Tropentag 2010
ETH Zurich, September 14 - 16, 2010
Conference on International Research on Food Security, Natural Resource Management and Rural Development

Biodiesel and Social Inclusion in Rural Areas: a Study Based on Principal Component Analysis in the North of Brazil

(Expanded abstract)

Marcus Vinicius Alves Finco[1,2*], Werner Doppler[2], Gopal Datt Bhatta[2,3]

[1]Federal University of Tocantins (Brazil)
[2]University of Hohenheim (Germany)
[3]Himalayan College of Agricultural Sciences and Technology (Nepal)
*Email: marcus.finco@gmail.com

1. Introduction

The debate about climate change, energy security, poverty alleviation and therefore the search for sustainable development makes agrienergy an emblematic topic, not just because of the possible negative externalities, but especially because of the positive multiplier effects, especially on rural spaces (FAO 2008a, FAO 2008b, FAO 2008c). Based on this, Brazil launched a biodiesel program in the year of 2004 – the National program of biodiesel use and production (PNPB) -, which is based on a scenario of high oil prices, a growing demand for renewable fuels, and the country's comparative advantage in natural resources (NASS *et al*. 2007). Moreover, the PNPB has several specific objectives, such as diminish the import of diesel and therefore its dependence from outside; increase the share of renewable energy on the national energy matrix; foster the rural development and increase the share of small-scale farmers in the biodiesel chain through the so-called social inclusion (PNPB 2005), which is a process that aims to offer opportunities to access goods and services to **the most excluded people within a system** and therefore that benefit all and not only those in better off conditions (Silver and Miller 2002, Pierson 2002) [Emphasis added].

The impact on farmers will be contingent of a host of factors like the market structure, the type of contracts, and protection against risk, for instance. This is another area that has not been addressed in the current literature (Rajagopal and Zilberman 2007). In this context, the present study aims to analyze the relationship and linkages between poor rural families and the adoption of small-scale oil seed production from two different farming systems in northern Brazil. Therefore, assessing whether PNPB's 'pro-poor' strategy is effective or not. The research will support the regional and national governments in improving the PNPB and social inclusion targets. Moreover, the results presented can play an important role in integrating efforts to consolidate a new economic alternative for the small-scale farmers in the country.

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). 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.

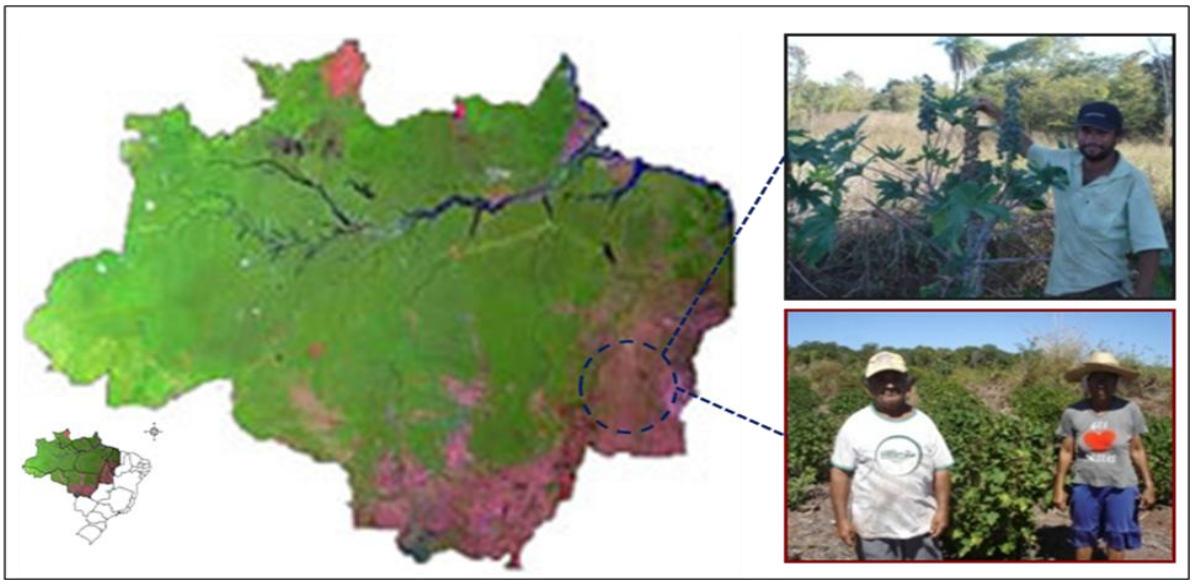

Figure 1: Research area in the Brazilian Amazon Region

After the data collection, the analysis started and therefore links were drawn between the smallholder living standard and the effectiveness of the PNPB social inclusion target, i.e. the inclusion of poor rural families in the Brazilian biodiesel chain. A factor analysis were applied to summarize the indicators of deprivation based on living standard criteria, and a non-linear *probit* model was formulated to estimate the relationship between the deprivation factors and the adoption of oil seed activity. The software STATA was used to support the factor, as well as, the econometric analysis.

3. Results and discussion

Aiming at obtaining more accurate analyses of the linkages between farmers' living standard (degree of poverty) and oil seed activity adoption, social, as well as, economic indicators were taking into account. Therefore, variables related to economic and social aspects of households were selected to better demonstrate the multi-dimensional situation of rural poverty in both sub-study regions in question. The variables selected are shown in Table 1. So, first of all, to check whether the proposed model was adequate, an analysis of the correlation matrix between the twelve indicators was done. The results point towards a low correlation, on average, despite the fact that most of them are significant. In this context, aiming at testing the model adequacy with more accuracy, the Kaiser-Meyer-Olkin (KMO) was applied and shows the figure of 0.64 (low to medium adequacy), which can be explained, at least in part, to the fact the some of the indicators are dichotomous and polytomous, and thus the correlations are not so robust when compared to continuous variables (Mattos and Waquil 2005). In addition, the Bartlett's Test of Sphericity was also applied and shows a result of 144.78 ($p < 0.00$). Therefore, the results suggest that the model can be considered adequate and robust, regarding the exploratory nature of the present study.

The indicators follow an increase degree of living standard, i.e. high values reflect better living standard conditions. Based on this, the factor analysis was applied to reduce the number of

variables towards a small number of factors which, for its turn, reflect the original variables. The point at which the curve first begins to straighten out is considered to indicate the maximum number of factors to be extracted. Therefore, four different factors could be identified, which are responsible for roughly 55% of the total data variance. In addition, the Scree plot, based on Eingen values was estimated and also reflected four different factors.

Table 1: Living standard indicators

Indicator	Description
Family income *per capita*	Quantitative variable by nature, and the lower anchor is the value of R$2400 (Brazilian reais)[1] per year, which is the half of minimum salary established by the national government at the moment the research was carried out. A person below this value can be considered poor. On the other hand, the upper score is established by multiplying the lower score by two or R$4800 per year, i.e. the minimum salary established by law and which reflects that above this value a person cannot be considered poor
Ownership of durable goods	Ordinal variable and ranges from 1 to 5, where 5 means that the family owns all the five goods in question - television, refrigerator, telephone, gas stove and a small wash machine - and 1 when the family owns just one of these items
Transport mean	Ordinal variable and ranges from 1 to 5. Where 5 reflects that the family has the car as their main mean of transportation; 4 when the family has the motorcycle as the main transport mean; 3 when has the bicycle is the main transport mean; 2 when the family does not possess any kind of transportation, but can afford a bus ticket and 1 when the family does not possess any means of transportation and cannot afford a bus ticket
Toilet facilities	Dichotomous variable by nature and, thus, receive a value of 1 when the family possesses toilet facilities, i.e. toilet linked to sewer and 0 when the family does not possess it, i.e. latrine or other
Water piped into dwelling	Dichotomous variable by nature and the indicator follows that of toilet facilities, i.e. when the family possess a system to pipe water into the dwelling then the family is considered non poor (1) and if the family does not possess it the family is considered poor (0)
Head Educational level	Ordinal variable and ranges from 1 to 5: where 5 reflects that the household head has at least completed the secondary school; 4 when the household started and did not complete the secondary school; 3 when the household hold completed the primary school; 2 when the head started and did not complete the primary school; and 1 when the household head is illiterate
Social capital	Ordinal variable and ranges from 1 to 3, where 3 represents those families who have strong relations with the rural settlement association, as well as, with the rural trade union; 2 when the families have strong relationships with only one of them; and 1 when the families do not have any kind of relationship with the institutions mentioned
Crowding factor	Reflects the number of persons who share the same room in the house. The variable is continuous by nature and has been computed as the ratio between the total number of rooms and an equivalence coefficient determined on the basis of the OECD scale. Accordingly, the following weights have been used: 1 for the first adult; 0.7 for any other adult (18 and over); 0.5 for children (under 18)
Health condition	Ordinal and the values range from 1 to 3, where 3 reflects that the household is not sick (good health condition); 2 when the family is sick, but it is not considered severe (regular health condition); 1 when the household is severely sick (bad health condition)
Food security	Ordinal variable and ranges from 1 to 3, where 3 demonstrates that the family has never faced food shortage during the year; 2 when the family faced food shortages, but not regularly, i.e. a deficit on food consumption during the year and; 1 when the family regularly copes with food shortage
Resource dependence	Dichotomous variable by nature and, thus, the families have been split into poor (0) when they rely on the municipality and/or on the association's machinery to run the farm activities; and non poor families (1) when the families do not depend on the municipality and/or on the association's machinery to run the farm activities
Drinking water shortage	Dichotomous by nature and the families who face a shortage of drinking water during the year receive the value 0 and are considered poor. The families who do not face this problem during the year are considered non poor and receive value of 1

After the factors extraction, the orthogonal rotation based on Varimax method was applied aiming at turning the factors into more understandable results[2]. The Varimax method aims to simplify the columns of the factor matrix. Thus, the maximum possible simplification is reached if there are only 1's and 0's in the columns, i.e. the method maximizes the sum of variances of factor matrix's required loadings aiming at obtaining an orthogonal rotation of factors. The rotate matrix is presented in the Table 2.

[1] At the time this study was conducted one Brazilian Real (R$) was equivalent to 0.5 American Dollars (US$).
[2] The other rotation is the oblique factor rotation.

Table 2: Rotated Component Matrix

Indicators	Component			
	1	2	3	4
Family income per capita	**.758**	.091	.096	.134
Durable goods	**.497**	-.447	.160	-.351
Transport mean	**.520**	.100	.214	.012
Toilet facilities	**.668**	-.059	-.237	-.145
Water piped into dwelling	**.689**	-.144	.048	-.248
Head educational level	-.276	**.490**	**-.467**	.120
Social capital	.060	.041	.268	**.687**
Crowding factor	-.049	**-.576**	-.197	.438
Health situation	.188	-.062	.179	**-.563**
Food security	.129	.013	**.639**	-.037
Resource dependence	.102	**.801**	.128	.146
Drinking water shortage	-.087	.135	**.722**	.061

Notes:
Bold values reflect factor loading above 0.45.
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Factor loadings in the range of ±0.30 to ± 0.40 usually are considered adequate to meet the minimal level for interpretation of structure. However, as the present study's sample lays around 100 units (smallholders), the range considered adequate was above ±0.45. To interpret the factors, one should pay attention to the higher figures presented in Table 2, since higher figures represent higher weights on factor composition. In this context, the factor 1 seems to reflect the capital security, once it is represented by family income *per capita*, the ownership of durable goods, transport mean, presence of toilet linked to sewer, as well as, the presence of water piped into dwelling. The factor 2 seems to reflect the dependence on external resources, and comprises the indicators resource dependence, crowding factor and head educational level. The factor 3 reflects the natural resources insecurity, since it is linked to the variables food security and drinking water shortage. Both the variables have positive signs and move together in the same direction. Herein, the head educational level appears as a cross-loading factor, i.e. when a variable is found to have more than one significant loading. As this variable has the higher weight in factor 2, its value was not considered in factor 3. And last but not least, the factor 4 seems to reflect the social security. Herein, the factor is linked to the variable social capital, as well as, to the variable health condition. Both variables are negative correlated.

An option for creating a smaller set of variables to replace the original set is the computation of factor scores, which are composite measures of each factor computed for each subject. So, the factor scores are estimated and then a process of linearization was done aiming at avoiding negative factor scores values, and thus guarantying that all scores lie in the range [0,1]. After the linearization, a nonlinear *probit* model was applied to estimate the relationship between the living standard factors and the adoption of oil seeds activity by small-scale farmers, in both sub-study regions (Greene 2008, Hill *et al*. 2008). In this context, two regressions were estimated: one for the *Ricinus communis* region, and one for the *Jatropha curcas* region. The analysis per sub-study region is necessary since the smallholders are located in different areas, produce different oil seeds and have contracts with different biodiesel companies[3]. Therefore, the weights for each indicator of deprivation were calculated per sub-study region, taking into account the

[3] A one-year contract in the case of *Ricinus communis* producers and a ten-year contract in the case of *Jatropha curcas* producers.

peculiarities and nuances and therefore the relative importance of each indicator of deprivation in each region.

The dependent variable *Y* refers to the adoption of oil seeds (*Y*=1) or otherwise (*Y*=0), and the factors (1 to 4) are the explanatory variables. Hence, when the signs of the estimated coefficients from the models are positive, the relationship between living standard and adoption of oil seed activity is direct, i.e. the probability of poor families adopt the oil seed activity is smaller than their non poor counterparts, and therefore the 'pro-poor' strategy is not being effective. By contrast, when the coefficient is negative, the relation is the inverse, i.e. poor families have a higher probability to adopt the oil seed activity and thus the social inclusion advocated by the PNPB is taking place. Based on this, the results of the *probit* model can be seen in the Table 3.

Table 3: Regression results for non-linear *probit* model

	***Ricinus communis* region**			***Jatropha curcas* region**		
	Coef.	SE	*z-statistic*	Coef.	SE	*z-statistic*
Constant	1.8692	1.2466	1.66***	-7.2435	2.3479	-3.10*
Factor 1	-2.2465	1.5638	-1.64***	4.7524	2.2341	2.08**
Factor 2	-2.3256	1.2275	-2.04**	4.1863	1.6681	2.42*
Factor 3	-1.5669	1.1811	-1.73***	2.3342	1.4288	1.65***
Factor 4	2.4368	1.7954	1.64***	4.5121	1.9287	2.32**
Number obs			50			51
LR χ^2			10.11**			16.88*

Notes:
SE = standard error
*Significance level of 0.01; ** Significance level of 0.05, *** Significance level of 0.10.

According to the results of the *probit* model, one can observe that all coefficients are significant at 1%, 5%, and 10% level. Also the likelihood ratio Chi-Square is significant at 1% and 5% level. Regarding the signs of the coefficients, positive signs reflect a direct relationship between better living standards and the adoption of oil seed activity. In this context, in the *Ricinus communis* region, for instance, the sign of the coefficients are negative (except for factor 4), i.e. a poor family has, on average, a higher probability to adopt the oil seed activity than a non poor family. This outcome shows that in this region the social inclusion advocated by the PNPB is occurring, in other words, the poor families are being included in the Brazilian biodiesel chain. However, when one looks to the other region, the *Jatropha curcas* region, one observes that the signs of the coefficients are positive, showing that the better the living standards of families, on average, the higher the probability to adopt the oil seed activity when compared to those who are considered poor. Therefore, the results suggest that the social inclusion is not occurring, once the poor families are not taking part of the biodiesel production process, and thus in this case the effectiveness of the PNPB's 'pro-poor' strategy is doubtful.

The changes in the predicted probability for the factors were also estimated and show that in the case of *Ricinus communis* producers, a movement from 0 (worse living standard) to 1 (better living standard) change the probability of factor 1 in 49%, 60% in factor 2, 41% in factor 3, i.e. a movement towards a better living standard condition decrease the probability of adoption the oil seed activity in these percentages (except in the case of factor 4 which coefficient is positive). However, in the case of *Jatropha curcas* producers, a movement from 0 (worse living standard) to 1 (better living standard) change the probability of factor 1 in 71%, 76% in factor 2, 53% in factor 3 and 81% in factor 4, i.e. a movement towards a better living standard conditions increase, on average, the probability to adopt the oil seed activity in these percentages.

4. Conclusions

Apart the fact that the Brazilian program of biodiesel use and production (PNPB) does possess the laudable objectives of promoting social inclusion and regional development, the results presented hitherto demonstrate and suggest that a lack in specific policy mechanisms has resulted in the nonfullfillment of one of its main targets: inclusion of rural marginalized people in the biodiesel chain. Based on this, it is imperative to say that the involvement of local agents seems to be a *sine qua non* condition to overcome the shortcomings in policy mechanisms by aiming to minimize the gaps in the national biodiesel policy and therefore reach the social inclusion and the sustainable development advocated by the PNPB.

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