Brazilian Biodiesel Program and its impacts on income and food security of family farmers: cases from the Amazon Region

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Abstract

Biofuel production has been a greatly discussed topic in Brazil. In 2004, these debates lead the country to develop new policies and implement a national program for biodiesel use and production (PNPB) with the intent to increase the share of renewable energy and foster rural development. In this context, the present study aims to assess the impacts of small-scale oil seed production on the income generation of local farms, and on food production. For this purpose, a cross sectional study was conducted with family farms in the Tocantins state, in a region of transition between Cerrado and Amazon rain forest. Ranges of socio-economic indicators were collected among smallholders who cultivate *Jatropha curcas* and *Ricinus communis*. The preliminary results point toward a negative relationship between oil seed activity and local food production, which then aggravates local food insecurity. In addition, farm income, due to oil seed activity, is lower than with other conventional crops, such as, maize and cassava, for instance. This research is unprecedented in the region and the results can be extremely effective in supporting regional and national government subsidies on clean energy that does not harm the food production; helping Brazil achieve the regional sustainable development.

Keywords: biodiesel; farm income, food security; Brazil.

1. Introduction

The global concern for the depredation and exhaustion of natural resources has led governments and scientists around the world to identify alternatives and solutions to the problem. Since the beginning of 21st century, an international debate has taken shape, which is currently discussed at 10 out of 10 meetings on sustainable development around the world: biofuels and its pros and cons (DUBOIS 2008, FAO 2008a, FAO 2008b). From a socio-economic point of view, biofuels can positively impact rural development and diversify the utilization of the local environment. For example, enhancing rural space multi-functionality, where farms are used not only for crop production, but also eco tourism and, of course, generating strategies that reduce and alleviate poverty, so-called 'pro-poor' strategies [FAO 2008c, FAO 2008d, UN-Energy 2007).

Despite of the numerous advantages, some questions have been raised regarding the possible negative externalities generated by biofuel production. These include the decrease in local food production and supply, as well as, negative impacts on environmental services and climate change (FAO 2008a). Regarding the food supply issue, for instance, the main concern is that biofuels may compete with food crops. This competition for land becomes an issue especially when some of the crops (e.g. maize and soybean), which are currently cultivated for food and feed, are redirected towards the production of biofuels. As food-oriented agricultural land is converted to biofuel production, significant negative impacts on food security can be observed, the so-called "food versus fuel" debate (FAO 2008, PINGALI et al. 2008, COTULA et al. 2008).

Moreover, one of the main disadvantages of biofuels is that they can be a threat to regional biodiversity and the climate. This is especially observed through the deforestation of native biomes, such as, Cerrado and rain forests, and the impact of introducing invasive species for biofuel production. Land use changes associated with expanded biofuel production can have major impacts. By converting forestland to biofuel crops or agricultural crops to biofuel feed stocks, large quantities of carbon are released that would take years to recover through the emission reductions achieved by substituting biofuels for fossil fuels.

Therefore, in 2004, Brazil launched a biodiesel program, the National program of biodiesel use and production (PNPB), which is based on a scenario of high oil prices, a growing demand for fuels from renewable sources, and the country's comparative advantage in natural resources (NASS et al. 2007). Moreover, the PNPB has several specific objectives, such as, reducing the import of diesel. Brazil would increase its independence, increase the share of renewable energy on the National energy matrix, foster rural development and increase the share of small-scale farmers in the biodiesel chain through social inclusion by implementing PNPB (PNPB 2005).

Regarding Food and Nutrition Security (FNS), Brazil has significantly advanced on this topic. During the II CNSAN (National Conference of Food and Nutrition Security) in 2004 (II CNSAN 2004), under a participatory process, a Brazilian definition of "Food and Nutrition Security" was established and a specific policy for the country was designed, both of which consider sustainable development, as follows:

"Food and Nutrition Security is the achievement of the right to all people to access food regularly and permanently, with enough quality and quantity, without compromise the access to other basic needs, based on food practices to promote health, with respect to cultural differences and being social, economic and environmentally sustainable."

Based on this definition, it is clear that FNS is connected to sustainable development, as well as, all other issues related to its achievement. Social inclusion and income generation, which can promote access to food, is also included in the FNS debate and policies. Not least, the preservation of biodiversity is essential to assure sustainability and, therefore, is also included in food and nutrition security in Brazil. It is not possible or advisable to remove one of the above-mentioned topics based on the Brazilian guidelines for FNS. In addition, it is important to mention that the III CNSAN (2007) (III CNSAN 2007) concluded that an increase in biofuels cannot interfere with internal food production and must promote the generation of income for farmers. Also, actions on FNS should follow an interdepartmental and interdisciplinary approach, as the PNPB can also be considered an interdepartmental initiative.

However, now 7 years since its implementation, the impacts of the Brazilian biodiesel program remain uncertain, especially regarding local food and nutrition security and regional sustainable development. Thus, the present study aims to analyze the relationship and links between the small-scale oil seed production and the impacts on farm income generation and on local food production. The present study should support the regional and national governments in improving the PNPB and food and nutrition security targets. Moreover, the results presented can play an important role in integrating efforts to consolidate a new economic alternative for the small-scale farmers without harming local food production.

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) (IBAMA 2007). 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.

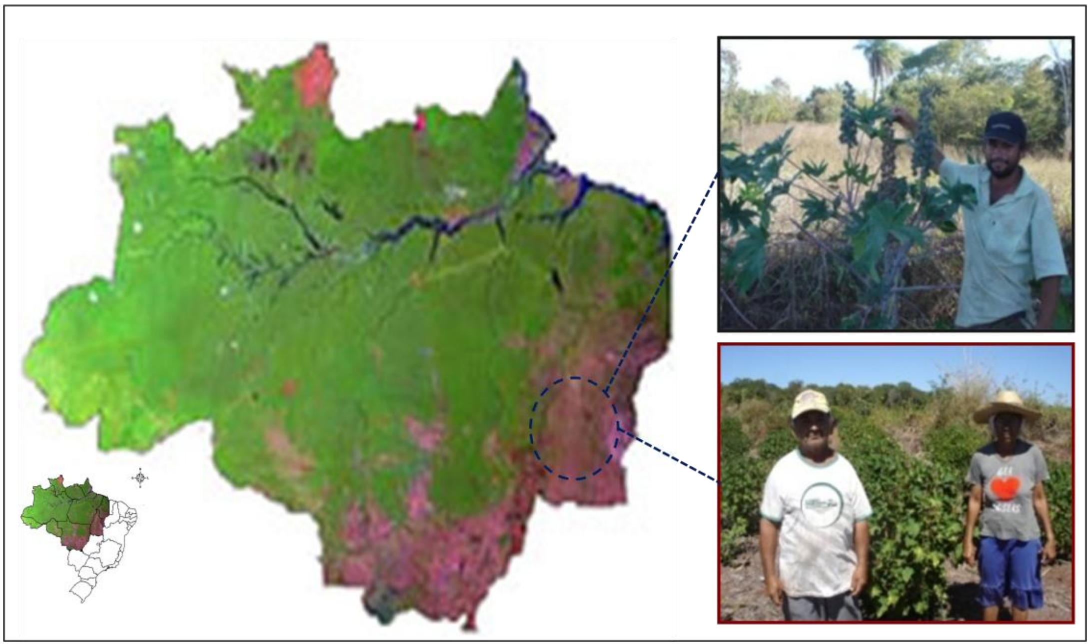

Figure 1: Research area within the Brazilian Legal Amazon region

3. Results and discussion

3.1 Food production and impacts on food security

The food security of local communities is affected by the relationship between oil seed activity and food production. Therefore, it is necessary to present, *ex ante*, an overall picture of the total food consumption by families, as well as, the quantity of food produced by them. This picture is important since it approximates of the quantity of food produced within the rural property and the quantity that must be purchased at the market. In this context, Table 1 focuses on the most produced and consumed feedstock of local families.

Table 1: Amount of food consumed by families, per year

Quantity (kg)	***Ricinus communis* Producers**		***Jatropha curcas* producers**		*p*-value
	Mean	SE	Mean	SE	
Total amount of rice consumption	276.80	26.43	204.44	9.09	0.06
Rice from the property	36.80	14.03	71.85	10.65	0.09
Total amount of bean consumption	87.36	9.28	78.22	6.84	0.34
Bean from the property	8.16	3.25	9.18	5.70	0.07
Total amount of cassava consumption	417.60	4.21	415.55	4.41	0.21
Cassava from the property	112.80	26.22	294.81	29.38	< 0.00

Source: research results (2010).

Notes: SE = standard error of the mean.

Mann-Whitney test was applied to check the differences between means ($p < 0.05$).

As one can notice in Table 1, families in both groups (*Ricinus communis* and *Jatropha curcas*, RC and JC, respectively) have to buy a considerable part of the consumed food at local markets: 86% of rice, 90% of bean and 73% of cassava has to be purchased by smallholders in the RC group; and 65% of rice, 88% of bean and 29% of cassava has to be purchased by smallholders in the JC group. This demonstrates that families depend on local markets to fulfill their needs, i.e. relying only on self-production is not sufficient to feed the family and, therefore, families in the region in question can be considered as food net buyers.

In addition, when asked about the area used to cultivate oil seeds, 11 families (44%) in RC group and 15 families (55.6%) in JC group responded they have changed the land use from an ordinary feedstock cultivation, such as, maize, rice, cassava to *Ricinus* and *Jatropha* production, respectively. Table 2 illustrates that at least 27% of the feedstock area in the RC group and 47% in JC group has been changed to the oil seed activity.

Table 2: Total crop area and land changed to oil seed activity

Hectares	***Ricinus communis* producers**		***Jatropha curcas* producers**		
	Mean	SE	Mean	SE	*p*-value
Total crop area	2.66	0.63	2.87	0.51	0.44
Area changed to oil seed activity	0.74	0.20	1.37	0.26	0.08

Source: research results (2010).

Notes: SE = standard error of the mean.

Mann-Whitney test was applied to check the differences between the means ($p < 0.05$).

In addition to the figures presented in Table 1 and Table 2, when families were inquired about food shortage during the year, 56% of smallholders in RC group responded positively, i.e. they suffer, in some level, of food deficit during the year, against 25.9% of smallholders in JC group whom responded similarly. Besides the difference in the figures, one can be assured that at least one fourth of the families in JC group face deficits on food consumption and what is more serious, more than a half of the families in RC group have to cope with food shortage during the year. These results raise an important question in the context of food rights and highlight the ongoing discussion about the effect of biofuels on food insecurity. Table 3 shows the relationship between oil seed activity and feedstock land converted oil seed production from two different scenarios. The first scenario (scenario A) is established based on the current land used, on average, to produce the main feedstock, such as, rice, maize, bean and cassava.

This scenario reflects the current situation, i.e. the situation after the adoption of oil seed activity by families. In addition, the current production of feedstock, on average, is also presented for each group: RC and JC, respectively. The second scenario (scenario B) represents a situation where families did not adopt oil seed activity. Here the estimation was based on all land that was used previously to produce feedstock, i.e. available land before the adoption of oil seed activity. Again, the potential production of feedstock, on average per family, is presented and one can observe the differences, expressed by Δ%.

Table 3: Area and production scenarios with and without the oil seed activity

Activity	***Ricinus communis* producers**					***Jatropha curcas* producers**				
	Scenario A		Scenario B			Scenario A		Scenario B		
	Mean	SE	Mean	SE	Δ%	Mean	SE	Mean	SE	Δ%
Area (ha)										
Rice	0.30	0.11	0.58	0.14	48.2	1.14	0.19	1.55	0.21	26.4
Maize	1.14	0.27	1.24	0.27	8.0	1.05	0.17	1.53	0.22	31.3
Bean	0.46	0.14	0.62	0.20	25.8	0.40	0.08	0.40	0.08	0
Cassava	0.38	0.11	0.58	0.18	34.4	0.72	0.12	1.20	0.24	40.0
Production (kg)										
Rice	220.80	104.76	363.60	146.39	39.2	688.88	147.77	835.55	139.72	17.5
Maize	1022.00	251.59	1185.33	288.39	13.7	742.61	117.79	1125.03	141.20	33.9
Bean	50.66	19.84	61.33	21.33	17.4	9.56	2.50	9.56	2.50	0
Cassava	157.06	79.78	299.06	170.55	41.7	607.90	172.92	970.86	225.37	37.3

Source: research results (2010).

Notes: SE = standard error of the mean.

Scenario A = current production after the land use change due to adoption of oil seeds activity.

Scenario B = potential production if the oil seeds activity was not adopted and therefore there was no land use change.

In 2007 the Brazilian Ministry of Agrarian Development (MDA) published a report on the implementation of the biodiesel program and stated that there is no risk of a competition between the production of biodiesel and food, for the following reasons: (i) oil need for biodiesel is grown through oil crops and results in unused fiber, that can serve as animal feed or natural fertilizer and ; (ii) the cultivation of primary materials tends to occupy soils of less economic interest or during periods between the main crops (MDA 2007). However, as illustrated in Table 3, there was a conversion of land to oil seed production from all four feedstock production areas analyzed, especially regarding rice and cassava in the case of RC group (48.2% and 34.4%, respectively), and cassava and maize in the case of JC group (40% and 31.3%, respectively).

These outcomes clearly demonstrate land use change towards oil seed production. These figures are also corroborated by the final feedstock production, per family per year. When one compares the two scenarios, one can observe that the food produced by families, on average, decrease vis-à-vis the adoption of the oil seed activity. As the Table shows, roughly 42% less cassava and 39.2% less rice are produced by families in RC group due to the oil seed activity; and roughly 37% less cassava and 33.9% less maize are produced by families in JC group also due to the oil seed activity, which increases food insecurity of households in the region in question. Considering the farmers in the region in question as food net buyers, a decrease on family income could aggravate the lack of access to food, which also could lead to a food and nutrition insecurity situation or even aggravate the situation of those families that already are under a food insecurity condition[1].

[1] According to the PNAD (Brazilian national household survey) carried out in 2004 (IBGE 2004) roughly 50% of Brazilian rural families are under a certain level of food insecurity. Based on this, in another research carried out by our scientific group involving two rural communities in Tocantins State, around 84% of families were diagnosed with a mild level of food insecurity (data not shown). This figure calls the attention to the fact that programs, either governmental or not, that aim to fulfill social goals

3.2 Economic returns of oil seed production

In addition to the analysis on the impacts of oil seed activity on local food production, it is also important to understand the economic impacts. Gross margin is one of the main parameters for assessing resource use efficiency. It is calculated by deducting the variable costs of each activity from its respective revenue, based on one year. The gross margin can also be a *proxy* for the profitability of producing a certain crop in a farming system with respect to a specific unit of measurement, such as, land size (i.e. per hectare) (DOPPLER 2004).

It is also important to state the differences between *Jatropha curcas* and *Ricinus communis* production, *ex ante*, before proceeding. *Ricinus communis* is an annual crop in which farmers cannot receive an official credit line (true at the time the study was conducted). In this way, the farmer must use a part of the credit, which was accessed for other purposes, towards oil seed production. *Jatropha curcas*, on the other hand, is a perennial crop in which farmers can obtain an official credit line offered by Banco da Amazonia (BASA). In addition, having this credit line gives the farmer the ability to repay the credit after four years of production rather than after the first year.

The gross margin for *Ricinus* includes the costs carried out by smallholders, such as, planting and harvesting. Whereas, the gross margin calculation for *Jatropha* does not take these costs into account. This is because the activities considered are done within the first year and at this time *Jatropha* smallholders do not have any financial burden. The gross margin estimation for *Ricinus communis* and *Jatropha curcas* can be seen in Table 4.

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such as income generation and food access should take into account the food and nutrition security of families involved in this kind of initiative.

Table 4: Gross margin of oil seed activity production (R$)

Item	***Ricinus communis* producers**		***Jatropha curcas* producers**		*p*-value
	Mean	SE	Mean	SE	
Variable costs	86.40	3.48	-	-	-
Production value	182.70	39.55	42.60	10.78	0.01
Gross margin (GM)	96.30	39.03	42.60	10.78	0.70
GM per hectare	42.99	15.94	14.84	3.02	0.97

Source: research results (2010).

Notes: SE = standard error of the mean.

Mann-Whitney test was applied to check the differences between the means ($p < 0.05$).

As Table 4 illustrates, the gross margin of *Ricinus communs* is considerably higher when compared to *Jatropha curcas*. One possible reason for this is the fact that *Jatropha* activity in the first year does not generate considerable yields to family farmers. It is important to highlight that even the productivity of *Jatropha curcas* during the first year is very low when compared to the minimum expected by the biodiesel company. Therefore, producing *Jatropha* might jeopardize the economic returns for farm families in the short and long term. The average production of *Jatropha* seeds in the first year is 42.5 kg, per hectare, while the minimum expected by the biodiesel company is 100 kg, per hectare. Therefore, current production is less than half of the minimum, which is a prominent reason many smallholders choose to cease production. When inquired about the following year of *Jatropha* cultivation, 5 families (18.5%) responded that they would like to terminate production in order to cultivate conventional crops, such as, maize, rice and cassava. Roughly 41% of the families (11 smallholders) responded that they will observe production for one more year, i.e. to see if the productivity in the second year follows the first year's pattern, one should expect at least 50% fewer producers of *Jatropha curcas* in the sub-study region.

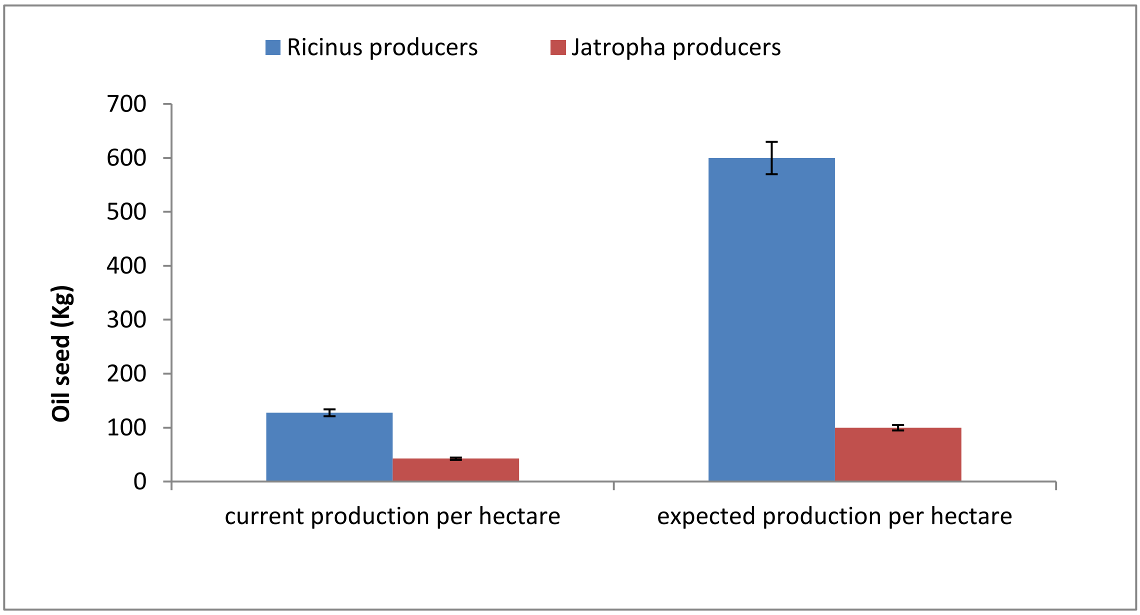

Figure 1: *Jatropha* and *Ricinus* production/hectare

Source: research results (2010).

Another important fact is that the gross margin estimated for *Jatropha curcas* is lower than all other conventional crops, which are considered economically profitable, such as, maize, rice and cassava (Table 5). *Jatropha* is expected to become profitable after the fourth year, however, the low productivity in the first year, in addition to the lower gross margin, makes *Jatropha curcas* an unprofitable economic activity in the sense of farm income generation as advocated by the PNPB.

The gross margin for *Ricinus communis* also presents a lower value when compared to other conventional crops in the sub-study region and, thus, low economic returns. This reflects the reality in Brazil, where smallholders put *Ricinus communis* aside and instead produce conventional crops. Not only the low productivity per hectare, but also the costs involved and the lack of technical assistance are making *Ricinus* an unprofitable activity for family farmers in the sub-study region (GARCEZ & VIANNA 2009).

The average production of *Ricinus* seeds was 127.71 kg, per hectare, in the sub-study region while the minimum expected by the biodiesel company was 600 kg, per hectare. The current production is much lower than the minimum expected by the company which might, like *Jatropha curcas*, be a strong reason for many smallholders to stop production. When inquired about the continuation of *Ricinus* production, for instance, 9 families (36%) responded negatively, i.e. they will stop cultivating *Ricinus communis* in the following year, and 40% of the families (10 smallholders) responded that they will only continue with *Ricinus* if they have the opportunity to access official credit lines and technical assistance. As has been illustrated, the future of *Ricinus communis* production in the sub-study region is not optimistic and might jeopardize one of the targets of the PNPB, which establishes *Ricinus* as the main vegetable oil that should be used by family farmers for biodiesel production in Brazil.

Table 5: Gross margin of conventional crops and oil seeds (R$)

Gross margin	***Ricinus communis* producers**		***Jatropha curcas* producers**		*p*-value
	Mean	SE	Mean	SE	
Gross margin of cassava	367.91[ab]	217.28	965.45[c]	284.89	0.02
Gross margin of rice	200.00[ab]	146.99	237.14[b]	71.73	0.55
Gross margin of maize	546.84[b]	151.28	373.63[bc]	52.49	0.03
Gross margin of oil seed	96.30[a]	39.03	42.60[a]	10.78	< 0.00

Source: research results (2010).

SE = standard error of the mean.

Mann-Whitney test was applied to check differences between means in rows and thus different letters show significant statistical difference ($p < 0.05$). Kruskal-Wallis test was applied to check differences among means in columns and thus different letters show significant statistical difference ($p < 0.05$).

In summary, the gross margin obtained from oil seed production is lower than the gross margin from conventional food crops production. Therefore, oil seed production, the alternative activity advocated by the PNPB, is not improving the local farm income. In addition, as family farmers in the region are food net buyers, a decrease in their generated income could affect their access to food, as their purchase power will diminish. These results emphasize the fact that PNPB is not achieving one of its main goals, which is to decrease negative impacts on farm income generation and food and nutrition security of farm families.

Final remarks

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 its negative impacts on local food security. As presented in this paper, the oil seed production related to *Jatropha curcas* and *Ricinus Communis* has led to land use changes since the land used previously to cultivate crops that is now being used to produce oil seed.

The oil seed activity in both sub-study areas diminishes the local food production. In addition, the gross margin from oil seed activity is lower than the gross margin from conventional food crops production and, therefore, leads to a reduction in the farm family's income. These facts might reduce local access to food: (i) families have less food available for self-consumption; (ii) as families are considered food net buyers, their access to food could also be compromised by reduced income. Based on this, oil seed production might have undesired effects on the food security of families. In addition, roughly 56% of families in the RC group responded positively to food deficits during the year, and at the same time produced 25% less feedstock after integrating oil seed production. These outcomes address an important topic for policy and decision makers and highlight the fact that PNPB targets, regarding income generation and FNS, have not yet been met. Local food production and food security need to be supported and not harmed with the implementation of any new project.

This study is unprecedented in the region and the results are extremely important in helping to obtain an appropriate method for regional and national governments to subsidize clean energy production without harming the local food production. Therefore, helping Brazil to achieve regional sustainable development. Small-scale oil seed production in the Brazilian Cerrado can now be better gauged in other parts of the Brazilian Legal Amazon Region because our study highlights one of the most discussed topics in bioenergy debate: oil seed production and its precedence over the local food security. As the present study focuses only at family level in a specific region, we suggest that other studies focused on biodiesel production on regional and national levels should be carried out in order to attain a broader idea of the biodiesel production in Brazil.

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