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Carbon Market Funding for the Development of Areas of Pastures: The Case of Small Farms in the State of Rio de Janeiro, Brazil

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Abstract

This study aims to examine, within the Local Development, the reforestation with eucalyptus on land used for grazing. Uses the Market Certified Emission Reductions (CER) as a source for funding, through projects of Clean Development Mechanism (CDM). The study analyzes the cash flow of small-scale beef cattle operation and simulates the eucalyptus plantation on the farms. The area selected for this study covers the family-structured farms of small and medium extension on the beef cattle industry in north-central state of Rio de Janeiro, Brazil. The research method used was a literature review, application of the methodology recommended by the UN and cash flow analysis. Analysis of Net Present Value (NPV) considering the eucalyptus plantations for energy purposes, has brought positive values. The study confirms that the implementation of forestry along these models is itself a profitable activity. This study applied the methodology AR-AMS0001, recommended by the executive board of the United Nations on Climate Exchange.

Keywords: sustainable development, CDM for reforestation, engineering sustainability, local development

1. Introduction

The farms all over the state of Rio de Janeiro, whose source of income is agriculture and livestock, according to agricultural census of the Brazilian Institute of Geography and Statistics (CIDE, 2008) covers 1.6 million hectares. The cattle ranches basically depend on grazing and sugar cane, for the livestock maintenance and in some cases, a small farming focused not much more than subsistence. Many of these farms are maintained by families who hold possession of these areas because they are heirs of ancient estates, as presented in the study Nozoe (2006).

The work presented here aims to answer the following main question:

Is it financially and economically feasible to replace the beef cattle and milk production by small-scale eucalyptus plantations for siderurgical charcoal production and obtain financing through CDM forestry projects, after obtaining obtaining funding through forestry CDM projects?

The problem was investigated within the following economic and financial conditions observed in the Brazilian environment:

- Farmers who economically depends on the cattle on a small scale production have little chance to prosper economically;
- The charcoal supply for the steel industry does not fully address the necessary demand from steel producers, and the planned investments to increase forest for this purpose does not follow the same proportion of growth investments in steel production;
- The implementation of CDM forestry projects in Brazil for energy co-generation is a strategic alternative energy source to replace fossil fuels.

This paper aims to analyze the CDM implementation on forestry projects as a strategic alternative to the Local Development on underused areas focused so far only for grazing.

Derive the following specific objectives:

- Run the economic and financial analysis of beef cattle and milk in the area where the research was performed;
- Studying the cash flow of a eucalyptus plantation in reforestation;
- Simulate an economic and financial planning to plant eucalyptus trees and cut trees on a 20 years plan to meet the siderurgical charcoal market demand.

The object of study are the farms of Rio de Janeiro's north-central area, which comprises Macae, Conceição de Macabu, Quissamã and Carapebus, family-owned small and medium extensions, between 25 and 60 hectares, and who use the cattle beef and milk as a source of income.

2. Research Method

We use a comparative study between the average income of livestock farms and the income from the quantification of Certified Emission Reduction (REC) from reforestation with eucalyptus sales to the charcoal market during 20 years.

The project CARBON FIX-TERRA BOA developed in Guararapes-Sao Paulo, Brazil, used this method in your project to calculate the reducing emissions of greenhouse gases through carbon sequestration by restoration of native forest. The area where the project was developed had been degraded due to its use as pasture area.

3. Literature Review

Green and Unruh (2010) in their study report that the implantation of CDM reforestation, such as the region studied here, generate positive impacts on local agriculture and increase income to the farmer, improving soil quality, increased capacity hydrographic investments in regional infrastructure, transfer of technology applied to agriculture, among others. However, the authors alert that there are potential risks of negative impacts that can limit the project implementation, such as the destruction of existing vegetation resources, increase threats of watter damage or even the decrease of watter availability.

The possible impacts caused on this type of implementation is not part of this document. On Brazil, by December 2010 only one forest carbon credits project won approval by the Authority designated as told by Puentes (2010). The project developed by Plantar S/A, entitled "Reforestation as Renewable Source of Wood Supply for Industrial Use in Brazil", aims to reduce GHG emissions in Brazilian metal industry and has an area of 11,700 hectares, located in the state of Minas Gerais, providing removal of 2.27 million tons of CO_2 over a period of 30 years. Puentes (2010) continues, reporting that two other projects were under development in Brazil: the first is the AES Tiete to reforest areas for permanent preservation around the reservoirs of the Tietê River, an area of 8000 hectares can capture 2.7 million hectares of tonnes of CO_2 in 30 years. The second is the Agroforestry Soroteca with 2319 hectares, removing 6.5 million tons of CO_2 in 24 years.

Reforestation CDM projects worldwide are using the methodology AR-AMS0001 to support their estimates. Puentes (2010) cites in his dissertation projects in India, with reductions of 11.5 million tonnes of CO_2 in Vietnam with reductions of 2.66 million tons of $CO_{2,}$ and in Bolivia, Paraguay and Uganda minors scales.

3.1 Estimating Carbon Sequestration

According to the Brazilian Agricultural Research Corporation-EMBRAPA (2002), it is known that the ability of fixation and carbon uptake by trees is directly dependent on the species, considering the growth rate, longevity, planted area, the climate and other variables.

The study conducted here does not consider the costs of hiring regulated firms to analyze the feasibility of implementing the CDM project, the implementation of the project itself, and also does not consider the costs of monitoring and audits to be conducted during the 21 years of project implementation.

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3.1.1 Calculation Methodology Adopted

In the proposed case study, the AR-AMS0001 methodology will be used, which becomes the "Methodology simplified baseline and monitoring of afforestation and reforestation small-scale project activities under the clean development mechanism implemented on grasslands". This methodology is approved by IPCC-NGGIP, as part of ONU, to evaluate the economic potential of the use of CDM projects as a source of funding.

The methodology presents a series of equations for calculation, divided into two sections: the first is the baseline calculation and the second section is reserved for the monitoring processes.

The methodology provides equations to calculate:

- Carbon stock baseline;
- The above ground biomass estimates;
- Underground biomass estimates;
- Carbon stock below ground estimates;
- Baseline removal of Greenhouse gases within the project area;
- Calculation of identified leakage;
- RCE.

At the Monitoring section, there are equations to perform the following calculations:

- Carbon stocks of above-ground biomass;
- Carbon stocks in below-ground biomass;
- Measuring leakages;
- Net GHG removal calculation;
- Monitoring frequency.

3.2 Financial Analysis and Projections

To perform a detailed analysis of the feasibility of a project some mathematical equations were used-financial, where part of a baseline and projections based on statistical simulations.

In these sections it applies methods of mathematical and financial for the following scenarios:

- Small-scale farms;
- Wood market for charcoal from eucalyptus reforestation covering 11/12 of the pasture area;
- Implementation of CDM project to carbon credits market in the reforested area.

4. Data Collection and Analysis, and Proposed Use of Carbon Credit Market or Local Development Growth

4.1 Estimate of Economic and Financial Beef Cattle and Milk in the Region

Schier (2005), on his research, uses the principles of full absorption costing, which seeks to allocate the entire cost of producing the products.

The method described by Schier (2005) to calculate the full absorption costing considers the following variables:

- Expenses related to production (fixed and variable), which are treated as "sales cost";
- Net sales less cost of goods sold, resulting in gross profit for the period;
- Gross profit less the expenses of the period resulting in profit before applying taxes and social contribution on net income;
- When the production period is not totally sold, products in stock so go to the next period.

In this study, the following assumptions were made for the parameterization of the calculations for the determination of the cost:

- For the milk market, the entire production is purchased by the dairy cooperatives in the city;
- Regarding to beef cattle market, when a farmer has availability to sell, there are never problems in abattoirs and / or butchers cities in buying the squad;
- To consider these two items, the research will not be considered the remaining stock or it was not sold in the period, the milk is harvested or weight of cattle for slaughter;
- Since the raw material is nothing else than the amount of productive livestock that the farmer has, and knowing

that we are dealing with two distinct markets with the same ingredient (beef and milk), the cost of raw materials will result from the amount of productive animals and their depreciation;

• As characteristic of the region, because the flock feed predominantly on pasture, the cost of feeding livestock are derisory;

• The reproduction takes place by natural procedures, excluding the need to carry out artificial insemination. Therefore, there is no cost involved with insemination.

4.1.1 Accounting and Financial Analysis of Beef Cattle and Milk

For this study, the sample was taken for a property in the county of Macabuzinho in the city of Conceição de Macabu which has 72.5 hectares. Of these, 3 hectares for planting sugarcane, 1 hectare to the farmhouse and barn and all the rest, 67.5 acres for grazing. The property has 139 head of cattle crossbred with 98 matrices, 1 and 40 breeding males for fattening and subsequent sale for slaughter. This is scenario of livestock for the dairy industry used in this research.

4.1.1.1 Roster Maintenance

Using the method of calculating the cost of milk production Segala and Silva (2007), we have in Table 1 the distribution of cows for a period of 4 months.

Table 1. Distribution of the squad for a period of four months

Number of cows selected for reproduction	nov/09	Dec/09	jan/10	Feb/10
In lactation	61	58	58	62
Dry	18	19	20	19
Heifers and heifer calves	19	21	19	18
I cannot find precise English equivalent	98	98	97	99

The squad has an average of 59 cows with this characteristic and applied to the purchase price of the matrices is $ 2,000.00 already in milk production. Table 2 shows the monthly depreciation based on the presented data.

Table 2. Depreciation of matrices for the milk production

Matrizes	Valor de compra	Valor total	Depreciação por ano	% depreciação por mês	Valor depreciado por mês
59 in the production phase - Nov-09	2000	R$ 122.000,00	10%	0,83%	R$ 1.012,60
58 in the production phase - Dec-09	2000	R$ 116.000,00	10%	0,83%	R$ 962,80
58 in the production phase - Jan-10	2000	R$ 116.000,00	10%	0,83%	R$ 962,80
62 in the production phase - Feb-10	2000	R$ 124.000,00	10%	0,83%	R$ 1.029,20

Source: Research data.

About the energy costs were considered using a water pump used to clean and supply water tank, the equipment that keeps the refrigerated tank, forage harvester, tractor, milking equipment of the cane shredder (forage). At the time of getting vaccinated animals, buying up a lot for all the flock, and the cutting of milk plus a margin of 10%, so there is not a control vaccination per individual. On the farm, working directly with cattle in milk production the owner and one employee.

Table 3 shows the relationship of equipment and machinery used directly or indirectly for the milk production. Similarly the research used by Segala and Silva (2007), data were parameterized to contemplate the reality of the farm, and therefore the region.

Table 3. Monthly Depreciation of equipment

Item	Purchase amount	Purchase year	Annual depreciation	Percentage of use	Percentage of use in other activities	Monthly depreciation amount
Forage	R$ 9.700,00	2001	14,28%	100%	0%	R$ 115,43
Milking	R$ 30.000,00	2004	10,00%	100%	0%	R$ 250,00
Cooler	R$ 28.000,00	2005	6,67%	100%	0%	R$ 155,63
Mowing	R$ 2.800,00	2003	10,00%	50%	50%	R$ 23,33
Feed truck	R$ 30.000,00	2002	10,00%	20%	80%	R$ 250,00
Water pump	R$ 380,00	2000	5,00%	60%	40%	R$ 1,58
Equipment's monthly depreciation						R$ 795,98

Source: Research data, adapted to Segala and Silva (2007).

Table 4 below, is presented the calculation of depreciation of buildings and facilities that are designed to produce milk.

Table 4. Estimated monthly depreciation for facilities

Item	Investment value	Purchase year	Annual depreciation	Utilization percentage	Utilization percentage in other activities	Monthly depreciation
Covered corral	R$ 70.000,00	2001	4%	100%	0%	R$ 233,33
Machinery shed	R$ 25.000,00	2001	4%	33%	67%	R$ 83,33
Employee housing	R$ 20.000,00	2001	4%	100%	0%	R$ 66,67
Fences	R$ 10.000,00	2000	10%	100%	0%	R$ 83,33
Power grid	R$ 10.000,00	1999	10%	100%	0%	R$ 83,33
Water/plumbing network	R$ 10.000,00	1999	10%	20%	80%	R$ 83,33
Breeding bull	R$ 5.000,00	1999	10%	100%	0%	R$ 41,67
Monthly depreciation of facilities						R$ 675,00

Source: Research data, adapted to Segala and Silva (2007).

4.1.1.2 Overall Production Costs

From these surveys covering up the front approaches and adaptations to research Segala and Silva (2007), Table 5, below was generated, and presents a summary of the realized values, containing the calculation of the monthly average cost of milk production. On not considering the depreciation, the value of production would decrease a lot, and it is shown in Table 6 below.

Table 5. Overall cost production

Cost of Milk Production	November 2010	Vertical analysis	December 2010	Vertical analysis	January 2010	Vertical analysis	February 2010	Vertical analysis
Fuel	R$ 400,00	5,72%	R$ 400,00	5,73%	R$ 400,00	5,76%	R$ 400,00	5,70%
Light consumption	R$ 800,00	11,43%	R$ 800,00	11,46%	R$ 800,00	11,52%	R$ 800,00	11,41%
Facility depreciation	R$ 675,00	9,65%	R$ 675,00	9,67%	R$ 675,00	9,72%	R$ 675,00	9,63%
Depreciation of matrices	R$ 1.012,60	14,47%	R$ 962,80	13,79%	R$ 962,80	13,86%	R$ 1.029,20	14,68%
Depreciation of machinery and equipment	R$ 795,98	11,37%	R$ 795,98	11,40%	R$ 795,98	11,46%	R$ 795,98	11,35%
Service, maintenance and cleaning	R$ 45,00	0,64%	R$ 45,00	0,64%	R$ 45,00	0,65%	R$ 45,00	0,64%
Medicine, vaccines, and veterinary	R$ 114,50	1,64%	R$ 148,00	2,12%	R$ 112,00	1,61%	R$ 112,00	1,60%
Salaries (including charges)	R$ 3.154,60	45,08%	R$ 3.154,60	45,19%	R$ 3.154,60	45,42%	R$ 3.154,60	44,99%
Total costs	R$ 6.997,68	100%	R$ 6.981,38	100%	R$ 6.945,38	100%	R$ 7.011,78	100%
Monthly milk production	21960	litros	20880	litros	20880	litros	22320	litros
Cost per liter of milk	R$ 0,32		R$ 0,33		R$ 0,33		R$ 0,31	
Selling price per liter	R$ 0,65		R$ 0,65		R$ 0,65		R$ 0,65	
Profit or loss per liter of milk produced	R$ 0,33		R$ 0,32		R$ 0,32		R$ 0,34	
Monthly revenue	R$ 7.276,32		R$ 6.590,62		R$ 6.626,62		R$ 7.496,22	

Source: Research data, adapted to Segala and Silva (2007).

Table 6. Overall cost production excluding depreciation

Cost of Milk Production	November 2010	Vertical analysis	December 2010	Vertical analysis	January 2010	Vertical analysis	February 2010	Vertical analysis
Fuel	R$ 400,00	8,86%	R$ 400,00	8,80%	R$ 400,00	8,87%	R$ 400,00	8,87%
Light consumption	R$ 800,00	17,72%	R$ 800,00	17,59%	R$ 800,00	17,73%	R$ 800,00	17,73%
Service, maintenance, and cleaning	R$ 45,00	1,00%	R$ 45,00	0,99%	R$ 45,00	1,00%	R$ 45,00	1,00%
Medicine, vaccines, and veterinary	R$ 114,50	2,54%	R$ 148,00	3,25%	R$ 112,00	2,48%	R$ 112,00	2,48%
Salaries (including charges)	R$ 3.154,60	69,88%	R$ 3.154,60	69,37%	R$ 3.154,60	69,92%	R$ 3.154,60	69,92%
Total costs	R$ 4.514,10	100%	R$ 4.547,60	100%	R$ 4.511,60	100%	R$ 4.511,60	100%
Monthly Milk Production	21960	litros	20880	litros	20880	litros	22320	litros
Cost per liter of milk	R$ 0,21		R$ 0,22		R$ 0,22		R$ 0,20	
Selling price per liter	R$ 0,65		R$ 0,65		R$ 0,65		R$ 0,65	
Profit or loss per liter of milk produced	R$ 0,44		R$ 0,43		R$ 0,43		R$ 0,45	
Monthly revenue	R$ 9.759,90		R$ 9.024,40		R$ 9.060,40		R$ 9.996,40	

Source: Data from the survey, adapted the Segala and Silva (2007).

4.1.1.3 Values from the Slaughter Sales Operation

On the farm taken per sample, born approximately 45 males and 45 females annually, which represents 6-7 animals per month. Females are focused exclusively milk production and thus replacing the animals leaving the productive period and headed to slaughter. Table 7 shows the estimated annual births in the farm and the amount of animals that are fattening and subsequent slaughter. Table 8 shows the projected monthly revenue considering the income with cattle for slaughter. The price for the animal is published on an electronic online service market for cattle in Brazil (PECUARIA, 2012).It was taken the value of cattle for slaughter by R $ 1,170.00 and R $ 880.00 for the female.

Table 7. Estimated monthly revenue with cattle

Number of animals born	Per year	Females To Reset Milk Production	Annual surplus	Monthly for slaughter	Price of the animal for slaughter	Value calculated on sale
Males	42	0	42	3	R$ 1.170,00	R$ 3.510,00
Females	42	8	34	2	R$ 880,00	R$ 1.760,00
Total						R$ 5.270,00

Table 8. Forecast monthly and annual revenue of ranching family

Without Depreciation	Month 1	Month 2	Month 3	Month 4	Average monthly value	Average annual value
Milk Revenue	R$ 9.759,90	R$ 9.024,40	R$ 9.060,40	R$ 9.996,40	R$ 9.460,28	R$ 113.523,30
Revenue Cut	R$ 5.270,00	R$ 5.270,00	R$ 5.270,00	R$ 5.270,00	R$ 5.270,00	R$ 63.240,00
Balance	*R$ 15.029,90*	*R$ 14.294,40*	*R$ 14.330,40*	*R$ 15.266,40*	*R$ 14.730,28*	*R$ 176.763,30*
With depreciation	Month 1	Month 2	Month 3	Month 4	Average monthly value	Average annual value
Milk Revenue	R$ 7.276,32	R$ 6.590,62	R$ 6.626,62	R$ 7.496,22	R$ 6.997,45	R$ 83.969,34
Revenue Cut	R$ 5.270,00	R$ 5.270,00	R$ 5.270,00	R$ 5.270,00	R$ 5.270,00	R$ 63.240,00
Balance	*R$ 12.546,32*	*R$ 11.860,62*	*R$ 11.896,62*	*R$ 12.766,22*	*R$ 12.267,45*	*R$ 147.209,34*

4.2 *Simulation of Eucalyptus Plantation*

The survey includes soil preparation, planting and harvesting in two scenarios: with 67.5 ranch. Based on the forecast growth generated by SisEucalipto, Table 9 shows the growth trend as volume and curves Current Annual Increment (ICA) and Mean Annual Increment (MAI).By ICA has growth volume occurred within one year, and IMA to the result of dividing the volume by the age of the forest. Note that the curve ICA reaches a maximum value before the curve IMA, the 8th year of planting, and that the two curves intersect at the point of maximum IMA.

Table 9. Prognosis of forest yield per hectare planted eucalyptus

Age	Dominant height (m)	trees/ Ha	Average diameter (cm)	Average height (m)	Basal Area (cm^2)	Total Volume (m^3)	I.M.A.	I.C.A.
1	4,3	1650	4	3,6	2	3	3	3
2	9,7	1650	10,3	8,1	13,7	45,9	22,9	42,9
3	13,8	1650	14	11,6	25,4	122	40,7	76,1
4	17,1	1648	16,4	14,4	34,7	206,1	51,5	84,1
5	19,7	1646	18	16,6	42	288	57,6	81,9
6	22	1642	19,2	18,4	47,8	364,3	60,7	76,3
7	23,9	1638	20,2	20	52,4	434,2	62	69,9
8	25,5	1633	20,9	21,4	56,3	497,6	62,2	63,4
9	26,9	1628	21,6	22,6	59,4	555,1	61,7	57,5

Source: Research data generated by SisEucalipto.

Forest cycle is driving the growth of the buds of trees newly planted or freshly cut. To consider the horizon of 21 years and cuts every 7 years, the analysis is based on three cycles forest.

The information presented by the work of EMBRAPA are based on surveys conducted with farmers where its properties include planting pine and eucalyptus as a production system.

For operations of planting and cultivation of eucalyptus should be considered:

- Preparation area;
- Planting;
- Weed control;
- Age cut-off;
- Costs;
- Productivity;

In the simulation hypothesis of this project was performed to analyze the planting of *Eucalyptus urograndis* in Conceição de Macabu property that was taken per sample, 67.5.Estimates were calculated from the values suggested in the EMBRAPA research (2005) and CEPEA-Center for Advanced Studies in Applied Economics from USP.

It has a *stereo* equivalent to 1 m^3 of wood, commonly used measurement unit in the market forester. The CEPEA published in his newsletter in the month of Forestry September/2012 that the average value of the stereo stand for the energy market is priced at $ 50, 00.However, in considering whether a more conservative estimate, taking as reference values proposed by the Forestry Program of Arcelor Mittal (2008), the value of the stereo is $ 20.00. These values composes Table 10.

Table 10. Forecast of revenue cycle for forest planting in 65 hectares

Production and income	Volume produced by 7-year forest cycle (m^3/ha)	Stere Value (Value provided by CEPEA)	Estimated revenue per hectare	Revenue generated by forest cycle (65ha of forest)
Stere Value (supplied by CEPEA)	434,2	R$ 50,00	R$ 21.710,00	R$ 1.411.150,00
Stere Value (suggested by ArcelorMittal)	434,2	R$ 20,00	R$ 8.684,00	R$ 564.460,00

4.3 Execution of the Calculations According to the Methodology AR-AMS0001

With respect to this research project, the selected methodology is the AR-AMS0001, “Exhibit A”, which is to be applied in reforestation projects carried out in the pastures.

4.3.1 Baseline GHG Removal at the Sinkhole

The calculation methodology provides equations to calculate:

- The above ground biomass estimates;
- Underground biomass estimates;
- Baseline the baseline removal of Greenhouse gases (GHG) in the vicinity of the project;
- Estimated leakage calculation;
- RCE.

Some of the equations are presented in this summary. The equation 3.1 brings as a result the stock of carbon in living biomass in the project region.

$$B(t) = \sum_{i=1}^{I} (B(t) + B_{iB(t)i}) * A_i \tag{3.1}$$

Where:

$B_{(t)}$ = the carbon stock in living biomass in the project region at time (t) the absence of project activity expressed in tC (tonne of carbon);

$_{B\,(t)} = {}_i$ is the biomass carbon stock above ground so in time *(t)* of the stratum *(i)* in the absence of the project activity expressed in t C/ha (tons of carbon per hectare);

$B_{B\,(t)} = {}_i$ is the carbon stock in below-ground biomass at time (t) of the stratum

(I) in the absence of the project activity expressed in t C/ha (tons of carbon per hectare);

$A_{(i)}$ = Area of stratum design expressed in ha (hectares);

i = stratum i (i = total number of strata).

4.3.2 Calculation of Above Ground Biomass

To calculate the above-ground biomass, uses the following equation:

$$B_{a\,(t)} = M_{(t)} * 0.5 \tag{3.2}$$

Where:

$_{B\,(t)}$ = carbon stock in aboveground biomass in the year (time) t when the lack of implementation of the project, expressed in t C/ha (tons of carbon per hectare);

$M_{(t)}$ = above-ground biomass in the year (time) t when the lack of implementation of the project, expressed in t dm / ha (tons of dry matter per hectare);

0.5 = carbon fraction of dry matter expressed in t C/t dm (tonne of carbon per tonne of dry matter).

Table 11 is the simulation of the carbon stock of above-ground biomass, year-on-year.

Table 11. Biomass carbon stocks above ground every year

M	M_{woody}	$M_{woody\,(t=n-1)} + g * Dt$	M_{woody_max}	$M_{(t=n)}$	$B_{a\,(t)} = M_{(t)} * 0.5$
{0}6.2{/0}{1}{/1}	0	0	0	{0}6.2{/0}{1}{/1}	3.1

4.3.3 Calculation of Biomass Below Ground

The methodology guides to be performed to calculate the below-ground biomass, as it also does capture carbon from the atmosphere by being an organism alive. This calculation considers the roots of grass and evergreen trees.

Table 12 is the simulation of the carbon stock in below-ground biomass, year-on-year.

Table 12. Biomass carbon stocks below the ground each year

$Mgrass$	$Rgrass$	$Mwoody$	$Rwoody$	$Mwoody(t=n-1) + g * \Delta t) * Rwoody$	$Mwoody\_max$	$B_{B\,(t=n)} = 0,5 * [M_{grass} * R_{grass} + (M_{woody\,(t=n-1)} + g * \Delta t) * R_{woody}]$
6,2	1,58	0	1	0	0	4,898

4.3.4 Calculation of Baseline Actual Removal of Greenhouse Gases

To then determine the baseline actual removal of greenhouse gases in the analyzed region follows the equation:

$$\Delta_{BSL\,C,\,t} = (_{B\,(t)} - B_{(t-1)}) * (_{(44/12)}) \tag{3.10}$$

Hence:

Δ $CBSL,\ t$ = Baseline actual removal of greenhouse gases by sinks

$B_{(t)}$ = carbon stock in living biomass in the year (time) t would exist when the lack of implementation of the project, expressed as C t (tonne of carbon);

To be considered for Tables 12 and 13, which inform the biomass carbon in the study area, the change from baseline removal Greenhouse Gases is zero throughout the project:

$$B_{(t)} = B_{(t-1)} \Rightarrow$$

$$\Delta_{BSL\,C,\,t} = (_{B\,(t)} - B_{(t)}) * (_{(44/12)})$$

$$\Delta\, C_{BSL,\,t} = 0 * (44/12)$$

$$\Delta\, C_{BSL,\,t} = 0$$

Thus, the resulting equation for calculating the baseline carbon stock in the absence of the project activity during the period of the hypothesis:

$$B(t)=\sum_{i=1}^{I}(B(t)+B_{iB(t)i})*A_i \tag{3.11}$$

Adding Tables 11 and 12 then have the result in Table 13, with the baseline of the reference scenario.

Table 13. Baseline carbon stock of the reference scenario every year

$B_{a\,(t)\,I}$	$_{B}B_{(t)\,i}$	A	$B_{(t)}$
3.1	4898	1,000	7998

To consider that the methodology is only biomass above and below ground, not treating emissions from food, in the case of this research project, cattle, this issue was not considered in the calculations.

4.3.5 Designed Calculation Baseline in Project Implementation (ex ante)

According to the methodology, the carbon stock in the scenario that will occur in the project implementation start date of activity *(t* = 0) must be the same as the baseline carbon stock in the same period *(t* = 0).

4.3.6 Calculation of Carbon Stock in Aboveground Biomass

Analogous to the calculation of the baseline reference scenario, to calculate the carbon stock in living biomass above ground, must be considered stratum *i,* which comes to every geographic area of the project implementation. In the case of this research project is regarded only 1 stratum of 1000 hectares.

$$N_{A\,(t)} = T_{i\,(t)\,i} * 0.5 \tag{3.12}$$

Where:

$_{The}\,N_{(t)\,i}$ = carbon stocks in above-ground biomass in the year (time) *t* when the deployed project, expressed in t C/ha (tons of carbon per hectare);

$T_{(t)\,i}$ = above-ground biomass in the year (time) *t* when the deployed project, expressed in t dm / ha (tons of dry matter per hectare);

0.5 = carbon fraction of dry matter expressed in t C/t dm (percentage).

EMBRAPA (2002) in its methodology for estimating carbon stocks in trees, considers various land uses. In their study, Renner (2004) was used a methodology for calculating living biomass above and below ground, set by the Federal University of Paraná (UFPR) for tree species *Pinus taeda,* which resembles much as the eucalyptus Table 14.

Table 14. Biomass equations adjusted for *Pinus taeda* UFPR

		Ratios	
Compartment	Equation	a	b
PFV	$a(DAP^2H)^b$	0,0595	0,9279
PFVI		0,0012	1,0480
PFGv		0,0001	1,3922
PVR		0,4484	0,5619

Source: UFPR; ECOPLAN (2003, apud RENNER, 2004, p. 59).

Where: PVF: Weight Verde de Fuste; PVFl: Weight Green Leaves; PVGv: Weight Green Living Branches; PVR: Weight Green Roots; dbh: diameter, H: height

In continuation, the author presents the results of calculating the amount of carbon individually, here represented by Table 15. The result of these equations are expressed in t C/ha (tons of carbon per hectare).

Table 15. Equations for obtaining the amount of carbon in the compartments for individual trees

Compartment	Equation
Shaft	PCF = 0,1737 * PVF
Leaves	PCFl = 0,1422 * PVFl
Living branches	PCGv = 0,1595 * PVGv
Root	PCR = 0,1676 * PVR

Source: UFPR; ECOPLAN (2003, apud RENNER, 2004, p 60).

Where: PCF: Weight in Carbon Fuste; PCFl: Weight of Carbon in Leaves; PCGv: Weight of Carbon in Living Branches; PVF: Weight Verde de Fuste; PVFl: Weight Green Leaves; PVGv: Weight Green Living Branches; PVR: Weight Green Roots, PCR Weight Carbon in Root.

Note: Values are expressed in t C/ha (tons of carbon per hectare).

These equations allow us to estimate the carbon fixed up below ground by the implementation of the project.

The *software* SisPinus in his prognosis, presents the results of production expressed in cubic meters. The author reports that in a reference to his research, industry Klabin, believes that wood 1m equals 1 tonne mass.

She continues with the statement ROCK (2003, apud RENNER, 2004, p. 60), where a ton of carbon, the unit used by the carbon market, equivalent to 3.67 tons of CO_2, which means that in reverse situation, a ton of CO_2 equivalent to 0.27 tonnes of carbon. This information will be used for *the subsequent* calculation of REC.

Thus, in Table 16 is presents the amount of carbon estimated by summing compartments trunk, branches, foliage and roots for planting eucalyptus in the hypothesis of the research in years 7, 14 and 21, and these dates immediately before cuts.

Table 16. Fixed amount of carbon per hectare, prognosis based on lifelong project

	period	Total volume of wood produced (m^3)	Amount of Carbon (t/ha)	Qty. Carbon in 65 ha (t)	Qty. Carbon in 1000 ha (t)
First Cutting	7^{th} year	434,2	43,70	2840,5	43700
Second Cutting	14^{th} year	434,2	43,70	2840,5	43700
Final Cutting	21^{st} year	434,2	43,70	2840,5	43700

The prognosis in SisPinus calculated immediately after the first cut the amount of carbon fixed remaining 15% is in reference to the volume produced, this carbon associated with the existence of roots of trees.

Table 17 shows the evolution of tree growth and the amount of carbon fixed compartments corresponding to the stem, branches, leaves and roots, which is the baseline carbon fixed for the duration of the project.

In the year of implementation of the reforestation project, as directed by the methodology, the amount of carbon fixed equals before the implementation of the project.

Table 17. Evolution of growth of trees and baseline amount of carbon fixed

First Cutting			Second Cutting			Final Cutting		
Year	Timber volume in m3/ha	Fixed carbon in tC/há	Year	Timber volume in m3/ha	Fixed carbon in tC/há	Year	Timber volume in m3/ha	Fixed carbon in tC/há
1	3,00	0,30	8	65,13	6,55	15	65,13	6,55
2	45,90	4,62	9	87,99	8,85	16	87,99	8,85
3	122,00	12,27	10	145,00	14,59	17	145,00	14,59
4	206,10	20,73	11	206,10	20,73	18	206,10	20,73
5	288,00	28,97	12	288,00	28,97	19	288,00	28,97
6	364,30	36,65	13	364,30	36,65	20	364,30	36,65
7	434,20	43,68	14	434,20	43,68	21	434,20	43,68

4.3.7 Calculating the Carbon Leakage

According to the methodology if project participants demonstrate that the activity of small-scale reforestation under the CDM concept does not result in displacement of activities or people, or not yet generates other activities that did not exist before incurring increased emission of greenhouse gases, the calculation to estimate leakage is not required.

Table 18 shows the calculation of leakage estimated for the project based on the methodology and predictions generated from timber volume.

Table 18. Estimated trail regarding baseline amount of carbon fixed

Year	Timber volume in m^3/ha	ΔC_{ACTUAL}	ΔC_{ACTUAL} * 0.15
0	0,00	0,00	0,00
1	3,00	1,11	0,61
2	45,90	16,93	9,31
3	122,00	44,99	24,74
4	206,10	76,01	41,80
5	288,00	106,21	58,41
6	364,30	134,35	73,88
7	434,20	160,13	88,06
8	65,13	24,02	13,21
9	87,99	32,45	17,84
10	145,00	53,48	29,41
11	206,10	76,01	41,80
12	288,00	106,21	58,41
13	364,30	134,35	73,88
14	434,20	160,13	88,06
15	65,13	24,02	13,21
16	87,99	32,45	17,84
17	145,00	53,48	29,41
18	206,10	76,01	41,80
19	288,00	106,21	58,41
20	364,30	134,35	73,88
21	434,20	160,13	88,06

4.3.8 Anthropogenic GHG Removals by Sinks

The net GHG removals by sinks for each year of the first period carbon credit is calculated according to the equation below:

$$ER_{AR\ CDM,\ t} = \Delta C_{PROJ,\ t} - \Delta C_{BSL,\ t} - GHG_{PROJ,\ t} - L_t \tag{3.13}$$

Where:

$ER_{AR\ CDM,\ t}$ = anthropogenic GHG removal by sinks, expressed in t CO_2 -e/year (ton of CO_2 per year);

$_{PROJ}\Delta_{C,\ t}$ = projected GHG removal by sinks at time *t,* expressed in t CO_2 -e/year (ton of CO_2 per year);

$_{BSL}\Delta_{C,\ t}$ = Baseline GHG removal by sinks, expressed in t CO_2 -e/year (ton of CO_2 per year);

$GHG_{PROJ,\ t}$ = GHG emissions of the project, expressed in CO_2 -e/year t (tonne of CO_2 per year);

L_t - Escape assigned to the project activity at time *t,* expressed in t CO_2 -e/year (ton of CO_2 per year).

Given the chance to replace a pasture area, which emits a certain amount of greenhouse gases, methane in this case, as item 4. 3.1.3 of this research, the reforested area there will be no creation of food. Thus, the emission of greenhouse gases is not considered in this project.

The result of the Certified Emission Reduction (REC) in year t_v was assumed that the check is given by the following equation:

$$tCER_{(tv)} = \sum_{t=0}^{TV} ER_{AR\ \ CDM}\Delta_t \ * \ t \tag{3.14}$$

Where:

$tCER_{(tv)}$ - = Temporary Certified Emission Reductions in the year that the scan was taken;

$ER_{AR\ CDM\ t}$ = Net GHG removal by *sinks* expressed in t CO_2 -e/year (ton of CO_2 per year);

t_v - Year that was assumed to verification;

Δt - Increment of time (1 year).

Thus, Table 19 represents the result year-on-year reduction of emissions, the amount of carbon captured at the end of each cycle forest per hectare and the total amount of carbon captured at the end of the 21 years of the project, also per hectare. Table 20 is shown the amount of carbon sequestered in a forest and 65ha of forest in a 1000 HA.

Table 19. Results of calculation for certified emission reduction project

Year	Timber volume in m^3/ha	ΔC_{ACTUAL}	ΔCACTUAL * 0,15 (escape)	$ER_{AR\ CDM}$	
0	0,00	0,00	0,00	0,00	
1	3,00	1,11	0,17	0,94	
2	45,90	16,93	2,54	14,39	
3	122,00	44,99	6,75	38,24	
4	206,10	76,01	11,40	64,61	
5	288,00	106,21	15,93	90,28	
6	364,30	134,35	20,15	114,20	
7	434,20	160,13	24,02	136,11	458.77 t
				Subtotal -->	CO_2/ha end of the
8	65,13	24,02	3,60	20,42	forest cycle

9	87,99	32,45	4,87	27,58	
10	145,00	53,48	8,02	45,45	
11	206,10	76,01	11,40	64,61	
12	288,00	106,21	15,93	90,28	
13	364,30	134,35	20,15	114,20	
14	434,20	160,13	24,02	136,11	498.65 t CO_2/ha end of the forest cycle
				Subtotal -->	
15	65,13	24,02	3,60	20,42	
16	87,99	32,45	4,87	27,58	
17	145,00	53,48	8,02	45,45	
18	206,10	76,01	11,40	64,61	
19	288,00	106,21	15,93	90,28	
20	364,30	134,35	20,15	114,20	
21	434,20	160,13	24,02	136,11	
				Subtotal -->	498.65 t CO_2/ha end of the forest cycle
			Total:	1456,10	t CO_2/ha

Source: Adapted from RENNER, 2004 and survey data.

Table 20. Estimated carbon cycle captured by the two simulations forest area to be reforested

	Area (ha)	Amount of carbon captured per hectare for each forest cycle (t CO_2/ha)	Total amount of carbon captured by forest cycle on each farm (t CO_2)
1st Forest cycle	65	458,77	29820,05
	1000	458,77	458770,00
2nd Forest cycle	65	498,65	32412,25
	1000	498,65	498650,00
3rd Forest cycle	65	498,65	32412,25
	1000	498,65	498650,00

4.3.9 Monitoring Plan (ex post)

In this part of research that are treated the details of the monitoring plan of the CDM project. This monitoring plan basically performs checks throughout the duration of the project based on what was planned and considered for making the baselines.

4.3.10 Estimate (ex post) Baseline GHG Removal by Sinks

The method orients it is not necessary to monitor the baseline. The Baseline GHG Removal by Sinks will be the same as defined in section 4.3.13 of this research.

4.3.11 Estimate (ex post) of GHG Removal by Sink

The equation below shows the calculation of carbon stock to be used in monitoring.

$$P_{(t)} = \sum_{i=1}^{I} (P_{A(t)i} + P_{B(t)i}) * A_i * (44 / 12) \quad (3.15)$$

Where:

$P_{(t)}$ = the carbon stock in living biomass in the project region at time (t) in the project activity, expressed in $_{tCO2e}$ (tonnes of carbon dioxide);

$_{The}$ $P_{(t)} = _i$ is the carbon stock of above-ground biomass at time *(t)* of the stratum *(i)* the project activity, expressed in t C/ha (tons of carbon per hectare);

$P_{B(t)} = _i$ is the stock of biomass carbon underground in time (t) of the stratum;

(I) the project activity, expressed in t C/ha (tons of carbon per hectare);

$A_{(i)}$ = Area of stratum design expressed in ha (hectares);

i = stratum i (i = total amount of strata).

4.3.12 Measuring Above Ground Biomass

$$P_{A(t)} = E_{i(t)i} * 0.5 \quad (3.16)$$

Where:

$_{The}$ $P_{(t)i}$ = carbon stocks in above-ground biomass in the year (time) *t* when the project activity, expressed in t C / ha (tons of carbon per hectare);

$E_{(t)i}$ = aboveground biomass estimated in the year (time) *t* when the project activity, expressed in t dm / ha (tons of dry matter per hectare);

0.5 = carbon fraction of dry matter expressed in t C/t dm (tonne of carbon per tonne of dry matter).

To perform the estimation of aboveground biomass the following steps should be followed:

- Step 1 - Establish permanent plots and document analysis of their locations in the first monitoring report;
- Step 2 - Measure the diameter at breast height (DBH) and tree height and documented in the report;
- Step 3 - To estimate the aboveground biomass using equations developed or adapted locally or nationally.

4.3.13 Measurement of Biomass Below Ground

$$P_{B(t)} = E_{i(t)} * R_i * 0.5 \quad (3.17)$$

Where:

$P_{B(t)i}$ = Carbon stock in living biomass below ground in the year (time) *t* in the project activity, expressed in t C ha (tons of carbon per hectare);

$E_{(t)i}$ = estimate of underground biomass year (time) *t* of the project activity, expressed in t dm / ha (tons of dry matter per hectare);

R = ratio of mass of the tree and root mass (t dm/t dm);

0.5 = carbon fraction of dry matter.

It is driven methodology that values locally or regionally adapted to be used for this estimate.

4.3.14 Estimate (ex post) of Carbon Leakage

To estimate carbon leakage, you should monitor each of the following indicators during the first crediting period:

- Area in crops within the project boundary displaced due to there project activity;
- Number of animals that utilize pasture within the project boundary that have been displaced due to the project activity;
- Number of animals and volume of forage intake per animal per hectare that were brought to the project area.

As this activity of small-scale reforestation under the CDM concept does not result in displacement of activities or people, or not yet generates other activities that did not exist before incurring increased emission of greenhouse gases, the calculation to estimate the leakage is not required.

$$_{Tv}L = 0 \tag{3.18}$$

Where:

L_{tv} = Leakage attributable to the project activity at time t, expressed in CO_2 -e/ano t (tonne of CO_2 per year)

4.3.15 Estimate (ex post) Removal of Anthropogenic GHG at Sinkhole

Removal of anthropogenic greenhouse gas sink occurs at the designed result of removing less the baseline carbon fixed, less leakage. The resulting value of REC in the year the check is given as follows:

$$tCER_{(tv)} = \sum_{t=0}^{TV} P_{(t)} - \sum (GHG_{PROJ,(t)} - \Delta C_{BSL,t}) - L_{tv} \tag{3.19}$$

Where:

$tCER_{(tv)}$ = Certified Emission Reduction in year *t* the duration of the project;

P (t) = Inventory of carbon calculated for the proximity of the project in year *t* the duration of the *project,* expressed in t CO_2 -e/year (ton of CO_2 per year);

$GHG_{PROJ,(t)}$ = GHG emissions of the project, expressed in CO_2 -e/ year t (tonne of CO_2 per year);

$_{BSL}\Delta_{C,t}$ = Baseline GHG removal by sinks, expressed in t CO_2 -e/ year (ton of CO_2 per year);

L_{tv} = Leakage attributable to the project activity at time *t* scan, expressed as CO_2 -e/ year t (tonne of CO_2 per year);

t_v - Year of the verification.

All these equations are applied in the monitoring stage, part of the CDM project upon its implementation, therefore not applicable in this research project. However, spreadsheets monitoring should be made considering these calculations and parameters.

5. Analysis and Evaluation of Results

In the previous chapter, were made in the amounts raised beef cattle and milk for the 65ha property in Conceição de Macabu. The data analysis was based on information from four months of production and operation of the farm. From those data, Table 21 shows the forecast annual cash flow of the farm without considering depreciation, so it can be compared with the results of the NPV of culture eucalyptus, conducted year-on-year.

By calculation presented in Table 8, the average annual income derived from the operation of livestock in the region studied without considering the depreciation of R $ 176,763.30 and then the monthly income of R $ 14,730, 28.For the same scenario, considering depreciation, the average annual income is $ 1 47.209.34 and monthly income of R $ 12,267.45.

Timber production of 434.2 m^3/ha at the end of each cycle forestry, informed the prognosis of SisEucalipto, served as input to calculate the revenue from the sale of the stereo to produce coking coal, whose value is shown in Table 21 to below.

Table 21. Forecast values obtained in stereo commercialization of eucalyptus for metallurgical coal production

Production and income	Volume produced by 7-year forest cycle (m^3/ha)	Stere Value (Value provided by CEPEA)	Estimated revenue per hectare	Revenue generated by forest cycle (65ha of forest)	Revenue generated by forest cycle (1000ha forest)
Stere value (supplied by CEPEA)	434,2	R$ 50,00	R$ 21.710,00	R$ 1.411.150,00	R$ 21.710.000,00
Stere value (suggested by ArcellorMittal)	434,2	R$ 20,00	R$ 8.684,00	R$ 564.460,00	R$ 8.684.000,00

To conduct a feasibility analysis of the project, mathematical equations were used-financial, which started from a baseline projections and statistical basis, with simulations.

5.1 Net Present Value (NPV) without Carbon Credits

Through the analysis of results provided by VPL, you can identify whether the project is economically viable or not. If NPV is zero, the cash flows from the investment are all consumed to pay the cost of the capital invested. If NPV is positive, the result from the project covers the debt acquired to invest in the project and the rate of return determined by investors. Therefore, search is always a project that has positive NPV (NETO, 2006).

5.2 Calculation for 65ha Area and Value-Based CEPEA

Tables 22, 23 and 24 are the cash flows and NPV calculated for planting and felling eucalyptus charcoal to market the area to 65ha, the three cycles forest, considering the amount of stereo $ 50.00, suggested by CEPEA, and annual discount rate of 10%.

Table 22. Calculated NPV of the first cycle of eucalyptus forest for culture 65ha in area, with a value of $ 50.00 stereo

	First Forest Cycle						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Eucalyptus Planting							
Total Cost	R$ 77.949,00	R$ 20.250,00	R$ 18.900,00	R$ 17.550,00	R$ -	R$ -	R$ -
Total Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 1.411.150,00
Cash Flow	-R$ 77.949,00	-R$ 20.250,00	-R$ 18.900,00	-R$ 17.550,00	R$ -	R$ -	R$ 1.411.150,00
						Eucalyptus 1st Cycle NAV	R$ 610.358,08
						Annual NAV	R$ 87.194,01
						Monthly NAV	R$ 7.266,17

Table 23. Calculated NPV of the second cycle of eucalyptus forest for culture 65ha in area, with a value of $ 50.00 stereo

	Second Forest Cycle						
	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Eucalyptus Planting							
Total Cost	R$18.090,00	R$14.850,00	R$14.850,00	R$14.850,00	R$ -	R$ -	R$ -
Total Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 1.411.150,00
Cash Flow	-R$18.090,00	-R$ 14.850,00	-R$14.850,00	-R$14.850,00	R$ -	R$ -	R$1.411.150,00
						Eucalyptus 2nd Cycle NAV	R$ 674.125,12
						Annual NAV	R$ 96.303,59
						Monthly NAV	R$ 8.025,30

Table 24. Calculated NPV of the third cycle forestry culture eucalyptus 65ha in area, with a value of $ 50.00 stereo

	Third Forest Cycle						
	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21
Eucalyptus Planting							
Total Cost	R$18.090,00	R$14.850,00	R$14.850,00	R$14.850,00	R$ -	R$ -	R$ -
Total Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$1.411.150,00
Cash Flow	-R$18.090,00	-R$14.850,00	-R$14.850,00	-R$14.850,00	R$ -	R$ -	R$1.411.150,00
						Eucalyptus 3rd Cycle NAV	R$ 674.125,12
						Annual NAV	R$ 96.303,59
						Monthly NAV	R$ 8.025,30

5.3 Net Present Value (NPV) with Carbon Credits

In this subchapter are the calculations considering the values of marketing ton of carbon captured in the two markets REC: Market regulated by the Kyoto Protocol, in the manner pre-2012 and average values applied, and the Voluntary Market. It is here that all revenue from the sale of each REC planned for 7 years is inputted the beginning of each forest cycle. In Table 25 are simulations of revenue earned through the sale of CERs estimated in Table 20 of the previous chapter, considering an average value of $ 20.00 for the value and market price adjusted $ 3.10 for the voluntary markets, as referenced in chapter 2. The conversion rate used was U.S. $ 1.00 = R $ 2.09, extracted on 11/28/2012 Central Bank (Central Bank, 2012).

Table 25. Projected revenue obtained through marketing REC

		Value per ton of CO_2 (US$/Ton CO_2)	Area (ha)	Amount of carbon captured per hectare for each forest cycle (t CO_2/ha)	Expected value per forest cycle (US$)	Expected value per forest cycle (R$)
Regulated Market	1st Forest cycle	20	65	458,77	$ 596.401,00	R$ 1.246.478,09
		20	1000	458,77	$ 9.175.400,00	R$ 19.176.586,00
	2nd Forest cycle	20	65	498,65	$ 648.245,00	R$ 1.354.832,05
		20	1000	498,65	$ 9.973.000,00	R$ 20.843.570,00
	3rdForest cycle	20	65	498,65	$ 648.245,00	R$ 1.354.832,05
		20	1000	498,65	$ 9.973.000,00	R$ 20.843.570,00
Voluntary Market	1st Forest cycle	3,1	65	458,77	$ 92.442,16	R$ 193.204,10
		3,1	1000	458,77	$ 1.422.187,00	R$ 2.972.370,83
	2nd Forest cycle	3,1	65	498,65	$ 100.477,98	R$ 209.998,97
		3,1	1000	498,65	$ 1.545.815,00	R$ 3.230.753,35
	3rd Forest cycle	3,1	65	498,65	$ 100.477,98	R$ 209.998,97
		3,1	1000	498,65	$ 1.545.815,00	R$ 3.230.753,35

5.4 Calculation for 65ha Area, Value-Based CEPEA

Table 26 are the cash flows and NPV calculated for planting and felling eucalyptus market charcoal to the area of 65ha in the three cycles forest, considering the amount of stereo $ 50, 00, suggested by CEPEA, the annual discount rate of 10% and revenue from REC traded on Regulated Markets. This is the most optimistic scenario, since here applies the highest price per ton of carbon and also the highest value for the sale of stereo for the production of coking coal.

Table 26. - NPV calculated in three cycles forest for culture eucalyptus 65ha in area, with stereo value of $ 50.00, and revenue from REC in the regulated market

	First Forest Cycle						
	Year1	Year2	Year3	Year4	Year5	Year6	Year7
Eucalyptus Planting							
Total cost	R$ 77.949,00	R$ 20.250,00	R$ 18.900,00	R$ 17.550,00	R$ -	R$ -	R$ -
Revenue - Eucalyptus	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 1.411.150,00
Revenue CER-Regulated Market	R$ 1.246.478,09						
Cash Flow	R$ 1.168.529,09	-R$ 20.250,00	-R$ 18.900,00	-R$ 17.550,00	R$ -	R$ -	R$ 1.411.150,00

	Second Forest Cycle						
	Year8	Year9	Year10	Year11	Year12	Year13	Year14
Eucalyptus Planting							
Total cost	R$ 18.090,00	R$ 14.850,00	R$ 14.850,00	R$ 14.850,00	R$ -	R$ -	R$ -
Revenue - Eucalyptus	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 1.411.150,00
Revenue CER-Regulated Market	R$ 1.354.832,05						
Cash Flow	R$ 1.336.742,05	-R$ 14.850,00	-R$ 14.850,00	-R$ 14.850,00	R$ -	R$ -	R$ 1.411.150,00

	Third Forest Cycle						
	Year15	Year16	Year17	Year18	Year19	Year20	Year21
Eucalyptus Planting							
Total cost	R$ 18.090,00	R$ 14.850,00	R$ 14.850,00	R$ 14.850,00	R$ -	R$ -	R$ -
Revenue - Eucalyptus	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 1.411.150,00
Revenue CER-Regulated Market	R$ 1.354.832,05						
Cash Flow	R$ 1.336.742,05	-R$ 14.850,00	-R$ 14.850,00	-R$ 14.850,00	R$ -	R$ -	R$ 1.411.150,00

Regulated Market	NAVEucalyptus 1stforest cycle	***R$ 1.743.519,98***	NAV Eucalyptus 2ndforest cycle	***R$ 1.905.790,62***	NAV Eucalyptus 3rdforest cycle	***R$ 1.905.790,62***
	Annual NAV	***R$ 249.074,28***	Annual NAV	***R$ 272.255,80***	Annual NAV	***R$ 272.255,80***
	Monthly NAV	***R$ 20.756,19***	Monthly NAV	***R$ 22.687,98***	Monthly NAV	***R$ 22.687,98***

Table 27 are the cash flows and NPV calculated for planting and felling eucalyptus charcoal to market the area to 65ha, the three cycles forest, considering the amount of stereo $ 50.00, suggested by CEPEA, the annual discount rate of 10% and revenue from REC traded on voluntary markets.

Table 27. NPV calculated for the three cycles forest for culture eucalyptus 65ha in area, with stereo value of $ 50.00, and revenue in the voluntary market REC

	First Forest Cycle						
	Year 1	Year2	Year3	Year4	Year5	Year6	Year7
Eucalyptus Planting							
Total Cost	R$ 77.949,00	R$ 20.250,00	R$ 18.900,00	R$ 17.550,00	R$ -	R$ -	R$ -
Revenue - Eucalyptus	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 1.411.150,00
Revenue CER-Voluntary M	R$ 193.204,10						
Cash Flow	R$ 115.255,10	-R$ 20.250,00	-R$ 18.900,00	-R$ 17.550,00	R$ -	R$ -	R$ 1.411.150,00

	Second Forest Cycle						
	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Eucalyptus Planting							
Total Cost	R$ 18.090,00	R$ 14.850,00	R$ 14.850,00	R$ 14.850,00	R$ -	R$ -	R$ -
Eucalyptus Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 1.411.150,00
Revenue CER-Voluntary M	R$ 209.998,97						
Cash Flow	R$ 191.908,97	-R$ 14.850,00	-R$ 14.850,00	-R$ 14.850,00	R$ -	R$ -	R$ 1.411.150,00

	Third Forest Cycle						
	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21
Eucalyptus Planting							
Total Cost	R$ 18.090,00	R$ 14.850,00	R$ 14.850,00	R$ 14.850,00	R$ -	R$ -	R$ -
Eucalyptus Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 1.411.150,00
Revenue CER-Voluntary M	R$ 209.998,97						
Cash Flow	R$ 191.908,97	-R$ 14.850,00	-R$ 14.850,00	-R$ 14.850,00	R$ -	R$ -	R$ 1.411.150,00

Voluntary Market	NAVEucalyptus 1stForest Cycle	***R$ 785.998,17***	NAVEucalyptus2ndForest Cycle	***R$ 865.033,27***	NAVEucalyptus3rdForest Cycle	***R$ 865.033,27***
	Annual NAV	***R$ 112.285,45***	Annual NAV	***R$ 123.576,18***	Annual NAV	***R$ 123.576,18***
	Monthly NAV	***R$ 9.357,12***	Monthly NAV	***R$ 10.298,02***	Monthly NAV	***R$ 10.298,02***

5.5 Calculation for 65 ha Area and Value-Based Arcelor Mittal

Table 28 are the cash flows and NPV calculated for planting and felling eucalyptus charcoal to market the area to

65ha, the three cycles forest, considering the amount of stereo $ 20.00, suggested by Arcelor Mittal, the annual discount rate of 10% and revenue from REC traded on Regulated Markets.

Table 28. NPV calculated in three cycles forest for culture eucalyptus 65ha in area, with stereo value of $ 20.00, and revenue from REC in the regulated market

	FirstForest Cycle						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Eucalyptus Planting							
Total Cost	R$ 77.949,00	R$ 20.250,00	R$ 18.900,00	R$ 17.550,00	R$ -	R$ -	R$ -
Eucalyptus Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 564.460,00
Revenue CER-Regulated Market	R$ 1.246.478,09						
Cash Flow	R$ 1.168.529,09	-R$ 20.250,00	-R$ 18.900,00	-R$ 17.550,00	R$ -	R$ -	R$ 564.460,00

	SecondForest Cycle						
	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Eucalyptus Planting							
Total Cost	R$ 18.090,00	R$ 14.850,00	R$ 14.850,00	R$ 14.850,00	R$ -	R$ -	R$ -
Eucalyptus Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 564.460,00
Revenue CER-Regulated Market	R$ 1.354.832,05						
Cash Flow	R$ 1.336.742,05	-R$ 14.850,00	-R$ 14.850,00	-R$ 14.850,00	R$ -	R$ -	R$ 564.460,00

	ThirdForest Cycle						
	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21
Eucalyptus Planting							
Total Cost	R$ 18.090,00	R$ 14.850,00	R$ 14.850,00	R$ 14.850,00	R$ 14.850,00	R$ -	R$ -
Eucalyptus Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 564.460,00
Revenue CER-Regulated Market	R$ 1.354.832,05						
Cash Flow	R$ 1.336.742,05	-R$ 14.850,00	-R$ 14.850,00	-R$ 14.850,00	R$ -	R$ -	R$ 564.460,00

Regulated Market	NAVEucalyptus1stForest Cycle	***R$ 1.309.034,13***	NAVEucalyptus2ndForest Cycle	***R$ 1.471.304,77***	NAVEucalyptus3rdForest Cycle	***R$ 1.471.304,77***
	Annual NAV	***R$ 187.004,88***	Annual NAV	***R$ 210.186,40***	Annual NAV	***R$ 210.186,40***
	Monthly NAV	***R$ 15.583,74***	Monthly NAV	***R$ 17.515,53***	Monthly NAV	***R$ 17.515,53***

Table 29 are the cash flows and NPV calculated for planting and felling eucalyptus charcoal to market the area to 65ha, the three cycles forest, considering the amount of stereo $ 20.00, suggested by Arcelor Mittal, the annual discount rate of 10% and revenue from REC marketed in Voluntary Markets.

Table 29. NPV calculated in three cycles forest for culture eucalyptus 65ha in area, with stereo value of $ 20.00, and revenue in the Voluntary Market REC

	Ano 8	Ano 9	Ano 10	Ano 11	Ano 12	Ano 13	Ano 14
Plantio de Eucalipto							
Total de Custos	R$ 18,090.00	R$ 14,850.00	R$ 14,850.00	R$ 14,850.00	R$ -	R$ -	R$ -
Receita - eucalipto	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 564,460.00
Receita REC-Mercado Voluntirio	R$ 209,998.97						
Fluxo de Caixa	R$ 191,908.97	-R$ 14,850.00	-R$ 14,850.00	-R$ 14,850.00	R$ -	R$ -	R$ 564,460.00

	Terceiro Ciclo Florestal						
	Ano 15	Ano 16	Ano 17	Ano 18	Ano 19	Ano 20	Ano 21
Plantio de Eucalipto							
Total de Custos	R$ 18,090.00	R$ 14,850.00	R$ 14,850.00	R$ 14,850.00	R$ -	R$ -	R$ -
Receita - eucalipto	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 564,460.00
Receita REC-Mercado Voluntirio	R$ 209,998.97						
Fluxo de Caixa	R$ 191,908.97	-R$ 14,850.00	-R$ 14,850.00	-R$ 14,850.00	R$ -	R$ -	R$ 564,460.00

Mercado Voluntário	VPL Eucalipto 1o ciclo florestal	R$ 351,512.33	VPL Eucalipto 2o ciclo florestal	R$ 430,547.43	VPL Eucalipto 3o ciclo florestal	R$ 430,547.43
	VPL Anual	R$ 50,216.05	VPL Anual	R$ 61,506.78	VPL Anual	R$ 61,506.78
	VPL mensal	R$ 4,184.67	VPL mensal	R$ 5,125.56	VPL mensal	R$ 5,125.56

tabela 29

	FirstForest Cycle						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Eucalyptus Planting							
Total Cost	R$ 77,949.00	R$ 20,250.00	R$ 18,900.00	R$ 17,550.00	R$ -	R$ -	R$ -
Eucalyptus Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 564,460.00
Revenue CER-Voluntary Market	R$ 193,204.10						
Cash Flow	R$ 115,255.10	-R$ 20,250.00	-R$ 18,900.00	-R$ 17,550.00	R$ -	R$ -	R$ 564,460.00

	SecondForest Cycle						
	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Eucalyptus Planting							
Total Cost	R$ 18,090.00	R$ 14,850.00	R$ 14,850.00	R$ 14,850.00	R$ -	R$ -	R$ -
Eucalyptus Revenue	R$ -	R$ -	R$ -	R$ -	R$ -	R$ -	R$ 564,460.00
Revenue CER-Voluntary Market	R$ 209,998.97						
Cash Flow	R$ 191,908.97	-R$ 14,850.00	-R$ 14,850.00	-R$ 14,850.00	R$ -	R$ -	R$ 564,460.00

This is the best scenario, since here applies the lower the price per ton of carbon and also the lowest value for the sale of stereo for the production of coking coal.

5.6 Evaluating the Results Properly Said

The calculations presented in the previous subchapter are considering 3 variables:

- Area for the planting of 65 ha or 1000 HA;
- Value stereo eucalyptus wood stand, with data from the CEPEA and Arcelor Mittal;
- Value applied to a ton of carbon captured in Regulated Markets and Voluntary.

Table 30 summarizes the analysis performed in this section.

Table 30. NPV calculated in three cycles forest for culture eucalyptus associate of the REC market planted on a 65ha farm

	Suggested Stere value	Monthly NAV 65ha without REC	Monthly NAV 65ha withCER–Regulated Market	Monthly NAV 65ha withCER–Voluntary Market
CEPEA	R$ 50,00	R$ 8.025,30	R$ 22.687,98	R$ 10.298,02
Arcelor Mittal	R$ 20,00	R$ 2.852,85	R$ 17.515,53	R$ 5.125,56

Thus, the estimate is more economically aggressive to plant eucalyptus in order to market the production of coking coal, considering the price suggested by CEPEA stereo and sale of REC in the Regulated Market.

6. Conclusion and Suggestion for New Research

All calculations made show that all options resulting from combinations of the variables showed positive values of NPV. Eucalyptus plantations to meet demand for coking coal generation without considering the sale of REC, in itself shows a profitable operation.

Taking up by analyzing the different NPV results for each combination made for planting in the area of 65 ha, Table 30, compared with the average revenue of Table 21, divided into two studies:

- Average revenue livestock without considering the depreciation of R$14,730.28;
- Average revenue of ranching considering depreciation of R$ 12,267.45.

For both cases, only the planting of eucalyptus shows not bring economic advantage to that get with livestock, comparing cash flows. However, in adding up the revenues obtained by the sale of REC in the regulated markets of U.S. $ 22,678.98 to U.S. $ 17,515.53, which provides a considerably higher value in the sale of carbon credits compared to the voluntary markets, R$10,298.02 to R$5,515.56, brings an economic-financial advantage when adopting this strategy in increasing the income of small producers. In bringing up the revenue from the sale of REC start of each forest cycle, income is sufficient for the cultivation of livestock can be stopped without causing harm to the producer.

In considering the specific nature of this research, the following are some suggestions of related work that could increase knowledge about the subject studied here, such as expanding the model studied here researching up on creating a cooperative of producers of eucalyptus; study creation of an association of coal for generation of steel near the region studied; analyze the logistics network in the region and suggestions for new adaptations in various modes to meet the production flow of wood to the charcoal and charcoal production undertaken by steelmakers and finally find similar solutions outside Brazil so that we can assess whether the cultures of other countries use different criteria.

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