OILSEED ACTIVITY AND CLIMATE CHANGE LINKAGES: FAMILY FARMING CASES FROM NORTHERN BRAZIL

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ABSTRACT: The biofuel production has been strongly discussed in Brazil, leading the country to develop policies and implement, in 2004, a biodiesel program (PNPB) in order to promote rural and regional development. Based on this, the present study aims to assess the linkages between the oil seed activity and climate change, especially regarding the deforestation of native forests. Thus, a cross sectional study was conducted with small-scale farmers in Tocantins state, located in the Brazilian Legal Amazon Region. The survey was conducted in 2008 and comprises a range of socio-economic and environmental indicators, which were collected among smallholders who cultivate *Ricinus Communis* and *Jatropha curcas* oil seeds. Aiming at having more accuracy in the assessment of the linkages, REDD plus project analyses were also performed in the study. Results point toward a positive relationship between oil seed production and deforestation of native forests, which might then, aggravates climate change.

KEYWORDS: Oilseeds; Family farming; Climate change

RESUMO: A produção de biocombustíveis tem sido fortemente discutida no Brasil, levando o País a desenvolver políticas e implantar, no ano de 2004, o Programa Nacional de Produção e Uso de Biodiesel (PNPB), a fim de promover o desenvolvimento rural e regional. Neste contexto, o presente estudo busca avaliar a relação entre a atividade do cultivo de oleaginosas e as mudanças climáticas, especialmente no que diz respeito ao desmatamento de florestas nativas. Um estudo transversal foi realizado com agricultores no Estado do Tocantins, localizado na Região da Amazônia Legal Brasileira. O estudo foi realizado em 2008 e compreende uma gama de indicadores socioeconômicos e ambientais que foram coletados junto aos agricultores que cultivam pinhão manso e mamona. Para obter uma análise mais acurada das relações, análises de projetos REDD plus foram realizadas no estudo. Os resultados mostram uma relação positiva entre a produção de oleaginosas e o desmatamento de florestas nativas, o que pode agravar as mudanças climáticas.

PALAVRAS-CHAVE: Sementes oleaginosas; agricultura familiar; mudanças climáticas

1. INTRODUCTION

Tropical forests are continuing to disappear at an alarming rate: between 1990 and 2005, the rate of deforestation averaged about 13 million hectares a year, occurring mostly in tropical countries. Moreover, deforestation and forest degradation, mainly through conversion to pastureland, infrastructure development, and destructive logging and fires, account for nearly 20% of global greenhouse gas emissions (GHG). This is more than the entire global transportation sector and second only to the energy sector (IPCC, 2007). These trends are a result of land use change, mainly the expansion of agricultural land, which is in turn closely connected to the conditions of rural livelihoods, increasing demands for food, feed and fiber and, more recently, bioenergy (FAO/ UNDP/ UNEP, 2009; FAO, 2008c).

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Bioenergy production affects the environment at local and global levels, impacting land and water resources, biodiversity and the climate. Although there are environmental impacts throughout the production chain – feedstock production, conversion and use – most impacts occur in the feedstock production stage and mirror those related to agricultural production in general. When land with high carbon content, such as, forest or peat land, is converted to biofuel production, for instance, the immediate resulting carbon balance is negative. With conversion, "carbon debts" are created that could take decades or even centuries to "repay" (FARGIONE *et al.*, 2008; SEARCHINGER *et al.*, 2008). In addition, a comprehensive carbon balance assessment must take into account "indirect" land-use change, which refers to emissions from lands in which biofuel feedstock replaces food crops (FRONDEL & PETERS, 2007; FAO, 2008a; FAO, 2008b).

While biofuels will only offset a modest share of fossil fuel energy use over the next decade, they will have much bigger impacts on agriculture and climate change. Allocating land to biofuel production means taking land away from other uses, such as, food or environmental preservation. The conversion of such lands to crop production will release carbon, which is sequestered in the soil, into the atmosphere, offsetting some of the carbon benefits of a renewable energy, like biofuels (RAJAGOPAL & ZILBERMAN, 2007; FAO, 2008d).

Based on the discussion above, the present study aims to assess the impacts of small-scale oil seed production in the native biome. For this purpose, an estimation of CO_2 (carbon dioxide) emitted due to deforestation of Brazilian Savannah (Cerrado) was done and REDD plus analyses were performed to estimate the economic yields by farmers through environmental services payment.

2. RESEARCH AREA AND METHODOLOGICAL ASPECTS

The research was carried out in Tocantins State, located in northern Brazil in a region well known as Brazilian Legal Amazon. The State is situated in a transition area, presenting climate and vegetation from Amazon rain forest (15% of the territory) and Cerrado (85% of the territory). This transition area, so-called Ecotone zone, is the home to traditional communities (family agriculture, indigenous, as well as, quilombolas) and comprises rich biodiversity, which is responsible for numerous environmental services. For this reason, scientific studies and research in the area are extremely important. Often they are focused on understanding the different farming systems and their connections to the local economy and the very diverse environment.

Data collection necessary to create the database was formed through a comprehensive survey, which was carried out between April and September 2008 in two sub-study regions within Tocantins State. In one sub-study region, *Ricinus* *communis* (castor bean and also well known as mamona in Brazil) oil seed cultivated and in the other sub study-region *Jatropha curcas* (well known as pinhão manso in Brazil) is cultivated. Specific questionnaires were applied to smallholders, who were randomly selected: 27 in the case of *Jatropha curcas* producers; and 25 in the case of *Ricinus communis* producers. It is important to highlight that the selection of smallholders followed statistical procedures and that the sample can be considered representative since it comprises more than 90% of small-scale oil seed producers in the region in question. Parametric as well as non-parametric tests were used to demonstrate the statistical differences among the smallholders and the software STATA was used to support the statistical analysis.

3. RESULTS AND DISCUSSION

3.1. Impacts on climate change

When inquired about the deforestation of native forests in order to cultivate oil seeds, 6 families (24%) in the *Ricinus communis* group (RC) and 7 families (25.9%) in the *Jatropha curcas* group (JC) responded positively, i.e. they have cut down the forest in order to start oil seed production. At first glance, these figures are not impressive, since roughly 75% of the remaining families have not deforested the biome to produce oil seeds. However, when taking into account the environmental services provided by native forests, especially the carbon sequestration and storage, this perspective might change.

Table 1 below demonstrates the quantity of carbon storage, per hectare, as well as, the carbon sequestered, per hectare per year, for Cerrado '*stricto sensu*' and Ecotone zone. It is important to mention that families in JC group are located in the Ecotone zone, i.e. the transition area between Cerrado and Amazon rain forest, which comprises vegetation from both biomes.

Table 1. Carbon storage and carbon sequestered of Cerrado and Ecotone zone

Biome	Carbon storage ($Mg\ CO_2\ ha^{-1}$)	Carbon sequestered ($Mg\ CO_2\ ha^{-1}\ y^{-1}$)
Cerrado	45*	3.86 up to 7.2**
Ecotone zone	112.5*	2.74 up to 5.4**

Source: * adapted from Fearnside (2006), and Fearnside and Barbosa (2003).
** adapted from Finco *et al.* (2006), and Rezende (2000).

Note: figures are in CO_2 equivalent, the international measure for GHG emissions. 1 Mg is equivalent to 1 metric ton.

The Ecotone zone includes species from both Cerrado and Amazon rain forest and, therefore, has more capacity to store carbon when compared to Cerrado '*stricto sensu*'. Even though the latter has a higher capacity to sequester carbon from the atmosphere. The range of carbon sequestration values reflects the fact that entire process depends on several natural conditions, such as, humidity, quantity of rain and sun. As illustrated in Table 2, families in RC group deforested 0.50 hectare, on average, of Cerrado due to the oil seed activity and, therefore, released roughly 22.50 Mg CO_2 in the atmosphere. In the case of JC group, families deforested 0.72 hectare, on average, of Cerrado and emitted 81.00 Mg CO_2 to the atmosphere.

Table 2. Total area of Cerrado and Cerrado deforested due to oil seed activity

Area (hectares)	*Ricinus communis* Producers		*Jatropha curcas* Producers		
	Mean	SE	Mean	SE	*p*-value
Cerrado	4.26	1.17	9.25	1.25	< 0.00
Cerrado deforested	0.50	0.23	0.72	0.24	0.67

Source: research results (2009).
Note: SE = standard error of the mean.
Mann-Whitney test was applied to check statistical differences between means.

However, in the aggregate, i.e. considering all smallholders in the group (RC and JC), the results show that roughly 12.5 hectares of native forests were cut down in the case of *Ricinus communis* producers and 19.5 hectares in the case of *Jatropha curcas* producers group. Therefore, families who produce *Ricinus communis* emitted more than 562 Mg CO_2 into the atmosphere and families who produce *Jatropha curcas* released 2193 Mg CO_2. Moreover, since the native forest was cut down, between 48 Mg and 90 Mg CO_2 y^{-1} of carbon sequestration is lost in the case of RC producers and 53 Mg and 105 Mg CO_2 y^{-1}, in the case of JC producers, i.e. families are emitting GHG to the atmosphere and at the same time are avoiding carbon sequestration. In this context, the production of oil seeds in the region in question began with a carbon debt, since the activity started vis-à-vis deforestation of native forests.

In addition to the impacts on climate change, forests also provide a range of ecosystem services, such as; water storage, increased rainfall, nutrient recycling, biodiversity and soil stabilization, and can help with flood control and boost agricultural productivity. Thus, the deforestation of native biomes due to oil seed activity generates many negative environmental consequences, even at the risk of species extinction since the entire chain of environmental services is compromised.

3.2. Payment for environmental services

The value of afforestation was internationally recognized in 1997, when it was included in the Kyoto Protocol agreement on global action to reduce the risk of human induced climate change. Historically, decreasing deforestation and forest degradation has been absent from international negotiations mainly because of difficulties in monitoring (FAO, 2008a). Despite this previous shortfall in policy, REDD plus (Reducing Emissions from Deforestation and Forest Degradation) was created, in which developing countries are given incentive to reduce deforestation and forest degradation. In this way, carbon stored in forests is given a monetary value and, thus, supports developing countries in investing in low carbon paths to sustainable development (VERCHOT and PETKOVA, 2009).

If cost-efficient carbon benefits can be achieved through REDD plus, CO_2 concentration increase could be slowed, effectively buying much needed time for countries to move to low emission technologies. Support of efforts to reduce emissions from deforestation and forest degradation have been expressed at the highest political levels (G8, UN General Assembly) and have been included in the Bali Action Plan of the United Nations Framework Convention on Climate Change (UNFCCC, 2009). In addition, during the last UNFCCC Conference of the Parties (COP 15) held in Copenhagen in December 2009, countries such as Australia, France, Japan, Norway and the United States of America, collectively dedicated around US$3.5 billion on fast-start climate change financing for REDD plus over the 2010 to 2012 period.

Although REDD plus is not yet formally established in the UNFCCC framework, some REDD plus credits are already being sold in voluntary markets and some initial finance is provided for pilot projects. The World Bank's Forest Carbon Partnership Facility, for instance, includes a readiness mechanism to help governments participate in REDD plus. In particular, it helps developing countries estimate their forest carbon stocks, establish national reference scenarios, calculate opportunity costs, and design monitoring, reporting and verification systems (UNFCCC, 2009). Therefore, as land use change in the tropics is usually driven by people trying to maximize their economic gain, the farmers will also choose the most profitable option available. If REDD plus is to work as a real financial incentive, it must be robust enough to compete with other potential land uses. In this context, a country could accrue, for each hectare of forest saved from deforestation, a certain amount of money and use this number to compare the opportunity cost of using the land for agricultural purposes (SCHLAMADINGER *et al.*, 2004; SCHLAMADINGER *et al.*, 2005).

Based on the discussion above, as the 'forest standing' has no economic value to the smallholders, their opportunity costs might lead towards deforestation. A 'win-win' approach could be achieved by paying farmers to sequester carbon, which sets up a situation where: CO_2 is removed from the atmosphere (mitigation); high soil organic matter increases agro ecosystem resilience (adaptation); and improved soil fertility leads to better yields (production and income generation). If a carbon market successfully allows the trade of sequestered carbon on the international market, deforestation of native forests in tropical countries might decrease. If deforestation is business-as-usual (or the baseline scenario), then the conservation of native forests by farmers would implement change and generate additional positive externalities. Thus, REDD plus project would create a stimulus for the conservation of native forests and increase the amount of carbon sequestered and, therefore, decrease the amount of carbon that is emitted to the atmosphere (figure 1).

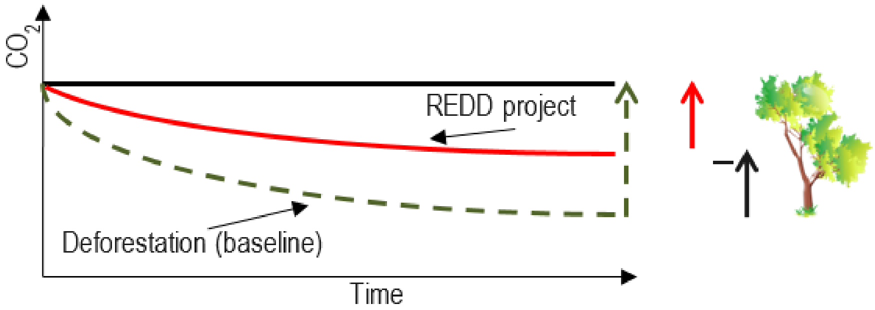

Figure 1. Differences on carbon sequestration due to the baseline (deforestation) and the REDD project (preservation) over the years.

Note: The difference between the CO_2 sequestered in the baseline and the CO_2 sequestered due to the REDD project is the so-called "additionality".

Nevertheless, the REDD plus project implemented and which will pay for environmental services, should adhere to certain prerequisites, such as, guaranteeing a reduction in GHG emissions compared to the baseline scenario (NEPSTAD *et al.*, 2007; JÜRGENS *et al.*, 2004). Once the REDD plus project is implemented additional positive externalities are generated and payment for environmental services can be made. The REDD plus project will most likely lead to a decrease in smallholder opportunity costs and increase the ability to maintain conservation practices. Even after the official commitment to reduce deforestation, in Amazon and in Cerrado, made by the Brazilian government during the 15th Conference of the Parties (COP 15) in Copenhagen, it is believed that the implementation of REDD plus project, which focuses on rewarding farmers through payment for environmental services, is a *sine qua non* condition to slow, halt or eventually reverse deforestation in Brazil.

Considering the low and high carbon sequestration rates according to Table 1 and the low and high prices of carbon credits (US$4 and US$10 per ton, respectively), one observes that according to the best/optimistic scenario, the yields earned by families in the RC group are around US$87 ha^{-1} y^{-1} or R$174 (Brazilian reais) ha^{-1} y^{-1}, and US$91.50 ha^{-1} y^{-1} or RS$183 (Brazilian reais) ha^{-1} y^{-1} by families in the JC group. In order to better compare the yields from the REDD plus project and yields from farm activities, Table 3 shows the gross margin values, per year and per hectare, of different farm activities carried out by the same farm families.

As one can observe in the table 3, even considering the best scenario of REDD plus project and, therefore, environmental services payment, conservation only has better economic returns when compared to bean cultivation in the both RC and JC groups. With the aim of visualizing the breakeven point, where the value of carbon credit generated by the REDD plus project will surpass the economic returns of other farm activities, simulations were produced. The results point out that: (a) for the RC group, US$12 per t CO_2 will be enough to surpass rice activity, US$20 per t CO_2 will be enough to surpass maize activity and only a carbon credit with a value above US$20 will surpass cassava activity; (b) for the JC group, US$12 per t CO_2 will be enough to surpass rice activity, US$15 per t CO_2 will be enough to surpass maize activity and only carbon credits with a value higher than US$50 will be enough to surpass cassava activity in this group.

Table 3. Gross margin for feedstock and REDD plus yields (R$/hectare/year)

Items	***Ricinus communis producers***		***Jatropha curcas Producers***		
	Mean	**SE**	**Mean**	**SE**	***p-value***
Rice	184.44	149.18	209.52	70.22	0.77
Maize	322.03	69.87	231.21	35.19	0.62
Cassava	356.04[a]	120.47	918.71[b]	789.55	< 0.00
Bean	149.50[a]	47.80	26.17[b]	6.02	< 0.00
REDD plus	174.00	-	183.00	-	

Notes: SE = standard error of the mean.
Different letters show significant difference between means according to Mann-Whitney Test.

However, as the economies of scale are an important issue in projects, such as, CDM and REDD plus, it is useful to simulate not the yields per hectare, but also the economic returns considering the total area of native forests in both groups. In this context, as a family in RC has, on average, 4.26 hectares of Cerrado, the total yield generated by the REDD plus project is R$741.24 per year, which is enough to surpass any other farm activity. In the case of families in JC group, the trend is similar and the yields are even higher. As families have, on average, 9.25 hectares of Cerrado, the total yield is R$1629.75 per year, which also surpass any other farm activity carried out by the families. So, in order to maintain the oil seed activity, as well as other crops without negative impacts on native forests, REDD plus projects should be fostered in the region in question.

4. CONCLUSIONS

Bioenergy and, especially, biodiesel is considered a renewable source of energy not only in Brazil, but also internationally. However, its production might be occurring without much needed caution, especially regarding negative impacts on climate change and on local food security. As presented in this paper, the oil seed production related to *Jatropha curcas* and *Ricinus Communis* has led to a land use change in a way that native forests are being cut down to produce oil seeds. This is especially due to the high opportunity cost of standing forests, as they currently generate no economic value.

Results suggest that the small-scale oil seed production in the region in question began with a carbon debt, since the activity was started up vis-à-vis the deforestation of the native forests. An alternative option could be the implementation of REDD plus or other projects, which encourage the reduction of emissions from deforestation and forest degradation in developing countries. These projects focus on diminishing smallholder opportunity costs through an exchange of payment for environmental services. At COP 15 in Copenhagen, the government of Brazil indicated the nationally appropriate mitigation actions that Brazil intends to take to slow GHG emissions within the country, such as, the reduction in Amazon and Cerrado deforestation. Nevertheless, we strongly suggest that REDD plus projects be fostered in the region in question as an instrument for native forests preservation, while concurrently providing an alternative source of income to small-scale farmers.

As the present study focuses only at family level in a specific region, we suggest that the study should be continued with larger sample and in the same or in other areas to get a more representative result. In addtion, other studies should be carried out considering the biodiesel production at regional and national levels with the aim of attaining a broader idea of the biodiesel production in Brazil.

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