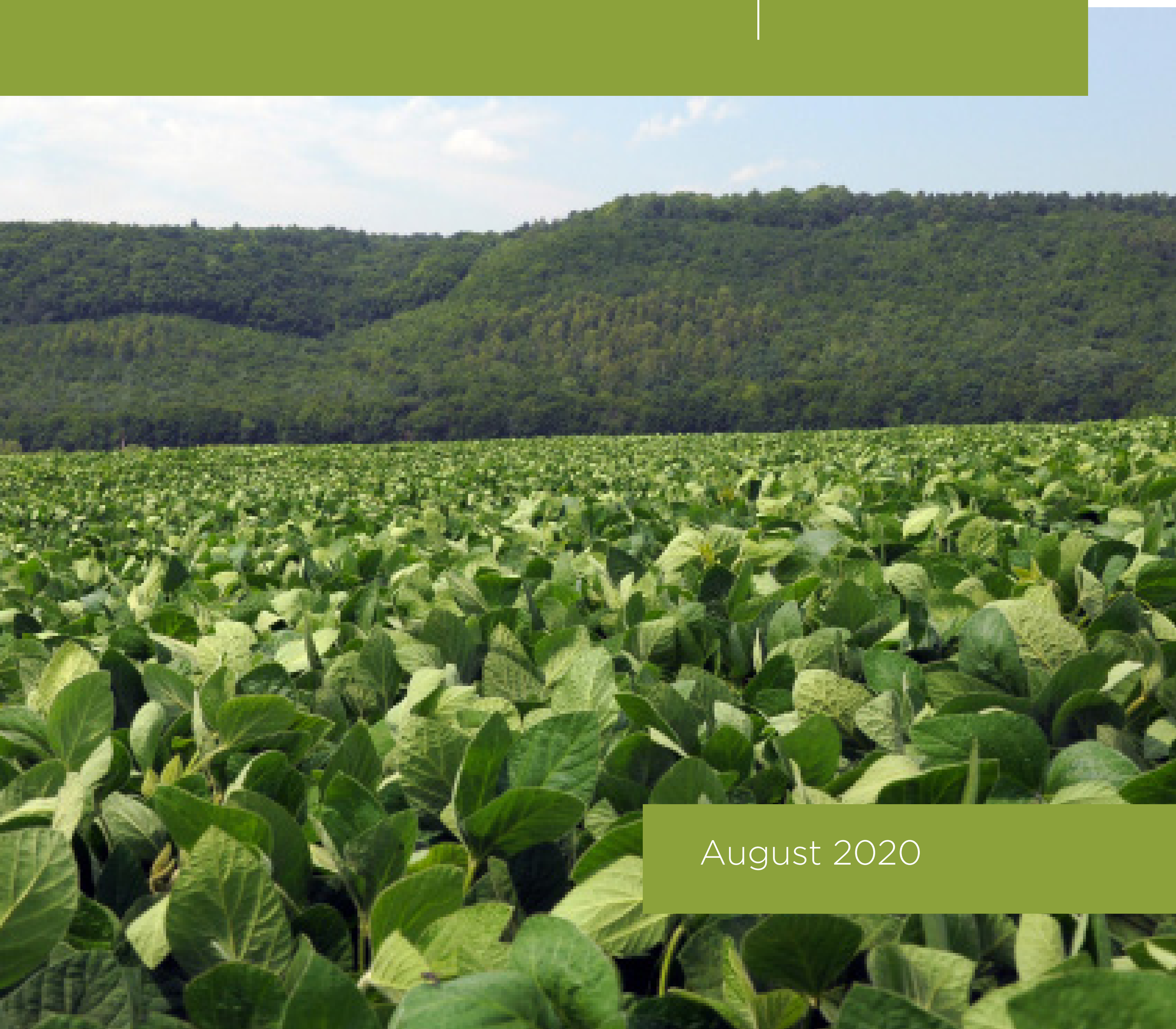
Evaluation of Incentive Strategies for Sustainable Soy Production

DISCUSSION PAPER



August 2020

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Evaluation of Incentive Strategies for Sustainable Soy Production: Maximizing the impact of conservation strategies on productive decisions

Pedro Gasparinetti
Leonardo Bakker
Felipe Vasquez
Manuel Cinfuentes

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EXECUTIVE SUMMARY

Farmers are, ultimately, the decision makers about land use types and production patterns. Among the decisions with the greatest potential to generate changes in environmental quality, we can list:

- **Sustainable Production Standard Type - No-Tillage System**
- **Productive Area Expansion Type - Use of Degraded Pastures**
- **Maintenance of Surplus Native Vegetation**

These decisions depend on many factors, such as market conditions, available technology, climate, and incentive policies. In order to design effective policies to encourage change in standards, the concept of Payment for Environmental Services (PES) first must be defined as incentives for voluntary compliance with environmental constraints provided to induce socially preferred environmental behavior, differing from a simple allowance. For the design of this instrument type it is necessary to understand how producers can react to different possible incentive strategy configurations. This study aims to understand the **willingness of producers to engage** with more sustainable standards, given **different incentive and conditioning alternatives**.

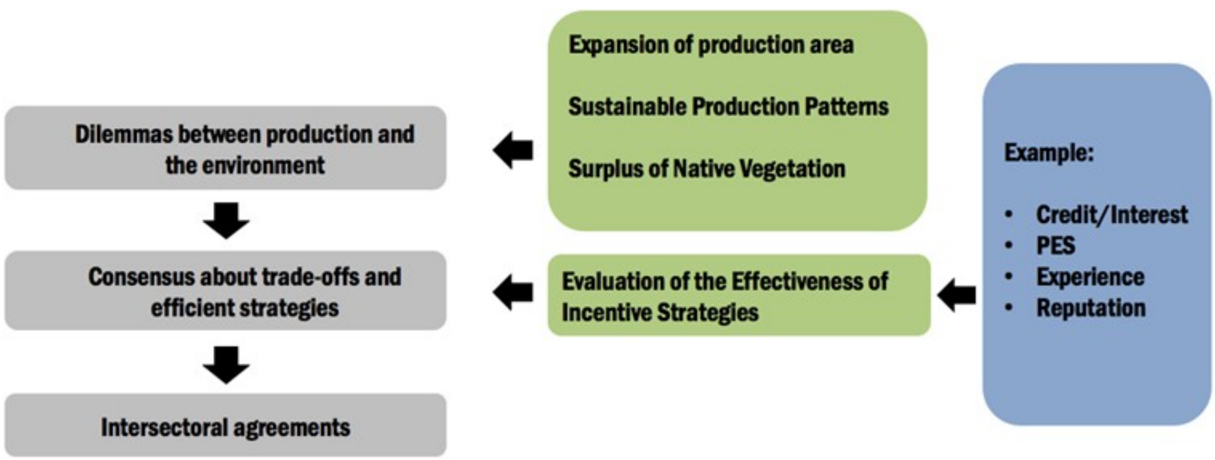


Figure 1 - Study design

This assessment is based on a behavioral economics approach, the choice modeling method, which analyzes economic, social and environmental values based on the real and hypothetical choice patterns of decision makers. We applied 3 different choice experiments to assess three key decisions. Fifty-three producers from Tocantins and Bahia were interviewed and asked about their preferences for different possible scenarios of incentives and environmental constraints. Statistical analysis of the choice pattern answers questions such as: "What is the most important and the most cost-effective for changing producers' land use and production decisions?"

In addition to the quantitative results, the pros and cons of each of the incentive approaches are discussed, as well as innovative strategies such as credit-based PES, a combination of direct and/or indirect payments for environmental outcomes, and as non-monetary incentives like the knowledge of successful cases near rural properties.

MAIN RESULTS

Strategies for Preserving Native Vegetation Surplus

- Less restrictive conditioners are more efficient than more restrictive conditioners; the opportunity cost within properties is heterogeneous, so the “first” share that the producer is willing to give up is the lowest incentive payment cost.
- The efficient level of PES in the region is R$ 664 / ha / year for a 10% native vegetation surplus, which can be combined with a reduction of the interest rate for investments, where a reduction of 1% per year equals a PES of R$ 109 / ha / year.
- Recognition that the opportunity cost of the portion allocated to the program is less than the average opportunity cost - or that the cost of reducing interest is less than the engagement it generates - can save millions of Brazilian Reais in a large-scale program.
- The engagement level with this payment amount can reach 31% of landowners, with 7% willing to participate with a more restrictive 20% legal reserve constraint - requiring a higher payment.
- This strategy has the disadvantage of needing a continuous payment. Conservation would be interrupted if payments are suspended.
- Environmental (hydrological and carbon) benefits from maintaining native vegetation were estimated at RS 1,027 / ha / year, higher than the public policy cost of R$ 664 / ha / year in the scenario of 10% native vegetation surplus.

Strategies for Changing the Pattern of Productive Areas Expansion

- This strategy seeks to minimize unnecessary expansion into areas of native vegetation being converted and then abandoned.
- The indirect effect of a broad PES program for the conservation of native vegetation can affect the relative prices of land, increasing the price of areas with native vegetation.
- If there is a 10% increase in the price of land covered by native vegetation, there would be a reduction in the expansion of soybean cultivated areas by 11%, while it would occupy 4% more pastures. Likewise, a licensing fee for vegetation removal would increase the total land price + conversion on the same scale (10%).
- Decisions regarding the type of expansion area may be closely linked to local conditions, such as the proximity of areas that are already open - which may make changes in decisions unfeasible.
- If a PSA is given for pasture occupation, undesired indirect effects may occur, such as the accumulation of capital for later conversion of native vegetation.

Strategies for Adopting More Sustainable Production Standards

- Ideally, work with a transition model that allows farmers to engage as a "test" on part of their rural property rather than requiring complete change.
- The strongest incentive for productive change is not the economic gain, but the knowledge of neighbors successfully adopting the no-tillage system (NTS), which doubles the chance of producer engagement. It is better to hear a recommendation from another producer than from a technician.
- The estimated PES level for generating a change from those who do not adopt the no-tillage rotation system in one year was R$ 208 / ha / year, which is roughly equivalent to a 1% reduction rate strategy interest for the purpose of costing production. The cost of reducing interest by 1% for production costs around R$ 40 / ha / year, which shows that this strategy may be the most efficient to achieve the desired results.
- The adoption of production standards such as no-tillage rotation generates environmental benefits - hydrological and carbon - estimated at R$ 260 / ha / year and private benefits derived from higher productivity generate an additional net income to the landowner at R$ 226 / ha / year, totaling additional benefit of R$ 486 / ha / year.
- The cost of public policy, in the scenario of 100% adoption no tillage rotation, is R$ 208 / ha / year, lower than the benefit, demonstrating the viability of the financial point of view.

What Strategy to Adopt?

Both evaluated strategies generate benefits greater than their costs. However, it is important to emphasize that the payment conditions should not be very restrictive, that is, they may require smaller portions of conservation and differentiated production patterns in order to reach a greater number of owners at a lower cost.

STRATEGIES FOR PRESERVING NATIVE VEGETATION SURPLUS

1. STRATEGIES FOR PRESERVING NATIVE VEGETATION SURPLUS

Native vegetation generates benefits for society and agricultural activity, such as water flow regulation, erosion control, climate regulation and natural pest control. Given the current trend of the worsening water crisis, soil degradation, and climate change, mechanisms are sought to increase the level of native vegetation beyond the minimum required by the Legal Reserve. Possibilities for incentives include:

- Annual payment per preserved additional arable hectare (PES)
- Lower investment credit interest rate
- Increased investment credit repayment term

We seek to answer here which are the most cost-effective strategies in terms of producer engagement potential and engagement efficiency.

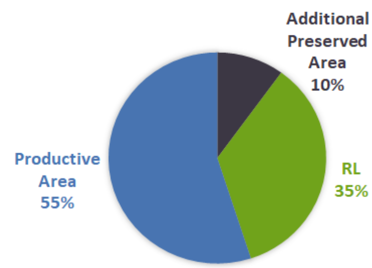


Figure 2 - Rural property proportion

Two environmental constraints are proposed:

- The preservation of 10% in addition to the minimum required as a legal reserve; or
- Preservation of 20% in addition to the minimum required as a legal reserve.

A farmer may have different levels of willingness to participate in the program (10% or 20%) depending on incentives, and different portions of farmers may or may not engage, i.e. if the proportion of engagement changes, the proportion of land allocated by farmer may also change.

1.1 PES Payment Level

There are two main factors that differentiate the willingness of rural landowners to participate in Tocantins and Bahia. The first is the difference in the legal reserve requirement (20% in Bahia and 35% in Tocantins), which makes rural producers in Tocantins state less likely to engage. On the other hand, Bahia’s productivity is higher, which decreases the willingness to give up their land. The model shows that these two factors cancel each other out, which means that it is possible to work with an **equal payment for both states, that is, an efficient payment would be R$ 664 / ha / year to obtain a 10% surplus of native vegetation for 31% of landowners.**

For rural producers to engage in a condition of preserving an additional 20% of RL, the required level of payment is considerably higher, at R$ 1,628 / ha / year - which shows that **a program that requires less producers will be more cost-effective.**

1.2 Equivalence between Payment and Interest Rate Reduction

Offering lower interest rates for investment is also a strategy that would be accepted by farmers. However, there is no scope for the reduction itself to generate significant changes, and this strategy should be combined with a PES. It has been estimated that a 1% per year reduction for investment credit equals a PES of R$ 109 / ha / year. Thus, in lieu of an annual payment of R$ 664 / ha to get an additional 10% of legal reserve, a PES of R$ 555 / ha / year could be combined with a 1% reduction in the investment interest rate. Given the cost level of borrowing, it was estimated that the cost of reducing the interest rate by 1% per annum would be equivalent to R$ 40 / ha / yr, generating a perception of producer benefit equivalent to R$ 109 / ha / yr. - which shows that the alternative of combining interest rate reduction with a PES may be more efficient than just paying PES.

Increasing loan repayment terms, while important, did not have a considerable impact on farmers' choice when compared to direct PES payments or lower interest rates.

Analysis beyond the average Opportunity Cost. The analysis brings two factors that can make the efficient amounts paid to producers vary depending on the average opportunity cost.

Productivity heterogeneity within properties. With a design that requires, for example, the conservation of an additional 10% of RL, the 10% chosen by the producers will be the ones with the lowest productivity, i.e., they will have a lower allocation change cost.

Uncertainty and Risk Aversion - PES as a "insurance". The soybeans net profitability varies over the years. According to economic theory, risk-averse agents are willing to accept values lower than the average value if there is no risk (variation)

1.3 Engagement Level

Given the proposed levels of payments, if both possible levels of engagement were offered simultaneously, we would have had that up to **31% of farmers would be willing to maintain an additional 10% of native vegetation** and 7% would be willing to maintain an additional 20% of native vegetation.

- **Potential additional native vegetation area (RL+10%)**
  - 15.811 ha (TO)
  - 12.825 ha (BA)

- **Additional carbon capture[1] (10% surplus)**
  - 1.3 millions tCO2 (TO)
  - 1 million tCO2 (BA)

- **Cost of an efficient program (RL+10%):**
  - R$ 10.4 millions/yr (TO)
  - R$ 8.5 millions/yr (BA)

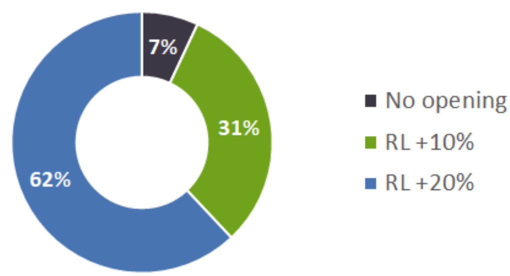


Figure 3 - Engagement capacity for scenarios of 10% and 20% surplus of native vegetation

- **Cost per hijacked tCO2**
  - R$66/t$CO_2$

1.4 Cost / Benefit Ratio:

From the comparison between costs and benefits, it is possible to verify that the cost of public policy, in the scenario of 10% of vegetation surplus, per hectare per year (R$ 664) is lower than the environmental benefits (R$ 1,027 / ha / year) derived from hydrobiological services and carbon services systematized by the literature. The B / C ratio is 1.54, which indicates that this policy is feasible. Meanwhile, the scenario with 20% proves to be unfeasible from the financial point of view as the cost of the policy would be R$ 1,628 / ha / yr.

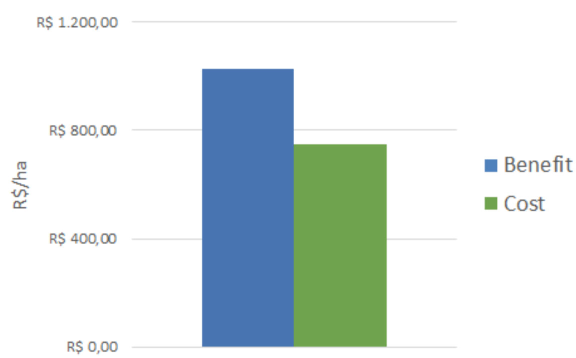


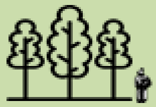
Figure 4 – Cost/Benefit comparison

On the other hand, although from a social and economic point of view, this policy is worthwhile, its capacity to mobilize the necessary resources for its implementation must be evaluated. It is then necessary to be able to mobilize willing institutions to avoid social losses related to the ecosystem service

[1] Average carbon density in the Cerrado biome = 137 tCO2 / ha.

values mentioned above. The cost of the policy, compared to just the value of the ton of carbon, for example, is R$ 66 / tCO_2 - while the value of the ton in the market is around R$ 20 / tCO_2.

Public Policy Benefits



Stop clearing native vegetation

Values in R$/ha/yr	Native veg.	Soy	Net Balance
*Evapotranspiration	406	192	214
*Aquifer recharge	323	85	238
*Water discharge	193	-78	271
* Carbon capture/ Emission	233	79	312
*Carbon capture in soil	33	-47	80
Total	1.188	161	**1027**

Biophysical Indicators:
Evapotranspiration Flow: 2,07 mm d-1,
Sweating flow: 1,95 mm d-1
Evaporation Flow:0,12 mm d-1

Public Policy Costs

Stop producing soy

PES Social Costs

	Native veg.	Soy	Net Balance
Values in R$/ha/yr	664	0	- **664**

This includes: Opportunity cost; etc.

Period

20 years (perennial / continuous)

1.5 Confidence in the Institutions

Most farmers reported preferring to engage in contracts directly with the federal government as opposed to other potential institutions like traders, banks, or basin committees. This result reflects the current context of strong resistance to actors and institutions associated with NGOs. For example, a possible moratorium on soybeans in the Cerrado has been linked to the names of some traders, which has led to strong rejection by farmers.

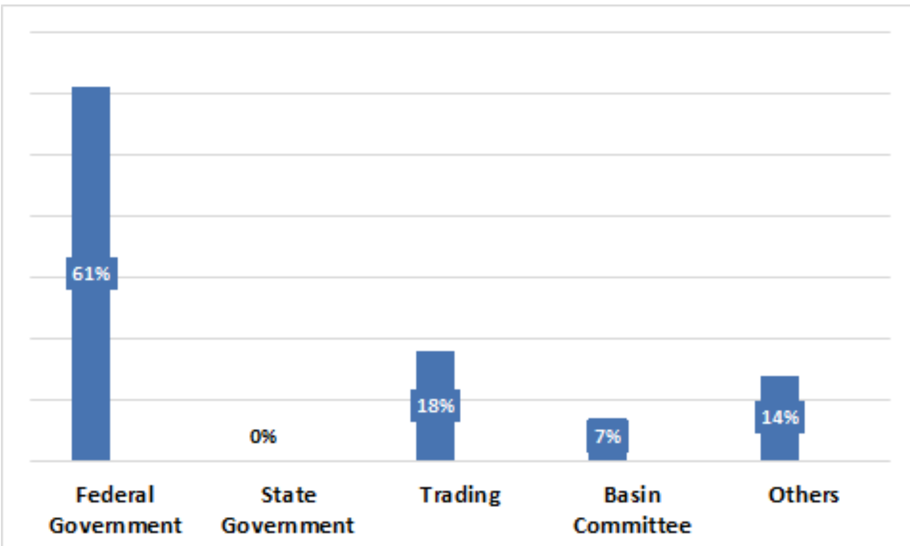


Figure 5 - Confidence in institutions (sample through interviews with rural owners)

1.6 Discussion

It is important to emphasize that, in order to maximize their environmental efficiency, incentive programs must focus on ecological priority areas.

An incentive program for the conservation of additional native vegetation assumes that the owner is entitled to clear an area, but does not do so due to the external incentive received. Unlike temporary programs that seek to encourage a productive transition, the incentive for conservation must be perennial because otherwise disrupting the flow of payments could lead to a decision to convert land use, negating its benefits in terms of, for example, carbon stock.

In addition to the primary objective of establishing a compensation flow for native vegetation preservation, a PES-type incentive program can lead to monetary appreciation of native vegetation areas, increasing their market price - as it starts to generate economic returns for those conserves it. The next section will analyze a potential impact of a PES on the price of native vegetation and, consequently, on the pattern of cropland expansion.

Finally, we must compare the strategy of continuous payment for preservation versus the purchase of native vegetation areas, which would generate greater guarantees in terms of conservation perennial, but is restricted by the capital required for its implementation.

Financial Sustainability of Legal Reserve Area

One possibility to overcome this risk is the economic use of RL and its surplus, such as agroforestry systems. Although not yet widespread, the economic use of the legal reserve with combinations of native and exotic productive species (following the possibilities established by the Forest Code) is an option to be encouraged to generate financial sustainability for sustainable land uses.

In the specific case of maintaining surplus native vegetation, an important strategy is to support rural landowners in the creation of Private Natural Heritage Reserves (RPPNs), where the landowner is committed to conserving the natural area with the following activities: recreation, research and environmental education. The creation of RPPNs could also be combined with other incentives (in addition to PES) such as the use of RPPN-related environmental criteria for the transfer of ICMS-Ecological resources. This would require an effort to create or amend environmental legislation in the states.

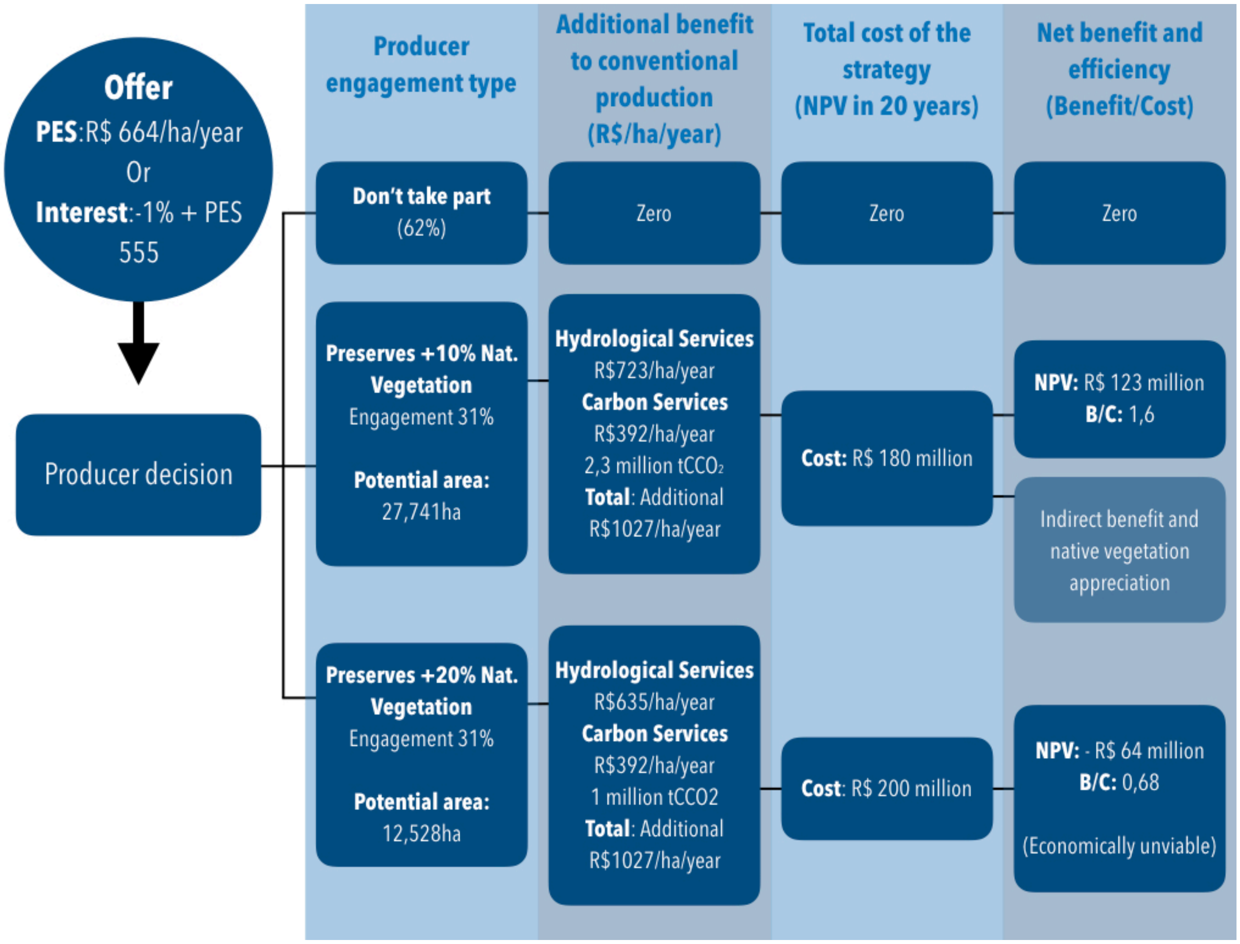


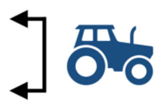
Figure 6 - Structure of the economic incentive from a PES to maintain surplus native vegetation

STRATEGIES FOR CHANGING THE PATTERN OF EXPANSION OF PRODUCTIVE AREAS

2. STRATEGIES FOR CHANGING THE PATTERN OF EXPANSION OF PRODUCTIVE AREAS

The expansion of soy cultivation in the Matopiba region presents several challenges for maintaining the available natural capital. Given that the region has less legal protection of native vegetation areas (Legal Reserve requirement of 20% and 35% in transition areas with the Amazon and few protected areas), this region has become the largest agricultural frontier in the country, with a long-term **trend of occupying all legally deforested arable areas, expanding by 2.14 Mha hectares of soybeans in Matopiba, of which 1.5 Mha represents expansion over native and 0.62 Mha over pasture by 2030 (TNC, 2019a).** It is necessary to create economic incentives that guide landowners in the sustainable and efficient expansion of soy, that is, with fewer impacts on the environment and good production results. The study looked at the impacts of land price fluctuations and incentives on the likelihood of a farmer expanding his crop area by purchasing:

- Areas of native vegetation
- Degraded pasture areas
- Consolidated agricultural areas



Type of land use	Average Price (Tocantins)
Native vegetation	R$ 5,350/ha
Degraded pasture	R$ 7,080/ha
Consolided area	R$ 13,600/ha

Land market changes can be an indirect result of different strategies:

- A PES program for vegetation conservation can cause an appreciation of land with native vegetation.
- Imposing a tax/fee for clearing vegetation.
- A PES or interest reduction to encourage soy expansion in pasture area instead of native vegetation.

A farmer may have different levels of willingness to participate in the program (either to purchase degraded pasture or consolidated agriculture) depending on incentives, which may result in changes in engagement decisions or in not engaging (maintaining their status quo).

2.1 Trends in Matopiba

Most (71%) of the sample consulted stated that if they decided to expand their productive area by buying land, they would buy pasture areas, while 29% said they would buy native vegetation areas.

Among the main reasons for this, according to the interviewees, are the high licensing bureaucracy and the high cost of converting native vegetation to pasture.

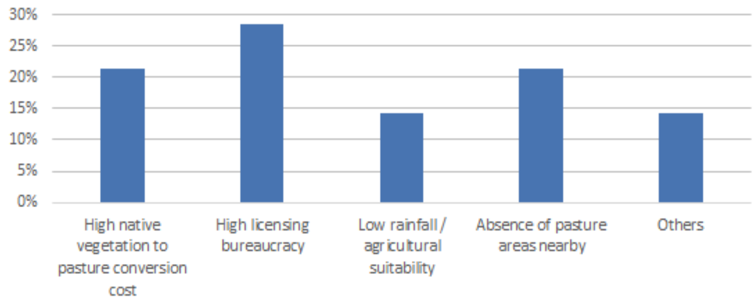


Figure 7 - Reasons for not expanding to native vegetation area

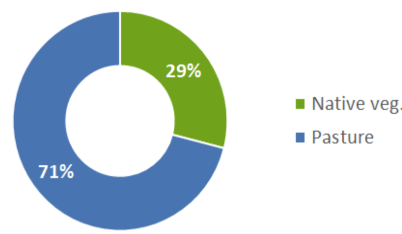


Figure 8 - Respondent response about the type of area they would expand their property

2.2 Results

From different simulations, the price elasticity of demand was estimated, i.e., how demand behaves from the change in land prices in different land uses.

The study concludes that if the price of native vegetation rises by 10%, the demand for the purchase of vegetation will decrease by 11%, while pasture should increase by 4%.

Type of land use	Demand Proportion		Demand Change Rate
	Average Price	Native veg. price +10%	
Native vegetation	26%	24%	-11%
Pasture	74%	76%	4%

Figure 9 - Effects of native veg. price change in demand by native veg. and pasture (+ 10%)

In the case of a 20% increase in the average price of native vegetation, from R$ 5,350 to R$ 6,420 / ha, a reduction in vegetation demand of 19% (reaching 21% of demand) is expected, while demand for pasture would increase. 7% (reaching 79% of demand).

Type of land use	Demand Proportion		Demand Change Rate
	Average Price	Native veg. price +10%	
Native vegetation	26%	21%	-19%
Pasture	74%	79%	7%

Figure 10 - Effects of native veg. price change in demand by native veg. and pasture (+ 10%)

The additional value of R$ 6,350 is also interesting to be analyzed, as it would be a projection of a new native vegetation price equilibrium if the PES described above (of R$ 664 / ha / year) [2]. In a scenario of a 1.2-million-hectare loss of vegetation by 2035 in the states of Bahia and Tocantins in Matopiba (TNC, 2019a), a 19% reduction in the likelihood of choosing to expand into **natural areas represents additional conservation. 236 thousand hectares.**

[2] Based on Net Present Value (NPV) of a 20 year PES, given a 8% discount rate per year.

In the case of a PES incentive, the probability of the farmer expanding his cultivation area in areas with native vegetation is reduced by 19% if there is a possibility of receiving a PES of R$ 100 / ha / year for 5 years - and of course if nearby pastures are available. This incentive has an impact equivalent to a native vegetation price increase of R$ 1,067 which equates to almost R$ 1,070 (20% of native vegetation price) increase over 25 years.

However, there are additional issues to consider for comparison. First, the PES flow would be 5 years, while the variation of R$ 1,000 is equivalent to a PES flow of R$ 100 / year for 25 years, given a time discount rate of 8% per year. On the other hand, a PES for pasture expansion may be little "additional," meaning that it would eventually pay those who would expand pasture production anyway. Therefore, in order not to lose efficiency, a possible mechanism such as this should focus on areas most likely to expand into native vegetation area.

In the case of a PES incentive, the probability of the farmer expanding his cultivation area in areas with native vegetation is reduced by 19% if there is a possibility of receiving a PES of R$ 100 / ha / year for 5 years - and of course if nearby pastures are available. This incentive has an impact equivalent to a native vegetation price increase of R$ 1,000, as shown earlier. However, there are additional issues to consider for comparison. First, the PES flow would be 5 years, while the variation of R$ 1,000 is equivalent to a PES flow of R$ 100 / year for 20 years, given an 8% discount rate. On the other hand, a PES for pasture expansion may be little "additional," meaning that it would eventually pay those who would expand pasture production anyway. Therefore, in order not to lose efficiency, a possible mechanism such as this should focus on areas most likely to expand into native vegetation area.

Finally, it is worth mentioning that a PES via interest rate reduction, although a plausible possibility, had no significant effect on the sample consulted.

Initiatives to support sustainable soy expansion

The Responsible Commodities Facility Program finances sustainable commodities through green bonds designed to capitalize Brazilian farmers and prevent deforestation in the Cerrado.

The Soft Commodities Compact initiative seeks to mobilize the banking industry to help transform commodity supply chains and help corporate customers achieve zero net deforestation by 2020.

The Nature Conservancy (TNC), Banco Santander and Bunge seek to encourage the expansion of soybean production in degraded pasture areas with a pilot project of around R $ 50

Financial analysis of costs and benefits of a scenario with a 10% increase in the price of native vegetation due to a fee for suppression of native vegetation

The figures below demonstrate the benefits and costs of public policy that directs the expansion of soy production in pasture areas based on the taxation of the price of native vegetation. As can be seen, the environmental / public benefits generated by the option to expand pasture areas is R$ 2,005 / ha / year, that is, higher than the costs of public policy that would be R$ 535 / ha in the scenario with the 10% taxation of the price of areas with native vegetation in the analyzed regions.

Therefore, the balance (cost-benefit) in 15 years corresponds to R$ 1,470 / ha, demonstrating the viability from an economic point of view with a cost/benefit indicator of 3.7. However, as previously mentioned, it should be considered that the price increase of the native vegetation area is only generalized if the taxation is carried out in the entire area, that is, if the taxation is applied only in 50% of the area, there will be the decrease in the occupation of native vegetation in only 50% of the area.

From the analysis carried out above, an infographic was built in order to summarize the possible choices made by rural landowners regarding the different economic incentives observed in this session. First, we can analyze that the rural owner has two choices in view of the possibilities of expanding his property: expanding in pasture areas or expanding in areas of native vegetation. The effect of a rate of suppression of native vegetation increases the price of native vegetation and, consequently, generates an increase in demand for pastures, that is, there is less environmental loss when choosing to expand soy production in pasture areas, instead areas of native vegetation. This same effect can be observed when carrying out a PSA for conservation, as occurred, for example, in the scenario of maintenance of 10% of surplus native vegetation.

Public Policy Benefits

Expand soy production area in pasture area

Environmental Benefits (public):

Instead of choosing to expand to native vegetation and having a greater environmental loss, the agent may choose to expand soybean production in pasture areas, generating a net benefit of R$ 234/ha/year.

	Balance of Native Veg. for soybean	Balance of Pasture for soybean	Net Balance
Values in R$/hs/yr*	-282	-48	234

*All values were updated from Watanabe (2012)

Public Policy Costs

Social Costs:

	Balance of Native Veg. for soybean	Balance of Pasture for soybean	Net Balance
Values in R$/ha/yr*	-282	-48	234

Period

The payment of taxes occurs only once in the amount of R$ 535 in 20 years to guide the expansion to pasture areas. This amount, when annualized, corresponds to R$ 62.54/ha/year at a discount rate of 8% per year.

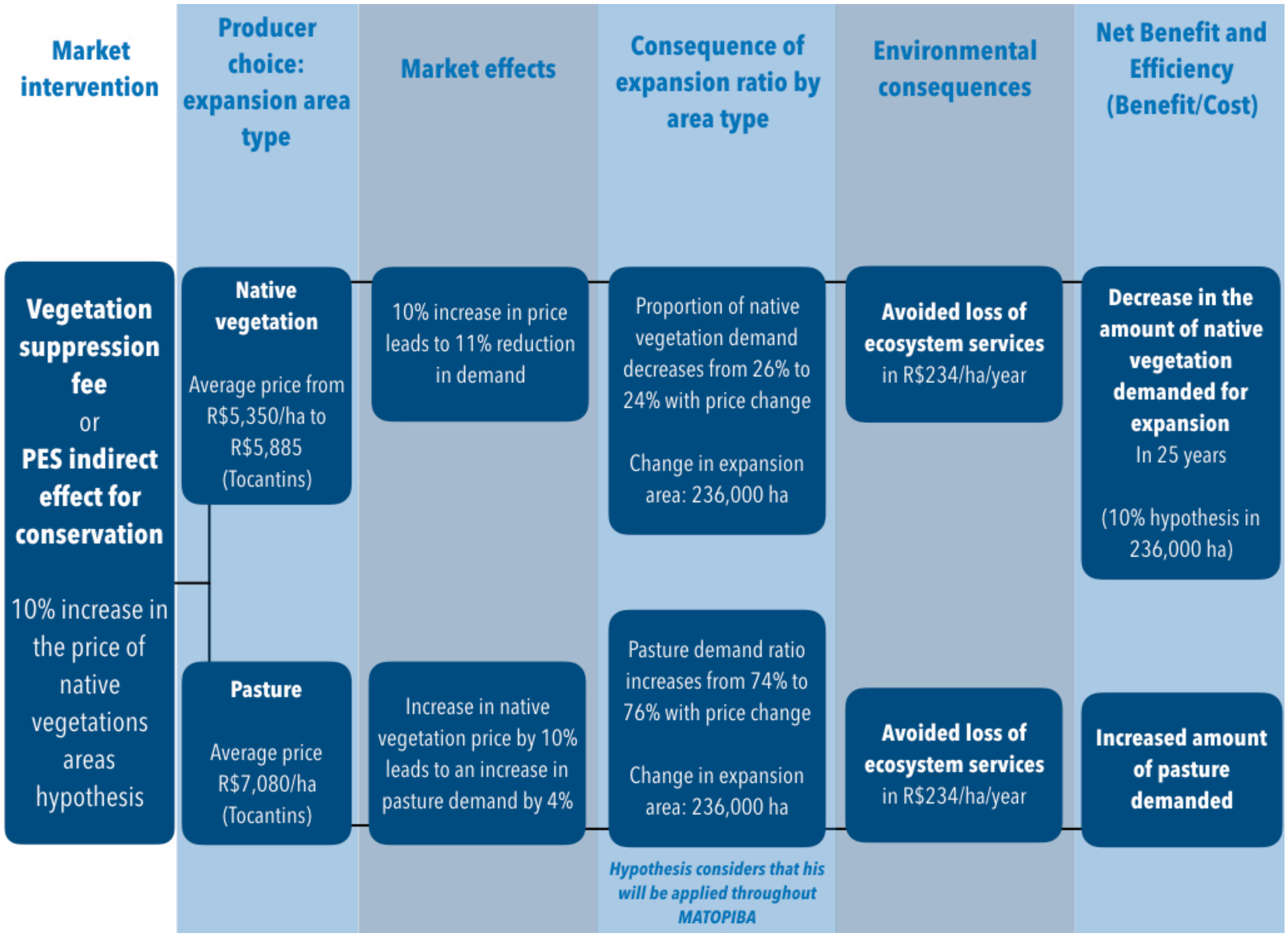


Figure 11 - Description of the different decisions of the producer in the face of incentives to guide the expansion of soy in pasture areas based on the rate of suppression of native vegetation (increase in the price of native vegetation areas

2.3 Discussion

Incentives seek to slow the movement of soy expansion into native vegetation, also minimizing irrational expansion in areas of vegetation that are converted, and later abandoned. However, decisions regarding the type of expansion area may be closely linked to local conditions, such as the proximity of areas that are already open - which may make part of the changes in decisions unfeasible.

One concept discussed by Margulius (2003) is the creation of a tax on vegetation suppression that would cause landowners to internalize the environmental costs of deforestation. The author demonstrates that even in the Amazon, which has lower opportunity costs, high rates would be required to significantly reduce deforested area. The study suggests that this is because growers would tend to change the crop mix first rather than reducing deforested area.

Another option would be to associate some benefit - such as access to financial resources - to join the Environmental Regularization Program (PRA) as an incentive for the purchase and recovery of degraded pastures or also the contribution defined in the Forest Code (Law No. 12,651 / 12) in art. 26 as "Forest Replacement Rate," mandatory in cases where there is exploitation or use of forest raw materials. Incentives seek to slow the movement of soybean expansion into native vegetation, while also minimizing irrational expansion into areas of vegetation that are converted and subsequently abandoned.

An additional vegetation conservation PSA can influence market prices, making expansion into natural areas more expensive and less likely. A 10% increase in the price of native vegetation areas, for example, would have the potential to reduce the rate of expansion over native vegetation by 11%.

Irrationality in the expansion of deforestation in areas with low agricultural aptitude. The "irrational" deforestation process in areas with low agricultural suitability results in environmental losses and subsequent land abandonment - that is, waste of resources. Given the normal dynamics of market prioritization, the suitability of the available areas decreases as the occupation process occurs.

Advance on pastures with more or less than 5 years of opening. Livestock generates economic returns in at least 4 years. Therefore, the advance of agriculture to pasture areas less than 5 years old would not be qualitatively different from the expansion to native vegetation area.

STRATEGIES FOR ADOPTING MORE SUSTAINABLE PRODUCTION STANDARDS

3. STRATEGIES FOR ADOPTING MORE SUSTAINABLE PRODUCTION STANDARDS

The adoption of good agricultural practices seeks to combine sustainability in agricultural production - keeping productive natural capital, such as soil and water, in good condition - while allowing productivity gains. In Matopiba, in general, the region's production pattern is relatively homogeneous, with few opportunities for adopting standards with a high level of sustainability in the context of commercial soybean planting - organic farming, for example, is “out of the question.” for most producers in the region. On the other hand, there are opportunities for improvements in production techniques that favor soil conservation and absorption of greenhouse gases.

Given the objective of the study to evaluate the potential of changing production patterns, we evaluated the adoption of the no-tillage system (NTS) with rotation of 3 crops in one year. This consists in the sowing of crops without tillage and with the presence of mulch consisting of the plant debris originated from previous crop conducted specifically to produce straw. In the case of Matopiba, the rotation of three crops over a year may be soybean, maize and, for example, brachiaria (*Brachiaria spp.*) or millet in the off season.

The no-tillage system provides both private benefits to the producer in terms of productivity gains as well as public benefits in terms of soil conservation, greenhouse gas absorption and water regulation services.

The main obstacle declared by the interviewed farmers was the lack of capital for additional investment for brachiaria sowing and additional use of herbicides in the early years of transition.

3.1 Analysis

The objective of this analysis was to identify which strategies are most cost-effective, both in terms of producer engagement potential and efficiency of such engagement. Two levels of payment constraints are proposed:

- Adoption of NTS in 50% of arable land;
- Adoption of NTS in 100% of arable land;

Different conditions and incentives generate different levels of willingness to participate in the program. The following incentives were analyzed:

- Annual payment per hectare (PES) using NTS;
- The reduction of the credit interest rate for production costing;
- Recommendation of specialized institutions;
- Relation of experience with the method, or knowledge of successful cases in the neighborhood;

3.2 Adoption of No-Tillage System in Matopiba

Of the interviewed farmers, 76% know of an institution or specialist that recommends the adoption of no-till with crop rotation. However, only 33% of the farmers interviewed use the crop rotation no-till system - most in western Bahia.

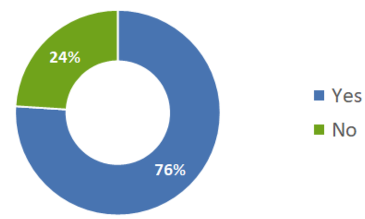


Figure 12 - Knows the institution that recommends NTS

To find out which major factors can contribute to the change in production patterns, we compare the interaction of providing economic incentives with reputational contextual factors, such as recommendations from technical and political institutions for the adoption of NTS, participation in field days that demonstrate their gains, or knowledge of successful cases of NTS use in the farmer's neighborhood.

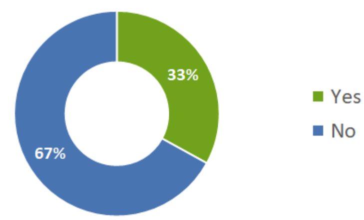


Figure 14 - Use NTS with 3 species rotation

Preference modeling showed that the strongest factor for changing production patterns was the knowledge of success stories in the neighborhood. On the one hand, landowners who are unaware of close success stories are unlikely to engage in productive change. On the other hand, farmers who know many successful cases have already been "convinced" and have already made productive change. Therefore, the target audience most likely to change their productive patterns due to incentive policies are those who know "some cases," i.e. areas at an early stage of dissemination, that are 2 times more likely to make a productive change than those who know no case.

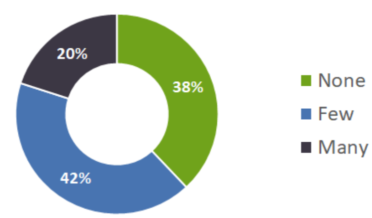


Figure 13 - How many NTS success cases known

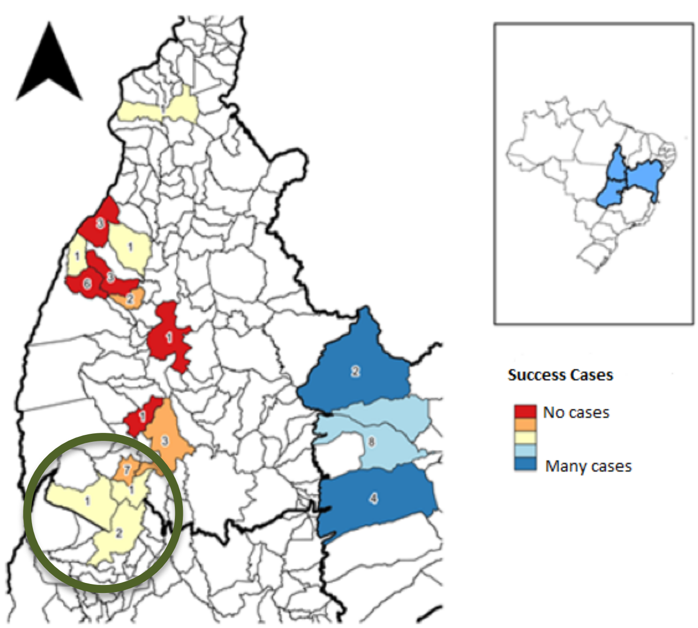


Figure 15 - Knowledge of NTS success cases

In terms of knowledge of successful cases in the neighborhood, 38% say they do not know success stories, 42% say they know few cases, and 20%, many successful cases of neighbors working with 3-tillage rotation in 1 year.

The map below shows an area of potential prioritization for the adoption of economic incentives, where there is an early stage concentration of NTS adoption with crop rotation.

3.3 PES Payment Level

The average Willingness to Accept Compensation with the condition of adopting the NTS in 100% of the cultivation area was R$ 208 / ha / year. This level was slightly higher than the additional cost of the third crop rotation system, which would be around R$ 115 / ha, showing that there is a level of uncertainty about productivity gains - in addition to the additional production costs.

On the other hand, a program with the condition of adopting NTS in 50% of the productive area, which resembles a “test” condition, seems to be the most promising approach. Although there is heterogeneity in the perception of this condition, it results in an additional openness for producers to engage. Although we have not achieved a “significant statistical average” for the payment of this modality - given the heterogeneity of perceptions and the low sampling - it is inferred that the incentive value may be slightly lower than in the case of a 100% requirement. of the converted productive area. Thus, conservatively, it is assumed that the same cost of R$ 208 / ha / year for the 50% NTS deployment scenario.

3.4 Equivalence between Payment and Interest Reduction

It was estimated that a reduction of 1% per year for production costing credit is equivalent to a PES of R$ 180 / ha / year. Thus, in lieu of an annual payment of R$ 208 / ha to make the system change, a PES of R$ 28 / ha / year could be combined with a 1% reduction in the interest rate for production costs. Given the proximity of the values, it is concluded that a policy of 1% interest reduction may be appropriate for the purposes of this strategy, as it is capable of overcoming the capital restriction that was pointed out by several producers as a bottleneck for the adoption of the NTS - even more appropriate than an ex post payment of a PES.

Given the level of borrowing costs, it has been estimated that the cost of reducing the interest rate by 1% a.a. would be equivalent to R$ 40 / ha / year, generating a perception of producer benefit equivalent to R$ 180 / ha / year - which shows that the alternative of combining interest rate reduction with a PES may be more efficient than just the PES payment.

The recommendation made by the specialized institution, although important, did not have a considerable impact on producers' choice when compared to the direct payment of PES or the reduction in interest rates.

3.5 Engagement Level

Among non-NTS landowners, the majority (63%) would be willing to test the method in 50% of their area if there are incentives or examples of successful neighboring cases. Additionally, 23% would be willing to adopt the NTS in 100% of their area if there are incentives. Finally, 14% of producers would not be willing to change their production pattern with the level of average incentives estimated as efficient by the choice model.

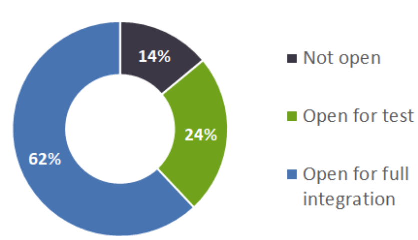


Figure 16 - Producers engagement level for NTS implantation

Equivalence with an incentive of R$ 120 / ha / year; or 1.2% reduction in interest for production costs

PES would be efficient in areas where there are already examples of neighbors.

Area with potential for conversion to NTS - 100% NTS adoption scenario (23% engagement)

- 211 thousand ha (TO)
- 368 thousand ha (BA)

Additional carbon capture (100% NTS)

- 2.5 million tCO2 (TO)
- 4.3 million tCO2 (BA)

Cost of an efficient program (100% NTS):

- R$ 43 million/year (TO)
- R$ 76 million/year (BA)

Cost per tCO_2 captured

- R$ 148/tCO_2 (TO)

Area with potential for conversion to NTS - 50% NTS adoption scenario (63% engagement)

- 289 thousand ha (TO)
- 504 thousand ha (BA)

Additional Carbon capture: (50% NTS)

- 6 million tCO2 (TO)
- 12 million tCO2 (BA)

Cost of efficient program (50% NTS):

- R$ 60 million/year (TO)
- R$ 105 million/year (BA)

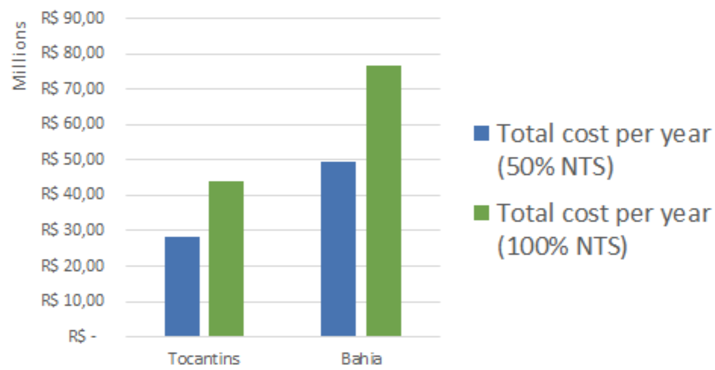


Figure 17 - Total cost per year (NTS scenarios)

Program Duration - Temporary Payment

A program that encourages the adoption of a more sustainable agricultural technique can only be used at a defined time, since after the implementation of the NTS on the property there will be an increase in productivity and cost reduction that will justify the maintenance of the agricultural technique.

3.6 Discussion

The results show that in a transition process towards sustainable agricultural practices, it would be more cost effective to first support the adoption of NTS on 50% of farms, as there is a significantly higher engagement capacity (63%, while for 100% NTS is 23%).

The practice of no-tillage system is better known and applied in western Bahia when compared to the Tocantins state. Therefore, the Tocantins state should take actions to spread the benefits of the NTS with an economic incentive policy, especially in those with few success stories, since there was twice the capacity for engagement.

Positive incentives can be combined with command and control instruments:

The Meat Conduct Adjustment Term (TAC) since 2009 in the Amazon has prevented credit to areas with livestock production originating from deforestation areas (MPF, 2012).

The Soy Moratorium in the Amazon that sought to support the soybean production chain in the biome to prevent the advance of deforestation for conversion to soybean production.

In addition, an important factor to consider is prioritizing PES in areas near the pilot municipalities of the Partnership for Good Development project in Western Bahia and Tocantins.

Public Policies Benefits

Perform no-till with crop rotation

Environmental benefits (publics):

	NTS	Conventional	Net Balance
Hydrological Services	356	198	158
Carbon services	133	31	102

Values in R$/ha/yr

Private benefits (productivity increase Additional Net Income):

NTS	Conventional	Net Balance
226	0	226;602

Values in R$/ha/yr

Social benefits (Environmental):

NTS	Conventional	Net Balance
715	229	486

Values in R$/ha/yr

Public Policies Costs

Social Costs:

NTS	Conventional	Net Balance
0	208	-208

Values in R$/ha/yr

Timeframe

5 years (temporary PES)

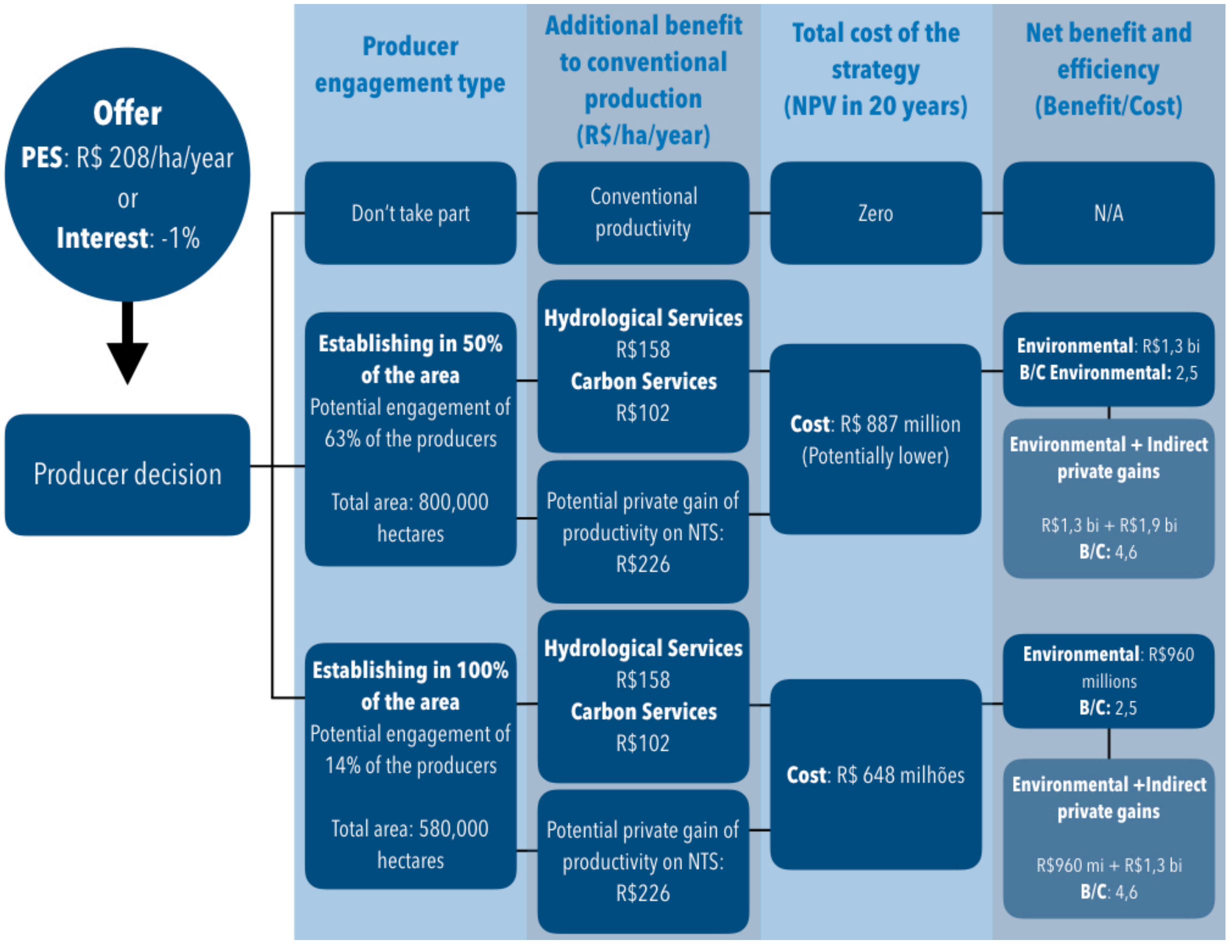
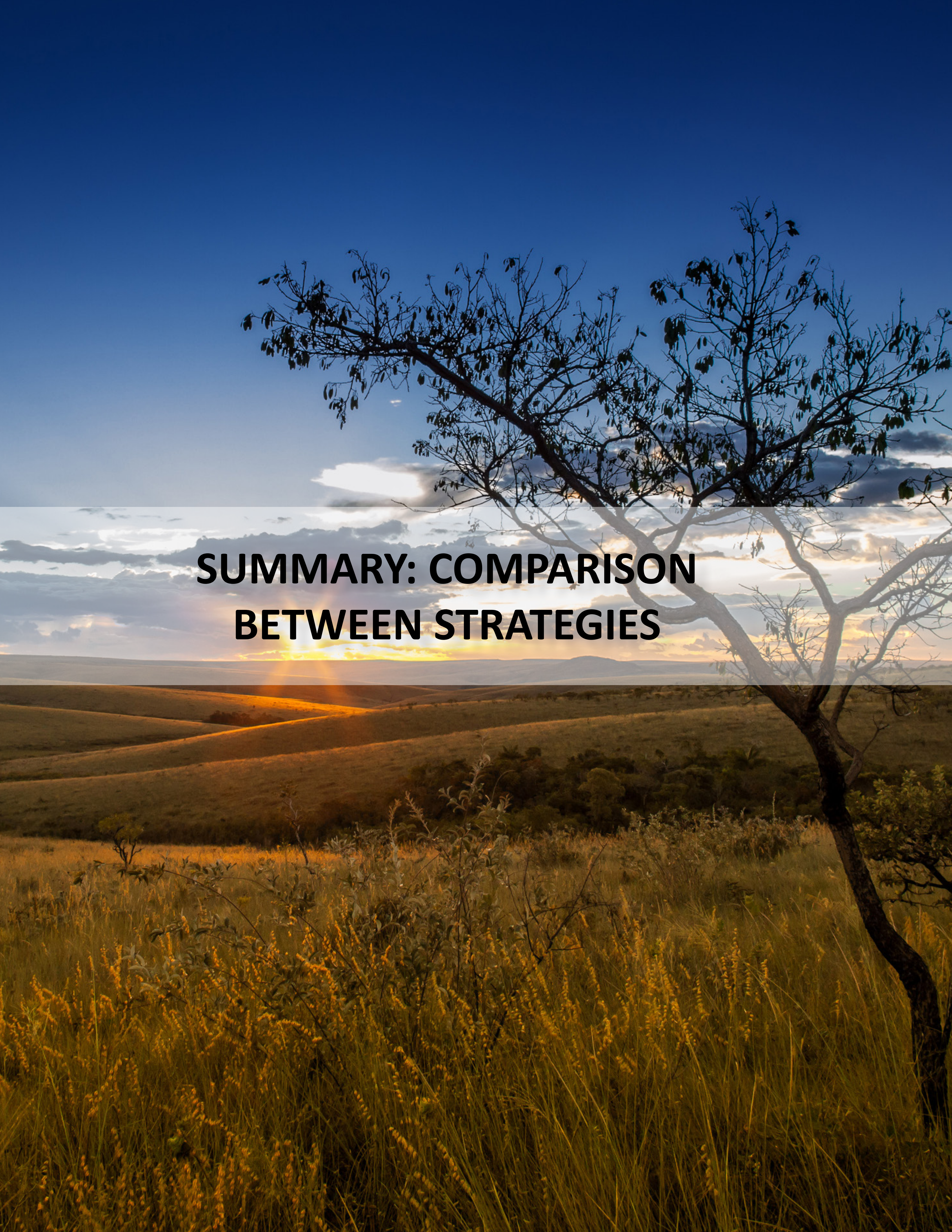


Figure 18 - Description of producer different decisions before incentives to increase NTS adoption

SUMMARY: COMPARISON BETWEEN STRATEGIES



4. SUMMARY: COMPARISON BETWEEN STRATEGIES

We present a comparative analysis against the different economic incentives presented in the study, verifying those that are financially viable and, more than that, more efficient. For this, it will be necessary to present financial indicators such as the cost / benefit ratio and the balance (cost-benefit) of the net present value over 25 years. In addition, there is a description of the direct and indirect effects caused by each economic incentive.

It is important to highlight that, in the figure below, there are three economic incentives for rural landowners, however, each incentive is directed to a type of vegetation. First, the economic incentive to adopt sustainable standards, such as the no-tillage system (SPD) with rotation of three crops, is oriented to those properties that have conventional soybean plantations. Those rural landowners who have surplus areas of native vegetation could receive a PSA to encourage the maintenance of the forest standing. Finally, rural landowners who have soy plantation areas and wish to expand their production may receive incentives for this movement to occur in pasture areas, that is, the incentives are directed to pasture areas, these being direct - such as a PSA for areas that expand soy production in pasture areas - or indirectly - as a rate of suppression of native vegetation.

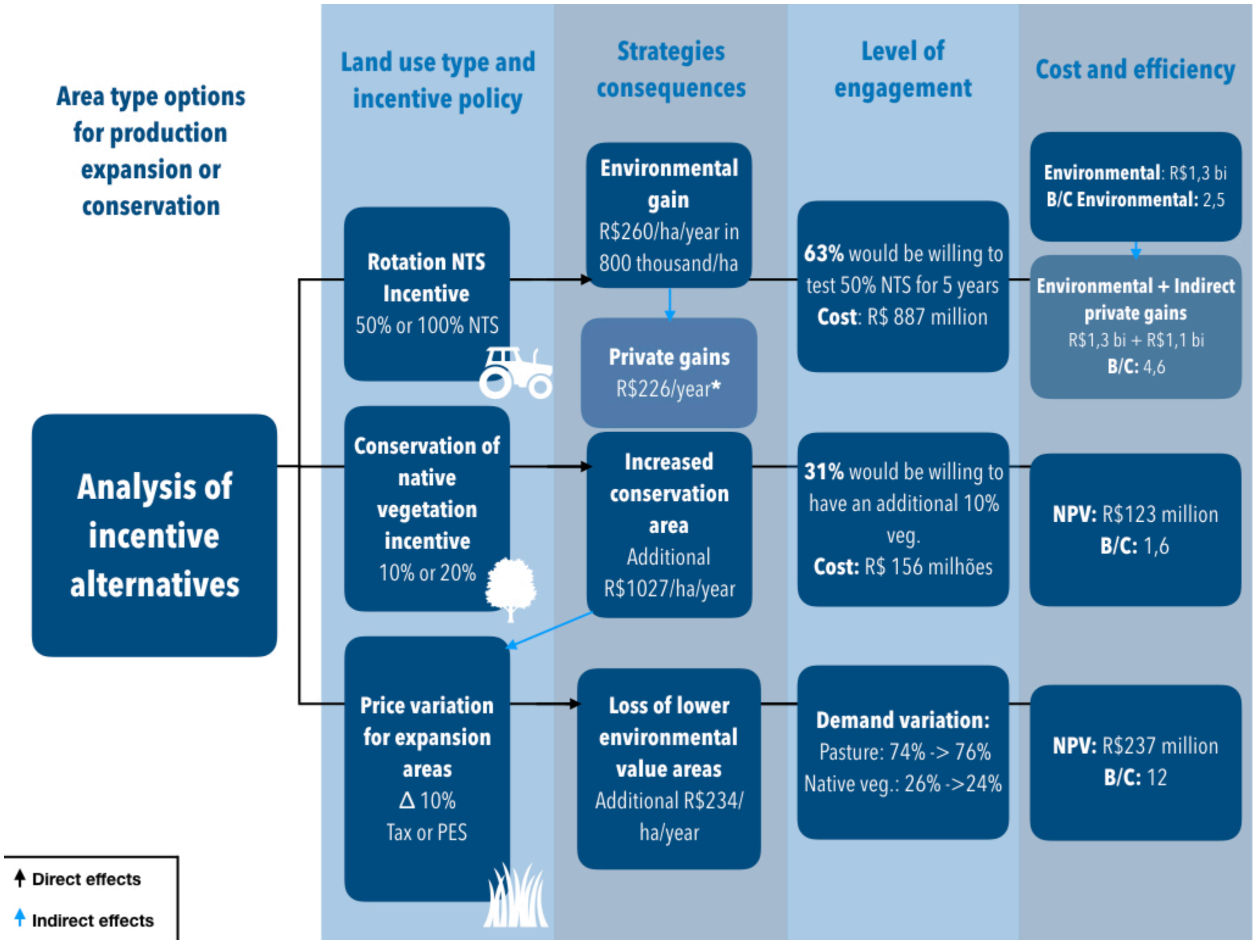


Figure 19 - Summary of the options of types of areas for expansion of production or conservation

After presenting all the results, it is possible to conclude with a comparative analysis of the different economic incentives for the three experiments of choice. The first analysis verifies the costs and benefits in net present value (NPV) per hectare. It is observed that the scenarios of 10% and 20% of maintenance of native vegetation have the greatest benefits per hectare (R$ 10,963 / ha) when analyzing their flows over time, since the maintenance of ecosystem services is important meaningful to society. Meanwhile, the 50% and 100% SPD scenarios have lower benefits / ha (R$ 5,187 / ha), as well as the scenario of a 10% and 20% increase in the price of native vegetation in soy expansion with R$ 2,500 / ha.

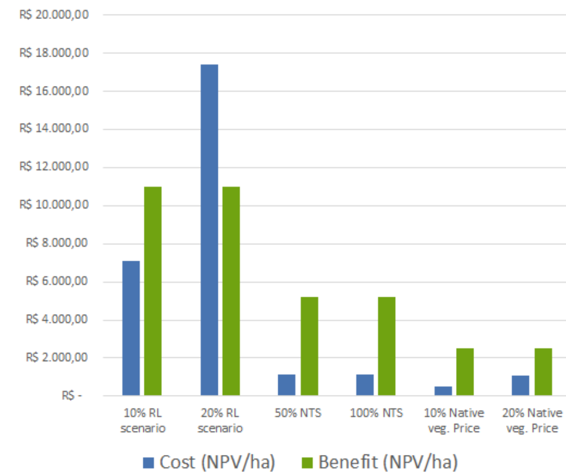


Figure 20 - NPV per hectare

From the above, it is still not possible to state that the scenarios 10% or 20% of maintenance of native vegetation are preferable to those of 50% and 100% SPD or an increase of 10% and 20% in the price of native vegetation, since the associated costs were not observed for each economic incentive. When visualizing the costs, in blue, it is possible to verify that the scenario of 20% of maintenance of native vegetation is greater than its benefits, that is, it proves unfeasible from a financial point of view. The 10% RL surplus maintenance scenario has lower costs (R$ 7,088 / ha) and below its benefits. However, it cannot be said that this would be the most efficient option yet, since the costs per hectare in the 50% and 100% SPD scenarios (R$ 1,117 / ha) are much lower. The low cost for these scenarios can be explained by the smaller PSA / ha / year, in the amount of R$ 208 / ha / year, when compared to the PSA required for the scenarios of 10% maintenance of native vegetation (in R$ 664 / ha / year) and 20% RL (in R$ 1,628 / ha / year) and the costs of 10% and 20% increase in the price of native vegetation are R$ 535 / ha in 20 years and R$ 1,070 / ha in 25 years, respectively.

it is important to highlight that in order to maintain the surplus of native vegetation, a continuous payment (25 years) to the rural owner is necessary, since he is giving up carrying out other activities such as soy planting. On the other hand, the scenarios for implementing the no-till system (SPD) can be carried out for only 5 years and the price increase of 10% and 20% occurs only once, since it aims to support the transition in adoption of more sustainable production patterns and guide the expansion of soy in pasture areas. In the specific case of adopting a no-till system, after 5 years, rural landowners will have both an increase in productivity (private benefit) and environmental benefits to society that will contribute to the maintenance of the agricultural technique, that is, their benefits (private and environmental) will occur over 25 years, but public policy costs will only occur for 5 years. Since the objective of the present study is not to analyze the private benefits arising from economic incentives, only environmental benefits related to the cost of public policy will be presented hereinafter.

Another important indicator to analyze is the number of hectares supported by each economic incentive. In this sense, the ability to engage rural landowners in each scenario is relevant mainly in the implementation of direct planting, since it makes it possible to reach more hectares than, for example, maintaining a 10% or 20% surplus of legal reserve in the properties--the next figure demonstrates this conclusion.

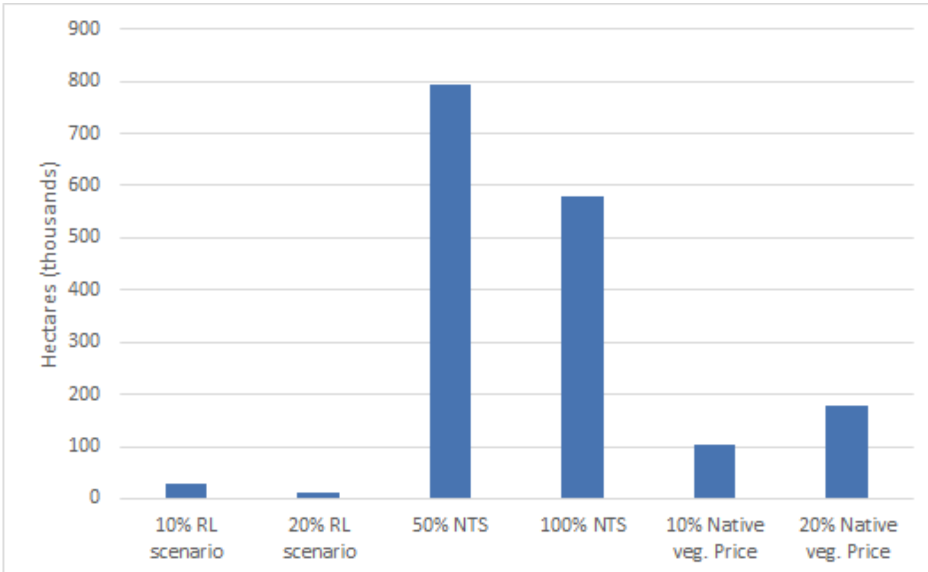


Figure 21 - Number of hectares supported by type of economic incentive

With that, we can check other indicators below, such as the balance (cost - benefit) of the net present value (NPV) per hectare, which is higher for the scenario of 10% maintenance of surplus native vegetation (R$ 4,443 / ha), that is, if the objective is to carry out a small project, it would be more interesting to observe the benefits generated / hectare. Meanwhile, for the scenario of 20% maintenance of the surplus of RL, it proves unfeasible from the financial point of view, since the NPV balance is negative by R$ -5,020 / ha, that is, the cost flows are greater than the benefits. The balance / ha of the scenarios of 50% and 100% of adoption of no-till system (SPD) corresponds to R$ 4,069 (R$ 2,412 / ha as private NPV, and R$ 1,657 / ha as environmental NPV, in blue). It is important to remember that both have equal NPV / ha balances since the average PSA for 50% was not significant and, therefore, the same PSA value was assumed, that is, the same cost of public policy for both cases (R$ 208 / ha / year). Finally, the balance per hectare of the scenarios with 10% and 20% increase in the price of native vegetation corresponds to R$ 2,300 / ha and R$ 2,100 / ha

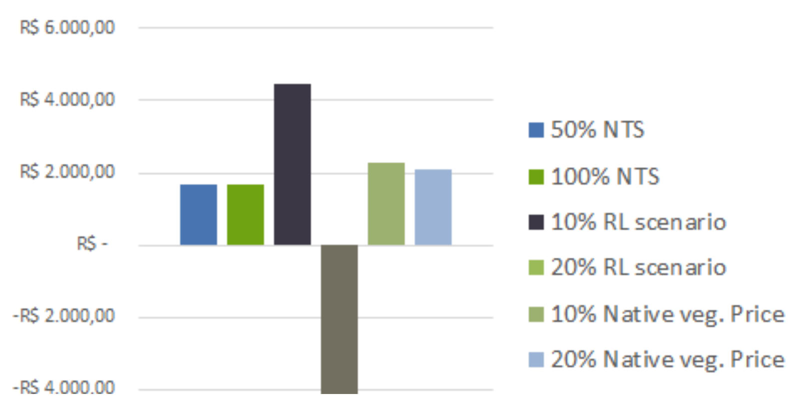


Figure 22 - Balance (benefit - cost) of net present value (NPV) per hectare over 25 years (Blue as environmental NPV and orange as private NPV)

The figure below shows the balance between total costs and benefits over 25 years for each possible economic incentive, always taking into account a discount rate of 8% per year. It is observed that the net benefit in 25 years is more efficient when choosing the 50% SPD implementation scenario, even considering only the net environmental benefits.

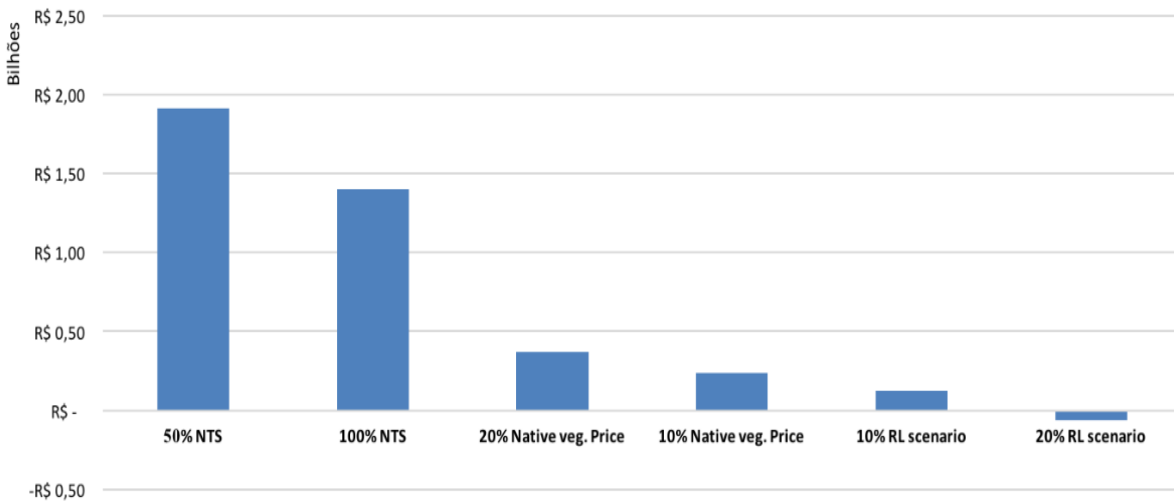


Figure 23 - Balance (Cost-benefit) of the total net present value (NPV) Environmental (Blue) and private (Orange) in 25 years

We must clarify that even with values of PSA / ha / year considered equal for the scenarios of 50% and 100% of SPD, at R$ 208 / ha / year, there is a greater capacity of engagement of the rural owners for the scenario of 50% - with 63% - than the 100% SPD scenario (with 23%). This can be explained by an aversion to the risk of the rural owner to adopt no-till in 100% of the property.

The present study concludes, after explaining with several analysis indicators, that the economic incentive that generates the greatest net benefit in 25 years is the scenario with the implantation of a no-till system (SPD) in 50% of the property that can generate a balance of Total NPV of R$ 1.3 billion in 25 years, considering only the environmental benefits.

The benefits of implementing SPD are divided into private ones (from productivity gains that interest rural owners) and environmental ones (which are of interest to those actors willing to offer financial resources to maintain the environmental service and create PES systems). That said, we can separately analyze the environmental benefit, in 25 years, of R$ 2.2 billion and a cost for the implementation of public policy of R$ 887 million.

However, the analysis does not end as, as we verified throughout the study, a combination of interest rate reduction with a PSA - which we call a credit-based PSA - would be more efficient for the 50% scenario. A 1% interest reduction corresponds to a PSA of R$ 180 / ha / year. Thus, in substitution of an annual payment of R $ 208 / ha to make the change of system, a PSA of R$ 28 / ha / year could be combined with a 1% reduction in the interest rate to finance production, which generates a perception of the rural owner of R$ 180 / ha / year.

Despite the owner's perception, the effective cost to the bank of the 1% a.a. is equivalent to R$ 35 / ha / year, generating a perception of benefit in the equivalent producer proving to be efficient from a financial point of view. Therefore, the present study projected that a combination of interest reduction with PSA in the implementation of 50% SPD would generate savings of 23% (from R$ 887 million in 5 years to R$ 201 million in 5 years), while the environmental benefits remains at R$ 2.2 billion in 25 years.

Finally, a possible source of financing capable of contributing to the 50% SPD implementation policy, which combines interest and PSA reduction, is the taxation of suppression of native vegetation, which, considering the scenario of 10% price increase, it would generate R$ 20 million in 5 years, that is, it would contribute to the PSA in 81 thousand hectares (10% of the area).

We must emphasize that the analysis does not consider the transaction costs necessary to implement these economic incentives. However, it can be said that, in a comparative analysis of the economic incentive via PSA or by the reduction of interest rates, the transaction cost for the reduction of interest rates by banks presents, possibly, a lower transaction cost, since there is less effort with costs of research and information, negotiation, decision making and monitoring and enforcement of compliance, both at the beginning of the implementation and also in the daily operation of the incentive (Curran et al, 2016). This demonstrates an additional reason for using interest cuts as part of the economic incentive.

Productive Standard - NTS

PES can be **temporary** to make changes

Resistance reasons: lack of capital to make the transition; lack of successful cases

High sensibility to neighbor success cases

Low sensibility to technical recommendations

PES level: R$ 208/ha/year (recommended)

Efficient incentive through reduction and **interest rates** (-1%)

Priority areas for SPD incentives in areas with some/few successful cases (neither none nor many)

Private benefits - subsidy characteristics outweigh social/environmental benefits

Benefit/Cost ratio: Between 1.8 and 4.1

Total public policy costs: R$ 119 million per year in 579,000 hectare (5 years)

Surplus of Native Vegetation

PSA must be **perennial** to keep change (higher cost)

Resistance reasons: desire to plant more, not less (52% of respondents did not engage in any of the incentive scenarios)

Low sensitivity to extension of payment terms

PES level: R$ 664/ha/year (recommended)

Potential: suspension of payment may lead to high deforestation risk

Opportunity to support the creation of RPPNs in the region to maintain native vegetation surplus

Indirect effect of PSA on native vegetation price

Significant environmental benefits from maintaining native vegetation

Benefit/Cost ratio: 1,54

Total public policy costs: R$ 19 million per year in 28,000 hectare (perennial)

Farming Area Expansion

PES can be **temporary** to make changes

Resistance reasons: barriers to policy implementation

Escapes: subsidies may speed expansion process

Low sensitivity: reputation (premium price does not exist)

If the price of native vegetation rises by 10%, the demand for the purchase of vegetation will decrease by 11%, while that of pasture should increase by 4%.

Potential irrationality of deforestation in areas with low agricultural suitability, resulting in abandonment of areas

Credit line opportunities to finance sustainable expansion in degraded pastures

Figure 24 - Summary with the main information for each experiment of choice

5. POLICY RECOMMENDATIONS: STEP BY STEP STRATEGIES

Incentive strategy to generate surplus native vegetation

Offer a NTS of R$ 664/ha/yr for surplus native vegetation in agricultural areas
Announce the offer and sign contracts with interested producers

5-year contract, preferably perpetually extended - transformation of the area into RPPN or easement. Alternative: single payment (purchase) of approximately R$ 6400/ha (to be returned if the area is deforested in the future)

Program Conservation Potential:
28 thousand additional hectares (Tocantins + Bahia)

Total Cost of Payments: R$ 19 million/year or R$ 180 million in 20 years.
Cost per hijacked tCO_2: R$ 66/tCO_2
•(include transaction costs)

Direct Benefits: Additional Ecosystem Services
Hydrological: R$723/ha/yr
Carbon: R$392/ha/yr

Policy would generate positive social balances
Social benefits 60% higher than program costs

Indirect Benefits: Potential increase in the price of land with native vegetation of around 10%, due to the PES Reduction in demand for land with native vegetation for expansion by 11%, and increase in demand for expansion in pastures by 4%.

Potential to reduce deforestation of native vegetation (if PSA is extended to the entire state of Tocantins and Bahia) of 236 thousand hectares (in a scenario with a projected loss of 1.2 million hectares of vegetation by 2035).

Incentive Strategy for More Sustainable Productive Standards (SPD)

In the municipalizeis where there is no case of NTS success: offer a 1% reduction in the interest rate for production costs (efficient incentive)
In the municipalizeis where there are cases of NTS success: offer a smaller reduction, for example, 0.5%.
Announce the offer and approach interested producers

5-year contract (temporary), subject to the adoption of SPD with rotation of 3 crops in 50% of the production area. Producers need to test and see that the SPD is worth it.

It is important to invest in the conversion of the first successful "pilot cases", as they are key to the acceptance of the standard. Producers are more sensitive to hearing recommendations from other producers.

Program Conservation Potential:
28 thousand additional hectares (Tocantins + Bahia)

Total Cost: 165 mi/year or 887 million (present value)
If banks "have no margin" to lower interest rates, the ideal is to transfer funds so that the bank can lower it, as the perception of interest rates has a greater potential than a direct payment. If a direct payment is chosen, this would have to be R$ 208/ha/year.

Environmental Benefits:
Hydrological Services: R$ 158/ha/year
Additional carbon sequestration: R$ 102/ha/year
Impacts due to additional use of herbicides in the SPD have not been evaluated
Private Benefits: possible productivity gain (R$ 226)

Benefits are up to 140% higher than program costs.