JATROPHA CURCAS AND *RICINUS COMMUNIS* IN BRAZILIAN CERRADO: A FARMING AND RURAL SYSTEMS ECONOMICS APPROACH[1]

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Abstract: The present paper applies the farming and rural systems economics approach to assess and analyze four different rural systems in Tocantins State, located in the north of Brazil. The farming systems are divided based on the local oil seed production and thus the small-scale farmers are split into: *Ricinus Communis* (well-known as Mamona) producers, *Ricinus Communis* non-producers; *Jatropha Curcas* (well-known as Pinhão Manso) producers; and *Jatropha Curcas* non-producers. A comprehensive survey was carried out between April and September 2008 through the application of specific questionnaires and comprises questions about socio-economic, environmental, financial and demographic aspects as well as other vectors of farm family living standard. The preliminary results point towards an overall better living standard among the families in the *Ricinus Communis* non-producers as well as in the *Jatropha Curcas* producers systems. The research is unprecedented in the region in question and one should expect that the results may subsidize and support local, regional as well as national policies especially those related to biodiesel and family agriculture.

Keywords: Farming and Rural Systems, *Jatropha Curcas*; *Ricinus Communis,* Brazilian Cerrado.

PINHÃO MANSO E MAMONA NO CERRADO BRASILEIRO: UMA ABORDAGEM BASEADA NA ECONOMIA DOS SISTEMAS AGRÁRIOS E RURAIS

Resumo: O presente artigo aplica a abordagem da economia rural e dos sistemas agrários para analisar quatro diferentes tipos de sistemas rurais no Estado do Tocantins, localizado na região norte do Brazil. Os sistemas agrários foram divididos baseados na produção local de oleaginosas e portanto os agricultores familiares foram separados em: produtores de Mamona; não produtores de Mamona; produtores de Pinhão Manso; e não produtores de Pinhão Manso. Uma pesquisa domiciliar foi realizada entre os meses de Abril e Setembro de 2008 através da aplicação de questionários específicos e compreendem questões socioeconômicas, ambientais, financeiras e demográficas bem como outros vetores sobre as condições de vida familiar. Os resultados preliminares apontam para uma melhor condição de vida das famílias pertencentes ao sistema agrário "não produtores de mamona" bem como "produtores de pinhão manso". A pesquisa é inédita na região em questão e pode-se esperar que os resultados subsidiem políticas locais, regionais e nacionais sobretudo aquelas relacionadas ao biodiesel e agricultura familiar.

Palavras-chave: Sistemas Agrários e Rurais, Pinhão Manso, Mamona, Cerrado Brasileiro.

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INTRODUCTION

In the present paper, the socio-economics of farm families[4] are examined considering the family as a complex system in which people make decisions and optimize resource allocations – on the farm, household and/or off-farm level - according to their problems, needs and objectives. For this purpose, the farm family analysis is based on the living standard criteria developed by Doppler (1993, 2004), which is embedded in a holistic and systemic approach and focus mainly on human being behavior. This approach is innovative since one can deeply understand the decisions made by the farm family as well as the context in which these decisions were made. Above all, the living standard criteria approach enables one to identify, to accompany and propose actions to enhance positive externalities generated by the farm family choices.

Thus the paper focuses on farm family level which is split into four farming systems within two different sub study areas in Tocantins State and deals mainly with resources endowment, its allocation and its usage efficiency as well as the economic success of farm families. A range of socio-economic, environmental, financial and demographic indicators are described aiming at analysing the families profile as well as their living standard and its relationship with the decisions made by them. The research is unprecedented in the region in question and one should expect that the results may subsidize and support local, regional as well as national policies especially those related to biodiesel and family agriculture.

2. RESEARCH AREA AND METHODOLOGICAL ASPECTS

The research was carried out in the Tocantins State, located in the north of Brazil, in a region well known as Brazilian Legal Amazon. The State is situated in a transition area, presenting climate and vegetation from the Amazon rain forest (15%) and Cerrado (85%) - or Brazilian savannah This transition area, so-called Ecotone zone, comprises traditional communities (family agriculture, indigenous as well as quilombolas) and a rich biodiversity which is responsible for several environmental services. For this reason scientific efforts, studies and research in the area are extremely important aiming at understand the different farming systems and its linkages to the local economy and environment.

Aiming at doing the data collection and therefore forming the database, a comprehensive survey was carried out between April and September 2008 in two sub study regions within Tocantins State. In one sub-study region, the oil seed cultivated is the *Ricinus Communis* (well known as Mamona in Brazil) and in the other sub study region *Jatropha Curcas* (well known as Pinhão Manso in Brazil) is cultivated. The survey includes smallholders who cultivate oil seeds used to produce biodiesel as well as with smallholders who decided not to cultivate it. The inclusion of non-producers in the survey is necessary to assess the differences and similarities among the families based on the living standard approach.

Specific questionnaires were applied to smallholders, who were selected randomly: 27 in the case of *Jatropha Curcas* producers; 24 in the case of *Jatropha Curcas* non-producers; 25 in the case of *Ricinus Communis* producers; and 25 in the case of *Ricinus Communis* non-producers. It is important to highlight that the choice of the municipalities, the rural settlements as well as the smallholders followed statistical procedures. After the data collection, its assessment started and therefore analysis was done on the smallholder living

[4] The concept farm family hereby is related to small-scale agriculture, also so-called family agriculture in Brazil. One could notice that throughout the paper the terms farm families, farmers, families and family farmers will appear. However, it is important to say that all of those terms have, in the present study, the same meaning.

standard. A linear model was formulated to estimate the relationship between the income parameter and family resources as well as parametric and non-parametric tests were used to demonstrate the statistical differences among the smallholders living standard. The software STATA was used to support the statistical and the econometric analysis.

3 RESULTS AND DISCUSSION

3.1 FARM FAMILY LIVING STANDARD

This section presents the living standard of farm families aiming at better understanding their current situation in respective sub-study areas. According to Doppler (2004) living standard is a multi-dimensional phenomenon and it is determined by eight criteria which are: (i) family income; (ii) cash and liquidity; (iii) dependence from resource owner; (iv) food supply and food security; (v) supply of water, housing, sanitary equipment, energy and clothes; (vi) health conditions; (vii) education and qualification and (viii) social security.

Those criteria can also be grouped into two sets of indicators: (1) farm family economic success and (2) household living conditions. Where the former indicator comprise the first, second and third criteria (i, ii and iii, respectively) and therefore reflect the family economic success; and the latter indicator reflects the household living conditions and includes the other five criteria (from iv up to viii, respectively). It is important to emphasize that all criteria rely on qualitative as well as quantitative data.

3.1.1 Farm family economic success

The farm and off-farm income and therefore the family income are assessed, analyzed and presented. In addition, one is enabling to check the importance of farm and off-farm income on the family income composition among the four farming systems. Also the cash balance and liquidity that families face throughout the year are presented aiming at comprehending the monetary inflow and outflow between the rural properties and market outside it. All those economic indicators give a glance and help to explain, at least in part, the behavior behind the resource use and its allocation by farm families.

3.1.2 Farm income

According to Doppler (1993, 2004) farm income is the economic ability of a farm, in one year, to provide an economic surplus to be used by the farm family and it is calculated as residual after deducting all expenses from all revenues which are not directly related to family resources. Farm revenues, on one hand, can be understood as the total value of all crops and animal production within a specified period regardless of whether they are supplied to the market or consumed by the family (self-consumption) plus the increases in the value of stock. Farm expenses, on the other hand, are those related to inputs and services of crop and animal production, value of decrease in stock, and depreciation of machinery and equipment. In the present study, farm income on one-year-basis was calculated for the period of year of 2007 (dry and rainy season)[5].

As one can notice in the table below, the livestock production is the major and most important farm activity among the four farming systems. The livestock revenues range from R$5926.48 (highest value) in the *Jatropha Curcas* producers (JCp) group and R$3267.00

[5] In the region in question, dry season comprises May up to October; and rainy season comprises November up to April .

(lowest value) in the *Ricinus Communis* producers (RCp). However, besides the difference in the values, it is interesting to notice that there is no significant statistical difference among the four groups (*p-value* > 0.05).

Cultivation is the second most important farm activity among the farming systems in the sense of economic importance in farm revenue composition. The analyses show that farm families within the group "oil seed producers" have the highest crop revenue, on average, R$3448.51 and R$2975.20 for JCp and RCp, respectively against R$2195.83 and R$1423.20 for *Jatropha Curcas* non-producers (JCnp) and *Ricinus Communis* non-producers (RCnp), respectively. It is important to say that the values present here have significant statistical difference, especially between RCnp and JCp as one can see according to the difference in letters.

Although forest activity is presented only in the JCp group, it is also an important source of farm revenue for these farm families and shows a peculiar feature about this farming system that one will not find in the others: exotic fruits extraction and their trade at local markets. So, one can conclude that the farm families within the JCp group have the highest revenues regarding crop, livestock and forest activities whereas the other three groups present alternate results and therefore trends.

When the farm expenses are deducted from farm revenues, the farm income is the result. Again, as one can see in the table below, the farmers within JCp group also have the highest farm income, R$8154.44 per year, on average whereas farmers within RCp have the lowest farm income R$3844.16 per year, on average. One could observe that although there is no significant statistical difference among farming systems (*p-value* in this case is equal to 0.09), there is a large difference in the values especially between the JCp and JCnp groupd and only a slight difference between the RCp and the RCnp groups.

Table 1 - Farm income of families by farming systems (R$ - annual values)

Farm Income	*Ricinus Communis* Producers		*Ricinus Communis* Non-producers		*Jatropha Curcas* Producers		*Jatropha Curcas* Non-producers		*p*-value
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Farm revenue	6242.20	1431.73	6548.80	2312.73	9897.22	2198.58	5564.37	809.94	0.16
Crop	2975.20[ab]	1058.37	1423.20[a]	575.99	3448.51[b]	780.12	2195.83[ab]	415.55	< 0.00
Livestock	3267.00	736.29	5129.60	2276.44	5926.48	1624.72	3368.54	778.21	0.56
Forest	0	0	0	0	522.22	256.11	0	0	-
Farm expenses	2398.04	526.28	2328.64	739.02	1742.77	187.88	1590.83	207.60	0.70
Crop	1063.80	421.14	500.80	212.21	636.92	100.00	658.58	94.32	0.14
Livestock	1280.44	293.48	1819.84	668.24	1053.62	131.20	910.41	151.26	0.32
Maintenance and depreciation	54.00	38.72	8.00	8.00	52.22	25.61	20.83	20.83	0.42
Farm income	3844.16	983.68	4220.16	1629.93	8154.44	2097.73	3973.54	701.98	0.09

Source: research results (2009).
SE = standard error of the mean.
Different letters show the significant difference between groups according to Kruskal-Wallis test for quantitative data when the data is not normally distributed, to the One-way ANOVA when data is normally distributed.

3.1.3 Off-farm income and the pluri-activity

Off-farm income is the income derived from all activities performed by a member of family inside the rural property (non-agricultural activity) or outside the rural property (agricultural activity and/or non-agricultural activity) as well as from pensions and transfers. In this context, as one can observe in the table 2, pensions appear to be the most important source and contributor to off-farm income among farming systems and its value is especially high in the group RCnp which can be explained, at least in part, by the number of members

above 60 years old. Despite family members above 60 years old, they are considered those who "do not contribute economically to the household" (BLAIR, 2007, p.17) hereby one can notice the importance of rural pensions to maintenance of household.

National transfers, well known as "bolsa-familia", show to be more significant to families in RCp and JCnp group, although the non-significant statistical difference among groups (in this case the *p-value* is equal to 0.08). Similar trends can be seen to regional transfers, so-called "bolsa mirim" since again this source of income shows to be more significant to the two groups mentioned previously (*p-value* is this case is equal to 0.72). Household head off-farm income is separated into two different sources aiming to better understand it: (1) the salary earned through regular off-farm activities, i.e. activities under contract along the year; and (2) the wage earned through seasonal activities outside the property and without any type of contract. One can notice that the head salary is higher, on average, if compared to head wage which is explained by the fact that under contract the person receive the minimum salary established by the national government whereas without contract this condition is not followed up.

Other off-farm activities inside the rural property appear to have little to no negligible impact on off-farm income, especially in RCp and in JCnp group. Rented out equipment and machinery demonstrate to have little importance on off-farm income composition but they are still present among farmers of JC group. One can also observe the share of spouse (women in the most of cases) and sons in off-farm activities. Special attention should be paid to spouses in JCp group who have an important role in family off-farm income. Below one can see the share of different sources of off-farm income on the total off-farm income. As mentioned above, pensions appear to be the most important source of off-farm income among farming systems.

Table 2 - Off-farm income of families farming systems (R$ - annual values)

Off-farm income	*Ricinus Communis* Producers		*Ricinus Communis* Non-producers		*Jatropha Curcas* Producers		*Jatropha Curcas* Non-producers		*p*-value
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Pensions	2601.12	715.05	3825.60	830.79	2582.22	615.99	1867.50	585.30	0.32
National transferences	465.12	116.96	241.92	91.31	228.44	84.84	473.50	111.37	0.08
State transferences	129.60	47.07	86.40	40.40	80.00	37.62	135.00	48.75	0.72
Head regular salary	900.00	631.13	1308.00	646.88	1022.22	490.86	1487.50	683.69	0.71
Head seasonal wage	776.00	412.20	224.00	95.44	303.70	171.92	583.33	497.95	0.82
Spouse wage	460.00	283.41	534.00	280.60	1837.03	976.98	387.50	235.60	0.73
Son wage	162.00	162.00	400.00	240.00	0	0	200.00	138.31	0.59
Rent equipment out	0	0	0	0	60.00	0	160.00	0	0.55
Other activities	540.00	387.21	0	0	0	0	208.33	208.33	0.51
Off-farm income	6033.84	806.37	6619.92	880.97	6109.18	952.68	5509.33	1019.98	0.55

Source: research results (2009).
SE = standard error of the mean.
Different letters show the significant difference between groups according to Kruskal-Wallis test for quantitative data when the data is not normally distributed, to the One-way ANOVA when data is normally distributed

Marini and Pierroni (1987) show that family as an active unit presents three basic characteristics: (i) linkages between the production and reproductive spheres: (ii) internal relationship among members defined by gender, age and labor capacity; and (iii) the social position in the family life cycle. So the family is transformed in a multi-dimensional unit where both agricultural and non-agricultural activities are practiced and generate different sorts of income. Based on this, the concept of pluri-activity pops up, which is a phenomenon that presupposes the mix of two or more activities where one is related to agriculture in one production unit by individuals that belong to the same family. Thus the pluri-activity is related

with the operation of multiple activities by members of the same family. In summary, a pluri-active family is the family where at least one of its members has a non-agricultural activity as the main or the secondary economic activity[6]. The expectative is that the pluri-activity becomes an alternative to family farmers in order to get new jobs, increase and diversify their incomes and, at the same time, contribute to create new functions to rural areas as a multidimensional space. Therefore, the pluri-activity should be considering as a driver to strength the rural population livelihood and one strategy of social reproduction capable to reduce uncertainties and vulnerabilities.

In this context, families in the four farming systems can be considered as pluri-active farm families. The major part of them presents at least one of its members working on off-farm activities inside and/or outside the property throughout the year and therefore contributes to the total family income[7].

3.1.4 Family income

Family income is the sum of farm income and off-farm income and can be considered as the main pillar of the living standard analysis. Moreover the farm-income is determined by several factors such as credit access, land size, access to market and rural extension service, etc. After the calculation of the family income, no differences among the four farming systems were found even though the values between JCp and JCnp are quite different. This difference can also be a gauge about the decision on adoption (or not) of oil seed activity. The farm families and especially those who are in worse conditions present a higher risk aversion and a short horizon which can explain, at least in part, the adoption of *Jatropha curcas* production by those farmers who present the higher family income.

Table 3 below gives further information on the family's income composition.

Table 3 - Farm, off-farm and family income of families by farming systems (R$ - annual values)

Family income	*Ricinus Communis* Producers		*Ricinus Communis* Non-producers		*Jatropha Curcas* Producers		*Jatropha Curcas* Non-producers		*p*-value
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Farm income	3844.16	983.68	4220.16	1629.93	8154.44	2097.73	3973.54	701.98	0.09
Farm income per capita	920.64	223.00	1262.09	453.40	2670.24	661.12	1169.98	216.30	0.07
Farm income per agricultural land	243.17	72.46	419.56	170.16	445.51	116.78	328.90	65.19	0.20
Farm income as % of family income	38.9		38.9		57.1		41.9		-
Off-farm	6033.84	806.37	6619.92	880.97	6109.18	952.68	5509.33	1019.98	0.55
Off-farm per capita	1520.51	220.16	1988.83	355.75	1914.53	350.00	1667.97	322.46	0.85
Off-farm income as % of family income	61.1		61.1		42.9		58.1		-
Family income	9878.00	1029.26	10840.08	1580.80	14263.62	2125.03	9482.87	1053.63	0.21
Family income *per capita*	2441.15	268.13	3250.93	519.02	4584.78	652.70	2836.95	397.89	0.10

Source: research results (2009).
SE = standard error of the mean.
Different letters show the significant difference between groups according to Kruskal-Wallis test for quantitative data when the data is not normally distributed, to the One-way ANOVA when data is normally distributed.

As one can observe in the table above, the farm income represents 38.9% of the total family income in the case of farmers in RCp as well as RCnp group, 41.9% in the case of farmers in JCnp group, and 57.1% in the case of farm families in JCp group, the highest

[6] More details can be seen in Fuller (1990), Marini and Pieroni (1987).
[7] According to Berdegue, Reardon and Escobar (2001) and Reardon, Berdegue and Escobar (2001) the rural non-agricultural job is responsible for 40% of the rural inhabitants' income in Latin America.

percentage among groups. So as one notices, the off-farm income has a crucial role in the family income composition among all four farming systems, but especially among farmers in RC group. Regarding the family income itself, on can see that farmers in JCp group present the highest value, followed by farmers in RCnp group. These two farming systems also present the higher values on farm as well as on off-farm income as one can observe in the table. Interesting to stress that besides the difference in values (farm, off-farm and family income) there is no significant statistical difference among farming systems (*p-values* > 0.05).

3.1.5 Family cash balance and liquidity

According to Doppler (2004) family liquidity is an important criterion in determining the living standard and can be considered the situation where cash is available at the point in time aiming at meeting family obligations without disrupting the production activities of the business. However, liquidity of the farm and the family cannot be separated since families allocate the resources they own to farm, off-farm and household, concomitantly (KAY, EDWARDS and DUFFY, 1999). In addition, as Blair (2007) pointed out, cash analysis does not seek to measure profitability or economic efficiency, i.e. the objective of liquidity analysis is to ascertain the degree to which households are capable (or not) of meeting their cash requirements. In this context, this section presents the cash inflow and cash outflow and therefore the cash balance at farm family level, which is equivalent to the liquidity of the family.

Family cash balance was calculated as the difference of cash inflow and cash outflow in a one-year-basis (year of 2007), considering the dry and rainy seasons. Cash inflow consists of cash from crop sales, cash from livestock sales, cash from sub-products, cash from forest activities, cash from credit and cash from off-farm income. On the other hand, cash outflow consists on crops and livestock expenses, hired labor, credit repayment and household expenses.

Table 4 - Cash balance and liquidity by farming systems (R$ - annual values / dry season)

Cash balance and liquidity	*Ricinus Communis* Producers		*Ricinus Communis* Non-producers		*Jatropha Curcas* Producers		*Jatropha Curcas* Non-producers		*p-value*
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Cash inflow	6035.16	1060.52	7698.80	1290.07	7880.11	1957.57	5948.62	706.63	0.19
Cash inflow from crops	1694.40[ab]	888.08	630.00[a]	345.92	1715.25[b]	522.25	858.75[ab]	347.25	0.01
Cash inflow from livestock	977.40	239.23	2570.20	1174.49	1787.59	543.16	1412.70	353.54	0.42
Cash inflow from sub-products	346.44	150.80	1188.64	373.56	952.29	339.37	922.50	504.31	0.44
Cash inflow from forest activities	0	0	0	0	370.37	180.20	0	0	-
Cash inflow from off-farm	3016.92	403.18	3309.96	440.48	3054.59	476.34	2754.66	509.99	0.55
Cash outflow	5836.29	678.97	5748.33	860.31	5705.88	601.50	5094.78	502.42	0.97
Cash outflow from crops	968.05	383.23	455.72	102.11	579.60	91.00	600.22	85.83	0.14
Cash outflow from livestock	1165.01	163.75	1656.05	608.09	958.80	119.39	828.47	137.64	0.33
Cash outflow from hired labor	78.40	26.45	43.20	19.92	60.74	20.04	60.83	26.19	0.63
Cash outflow from household expenses	2494.41	259.59	2449.35	234.32	2334.69	205.53	2392.32	243.59	0.97
Cash outflow from credit repayment	1130.40	266.25	1144.00	238.61	1772.03	433.89	1212.91	233.04	0.79
Cash balance	198.86	882.12	1950.46	650.29	2174.22	767.40	853.84	769.55	0.15

Source: research results (2009).
SE = standard error of the mean.
Different letters show the significant difference between groups according to Kruskal-Wallis test for quantitative data when the data is not normally distributed, to the One-way ANOVA when data is normally distributed.

According to table 4 one can notice that during the dry season the cash inflow from crops is the only inflow that presents a significant statistical difference among farming

systems (*p-value* < 0.05) and especially between the group RCnp and the JCp group. The higher values of crop inflow are related to RCp as well as JCp, R$1694.40 and R$1715.25, respectively. On the other hand, the cash inflow from livestock is higher in RCnp and lower in RCp. Thus, the cash balance analysis, in the dry season, points out that the farmers in JCp group present the highest liquidity among farming systems, and farmers in the group RCp present the lowest liquidity during the dry season. It is important to say that the dry season represents the months where farmers do not produce any kind of crop (unless they own irrigation systems) and therefore have more difficulties to feed the livestock. During roughly 6 months there is no rainfall in the sub study areas which represents the strongest constraint for farm activities (crop as well as livestock). The same trend can be seen in the rainy season, where farmers in RCp as well as in JCp group present the higher cash inflow values from crop activities and farmers in RCnp and JCp group show higher cash inflow from livestock activity. Thus, one can also observe similar liquidities for farmers in RCnp as well as JCp group, R$5681.34 and R$5819.22, respectively and similar results for farmers in RCp and JCnp group, R$2765.54 and R$2561.24, respectively. So, one can conclude that farmers in the group JCp are those that present the highest cash balance and liquidity in both dry and rainy seasons, followed by farmers in RCnp. Those farmers are the same that present the highest farm income, off-farm income and family income.

The results of cash balance of rainy season follow up similar trend and therefore are not presented here.

3.1.6 Dependence from resource owners

Decisions made by farm families are related to resource use and its allocation as well as strategies of getting extra resources outside the family. Thus, dependence in the context of the present study is predominately in the machinery issue, especially for land preparation in the case of cultivation of all crops. Without machinery one could expect that some farm families to not produce or exert any crop activity within the property. Those families who rely on the municipality or on the association machinery do not have, in most of cases, any other alternative since rent in private tractors in the sub-study areas in question are too expensive. Based on this, a high percentage of farm families in RC group depend on association or municipality tractor to prepare the land in comparison to farmers in JC group. This difference may be explained, at least in part, due to numerous large properties nearby the families in the JC group. Those families have the alternative to rent in the tractor for a lower price compared to the sub-study area where families in RC group are located. So, most of farm families in the group JC have an option besides the association or municipality tractor. But even so, more than 40% of the families in the group JCnp still depend on association or municipality tractor. In the case of harvesting, however, the work is done manually by family members and, sometimes, by hired labor without any kind of machinery.

3.2 HOUSEHOLD LIVING CONDITIONS

The present section focuses on some living standard criteria that are related to the living standard of families such as: food supply and food security; supply of water, housing, sanitary equipment, energy and clothes; health conditions; education and qualification; and social security. Those criteria include the supply of basic goods and services that are the minimum to the farm family survival and therefore must be satisfied.

3.2.1 Food supply and food security

According to Doppler (2004) food supply and food security comprise the amount and quality of food supply from farm as well as from the market. This amount is influenced by family size, access to market, diversification within the property and resources for production. In the sub-study areas, the market orientation is regular, i.e. even though farm families consume part of their own production, in most cases a surplus is offered in local markets. However, farm families within the four farming systems also buy part of their needed food in the market and it is interesting to state that the major part of household expenses is related to food purchasing and thus the farm families can be considered as food net buyers. In this context, forthcoming table 5 gives a view of the quantity of food purchased on local markets as well as the quantity produced which is self-consumed. Moreover, when inquired about the experience with food deficits throughout the year, the majority of farm families within RCp group (56%) responded positively, i.e. they suffer with food deficit periods, to some degree, during the year. The farmers in JCp group are those who suffer less from this problem, once 25.9% of them suffer from food deficit.

Table 5 - Total amount of food consumed by families versus the amount of self-consumed family production, per year by farming systems

Total amount of food consumed	*Ricinus Communis* Producers		*Ricinus Communis* Non-producers		*Jatropha Curcas* Producers		*Jatropha Curcas* Non-producers		*p*-value
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Total amount of rice consumption (kg)	276.80	26.43	198.40	17.81	204.44	9.09	216.00	37.33	0.06
Amount of rice from the property (kg)	36.80[a]	14.03	35.16[a]	14.70	71.85[ab]	10.65	100.67[b]	11.07	< 0.00
Total amount of bean consumption (kg)	87.36	9.28	85.26	12.85	78.22	6.84	88.00	7.46	0.34
Amount of bean from the property (kg)	8.16[ab]	3.25	4.48[a]	1.92	9.18[b]	1.55	11.67[b]	2.67	0.04
Total amount of milk consumption (lt)	307.20[b]	57.73	336.00[b]	41.19	114.04[a]	21.38	104.00[a]	27.66	< 0.00
Amount of milk from the property (lt)	259.20[b]	62.46	255.36[b]	44.57	32.44[a]	10.20	58.00[a]	24.34	< 0.00
Total amount of cassava consumption (kg)	417.60	4.21	406.00	2.08	415.55	4.41	424.58	6.19	0.21
Amount of cassava from the property (kg)	112.80[a]	26.22	105.60[a]	13.63	294.81[b]	29.38	260.83[b]	43.08	< 0.00
Total amount of cow meat consumption (kg)	93.12	11.61	104.64	13.06	112.00	13.79	106.00	14.14	0.74
Amount of cow meat from the property (kg)	9.60	6.78	15.36	10.26	3.55	3.55	8.00	4.71	0.68

Source: research results (2009).
SE = standard error of the mean.
Different letters show the significant difference between groups according to Kruskal-Wallis test for quantitative data when the data is not normally distributed, to the One-way ANOVA when data is normally distributed.

3.2.2 Water and energy supply

Although 100% of farm families within all the four farming systems have access to drinking water through wells, only part of them have access to water piped into dwelling (56% and 55.6% of farm families in RCnp and JCp respectively; and 44% and 41.7% of farm families in RCp and JCnp, respectively). Another question is that some of farm families suffer from drinking water deficit in the dry season. The wells no longer supply water and some farm families have to walk 1, 2 or even 4 km to get drinking water. The irrigation system is very rare in the sub-study regions due to costs of its acquisition as well as its maintenance. Nevertheless, some of farm families possess irrigation systems: 18.5% of farm families in the JCp; 8% in RCnp and 4% in RCp. The farm families in the JCnp are the only ones who do not possess any kind of irrigation system within the property and therefore cannot carry out crop

activities during the dry season. It is important to say that during the rainy season, all the water for crop production comes from the rain and therefore the irrigation system is not used. Regarding the energy, all farm families among the four farming systems have access to it, but the main source of cook mean is still the wood stove among families in all the four farming systems.

3.2.3 Dwelling and living conditions

Here the living conditions experienced by farm families regarding the living area and sanitary conditions. When one considers the living area of dwellings, table 6 below highlights the main findings. On average, dwellings are larger in RCnp groups, but no significant statistical difference was found among farming systems. Regarding number of bedrooms per house as well as the area per capita, i.e. per family member, farmers in RCnp group also present the best results, 15.95m^2 *per capita* and 2.36 bedrooms, *per* house, on average. When one considers number of family members per bedroom, the farmers in RCp group present the worse result, roughly 2.14 persons *per* bedroom against 1.72 persons *per* bedroom, on average, in RCnp group.

Table 6 - Dimension of dwelling by farming systems

Dimension of dwelling	*Ricinus Communis* Producers		*Ricinus Communis* Non-producers		*Jatropha Curcas* Producers		*Jatropha Curcas* Non-producers		*p*-value
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Total area (m^2)	47.20	1.04	49.80	1.67	47.22	1.04	46.87	1.03	0.43
Area (m^2) per capita	12.68	0.99	15.95	1.76	15.06	1.24	14.29	1.39	0.59
No. of bedrooms	2.16	0.07	2.36	0.14	2.14	0.06	2.12	0.06	0.45
Persons per bedroom	2.14	0.17	1.72	0.16	1.84	0.20	1.95	0.20	0.33

Source: research results (2009).
SE = standard error of the mean.
Different letters show the significant difference between groups according to Kruskal-Wallis test for quantitative data when the data is not normally distributed, to the One-way ANOVA when data is normally distributed.

3.2.4 Education and qualification

The educational level as well as the qualification of family members in the sub study areas in an indicator of skill's quality of available family labor resources. In this context, the figure below shows the percentage of household head per farming system that attend some kind of course offered by the local extension service and/or another local organization. As one can see, except for farmers in the group JCnp, the other three farming systems present a similar attendance (around 30% of household head) and thus reflect the similarity in access to information among those groups.

3.2.5 Social security, health condition and household expenditure

According to Kitchaicharoen (2003), social security means security of the families for the future. Moreover, social security may comprise the social capital that farm families had built up aiming at support them and therefore minimize risks, uncertainty and vulnerability whenever they face natural and/or man-made catastrophes. In addition, social capital is related to norms, institutions and organizations that promote the trust, reciprocity and cooperation

among its members. Thus, social security is hereby expressed through the farm family social capital.

Most of farmers have the religion as the main social capital. They attend mass regularly and have the church as an important symbol of support and help at difficult moments. The settlement association plays an important role especially among farmers in RCp as well as in JCp where 80% and 74.1% of them take part on it, respectively. The rural trade union appears to be an important organization only of farmers in JCp where 81.5% of them consider this organization a crucial supporter aiming at diminishes transaction costs and risks as well.

On the other hand, health condition is a crucial indicator of farm family living standard and thus some factors were selected aiming at assessing the health status of families in sub-study areas. When inquired about their perception regarding the health condition of the family, only around 4% of the farmers responded be good in RCp as well as in JCnp group against 56% and 54.2% who responded the health condition were bad in both groups, respectively. These outcomes are a little bit different among farmers in RCnp and JCp groups. However, when one considers the number of consultations, *per* year, farm families in latter groups are those who visit it the most, 7.2 consultations, on average. Regarding the days of work lost from diseases suffered by household head; farmers in RCnp are those who left work for more days, on average *per* year, 8.40 against 5.33 days, on average, of farmers in JCp group. Considering the farm family, the RCnp group presents, again, the highest number of days lost by some disease throughout the year, 10.40 on average against 8.29 days, on average, of days lost by families in JCp group. As one can see in the table below, farm families in "Castor oil non-producers" group are those who spend more money on consultation and/or medication among groups, R$279.92, *per* year on average.

According to Tai (2004) the household expenditure is a payback for the human capacity used as well as to be used in the production activities of the farm family. In this context the table below reflects the main household expenditures, in absolute values, by sub-study areas.

Table 7 - Household expenditure by farming systems (R$ - annual values)

Household expenditure	*Ricinus Communis* Producers		*Ricinus Communis* Non-producers		*Jatropha Curcas* Producers		*Jatropha Curcas* Non-producers		*p*-value
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Food	2218.56	171.87	2280.00	190.00	2240.44	147.82	2222.00	238.38	0.93
Clothes	576.00	72.29	600.00	78.74	374.07	40.50	418.75	56.20	0.06
Energy	447.84	60.72	526.56	75.41	430.22	50.61	332.00	26.57	0.20
Education	187.20	31.23	196.80	41.43	207.40	60.35	235.00	69.21	0.96
Health	252.72	122.22	279.92	71.84	220.74	53.46	270.00	67.14	0.40
Transport	766.00	363.80	561.20	205.74	664.44	220.08	790.83	231.48	0.58
Others	540.50	55.39	454.22	61.69	532.06	59.31	516.07	50.97	0.41
Total	4988.82	519.19	4898.70	468.64	4669.39	411.07	4784.65	487.19	0.97

Source: research results (2009).
SE = standard error of the mean.
Different letters show the significant difference between groups according to Kruskal-Wallis test for quantitative data when the data is not normally distributed, to the One-way ANOVA when data is normally distributed.

3.3 RELATION BETWEEN INCOME PARAMETER AND FAMILY RESOURCES

The impact of resource availability as well as its utilization on income parameters is important since it shows the significance of these resources in generating income and

indicates the variables which have greater impact on it (ABU SHABAN, 2007). The economic theory indicates that families who have more resources such as land, capital and labor, for instance might have higher income. However, the theory, *per se*, is not enough and one should carry out statistical procedures applied to economics aiming at detecting and assessing the variables impact on income generation. In this context and in order to analyze the linkages between the resources availability and its use and their impact on farm family economic success, an econometric analysis was carried out.

3.3.1 Regression analysis[8]

According to economic theory, farm revenue is generated by several resources such as labor, allocation of property land, diversification of farm activities within the property, access to official credit lines, etc. However, due to the difference among farming systems regarding resource availability in the sub-study areas, it is vital to analyze and investigate the importance of different variables in generating the farm revenues of families. In this context a range of variables were selected aiming at assessing the impact of each on farm revenue generation. Therefore, an economic model was formulated:

$$F = f(C, L, Fl, E, Hof, H, Ca) \quad (1)$$

Where:

F = farm revenue
C = crop size
L = livestock
Fl = family labor applied on farm activities
E = household head educational level
Hof = household head off-farm activity (*dummy*)
Hl = hired labor applied on farm activities (*dummy*)
Ca = credit access (*dummy*)

Regarding the coefficient signs, one should expect that as the larger the crop size becomes, the more land is converted to crop activities and therefore the higher the farm revenue. In the same direction, the larger the livestock, i.e. number of animals the higher the farm revenue. Thus, both signs are expected to be positive.

One should expect that more family labor applied to farm activities leads to more intense farm activity, higher production and therefore higher farm revenue. Regarding the household educational level, one should expect that the more years of study the household head has, the more skills and ability to diversify and improve the farm activity and thus the farm revenue. Here one should also expect positive sign for those coefficients.

Regarding the *dummy* variables, one should expect that when the household head exerts some off-farm activity (regular or seasonal), less time remains available for farm activities and therefore the consequence is lower farm revenue, i.e. the sign of coefficient is negative. The labor hired by the farm family tends to improve the farm production and thus increase the farm revenue, so one should expect a positive sign for the coefficient. And last but not least, one should expect a positive sign for credit access, once more money is available to apply on farm activities and therefore the production as well as the farm revenue tends to increase.

[8] This section was based on Greene (2008), and Hill, Griffiths and Lim (2008).

Therefore, aiming to obtain the estimate for the parameters associated with the described variables as well as test the hypotheses formulated previously, an econometric model was specified:

$$Y_j = \alpha_i + \sum_{i=1}^{4} \beta_i X_{ij} + \sum_{i=1}^{3} \delta_i Z_{ij} + \mu_j \qquad (j = 1, \ldots, n) \tag{2}$$

Where:

Y_j = farm revenue of farm family *j*, in R$ per year
X_{1j} = crop size, in hectares
X_{2j} = livestock size, cattle in number of heads
X_{3j} = family labor applied on farm activities, in man-days per year
X_{4j} = educational level of household head *j,* in years of study
Z_{1j} = 1 if household head *j* exerts an off-farm activity; 0 if otherwise
Z_{2j} = 1 if farm family hire external labor; 0 if otherwise
Z_{3j} = 1 if farm family received credit in year before: 0 if otherwise
μ_j = error terms
α_i, β_i, δ_i = parameters of regression (i = 1,…,4)

The ordinary least squares method (OLS) was applied to estimate the coefficients of the equation and the semi-log functional form was selected, in which the dependent variable is measured in logs and independent variables in levels, once this functional form better express the relationship between the dependent variable (farm revenue) and explanatory variables.

The dependent variable in equation (2) is the natural logarithm of farm revenue. To examine how explanatory variables affect the farm revenue, one needs to take the exponential of both sides (dependent as independent variables), since the exponential function reflects the anti-log of the natural logarithm:

$$Y = Exp\,[\ln\,(Y)] = Exp\,[\alpha_i + \sum \beta_i X_i + \sum \delta_i Z_i + \mu_i] \tag{3}$$

$$Y = e^{\alpha_i} e^{\Sigma \beta_i x_{ij}} e^{\Sigma \delta_i Z_i} \tag{4}$$

$$Y = e^{\alpha_i + \Sigma \beta_i x_i + \Sigma \delta_i Z_i + u_i} \tag{5}$$

The equation (6) is derived from the equation (5) and the interpretation of the estimated coefficients is called semi-elasticity and is represented by:

$$\frac{d(lny)}{dx} = \beta, \delta = \frac{(dy/y)}{dx} \tag{6}$$

For its turn, δ is the coefficients on Z in the sense that the percentage differences in the farm revenues when δ is equal to one compared to δ equal to zero. Aiming at checking the model assumptions, some tests were carried out such as the Breusch-Pagan/Cook-Weisberg as well as the White test to check the presence of heterocedasticity and the Variance inflation factors (VIF) to check the presence of multi-colinearity and thus the tests show negative results for heterocedasticity and multi-colinearity. In addition, the RESET test (Regression

Specification Error Test) was applied to check about omitted variables and again the results point towards the acceptance of no omitted variables in the model.

The hypotheses tests, identifying the coefficients that differ from zero, were made considering a significance level up to 10% (0.10). The STATA software, version 8.0, was used to run the regression analysis and the main results can be seen in the table below.

Table 8 - Coefficient estimation of farm revenue equation, semi-log functional form

Explanatory variables	Coefficients	SE	*"t" test*	*p-value*
Constant	6.6004	0.3257	20.27	< 0.00
Crop size (X_{1j})	0.0851	0.0433	1.96	0.05
Livestock (X_{2j})	0.0002	0.0044	0.06	0.95
Family man-days (X_{3j})	0.0026	0.0006	4.42	< 0.00
Educational level (X_{4j})	0.6999	0.0323	2.17	0.03
Head's off-farm activity (Z_{1j})	-0.4283	0.2018	-2.12	0.03
Hired labor (Z_{2j})	0.5729	0.1949	2.94	< 0.00
Credit access (Z_{3j})	0.3331	0.2247	1.71	0.09
Coefficient of determination (R^2)	0.32			
F statistic (7, 93)	8.14			< 0.00
No. observations (n)	101			

Source: research results (2009).
SE is the coefficient's Standard Error

When one observes the explanatory variable behavior, one can notice that all of them exert significant influence on the dependent variable, except for the variable livestock (number of animals – X_{2j}). Even so, one notices that the sign of this variable is positive as expected. The coefficient of crop size was significant and the sign (positive) goes hand in hand with economic theory, i.e. the larger the land converted to crop activity the higher the farm revenue. The elasticity, in the mean point, is 0.24, i.e. an increase of 10% on the crop size will lead to an increase of 2.4% on the farm revenue, *ceteris paribus*.

Regarding the variable family man-day applied to farm activities, one observes that the coefficient is significant and the sign follows up the economic theory, i.e. more family man-days applied on farm activity will increase the farm revenue. The man-days' elasticity, in the mean point, is 1.03 which can be considered elastic, i.e. an increase of 10% on the man-days applied on farm activities by the family will lead to an increase of 10.3% on the farm revenue, *ceteris paribus*. When one considers the variable years of study of household head, one observes that the coefficient is significant and the sign is positive as expected. The elasticity, in the mean point is 0.27, i.e. an increase of 10% in the household head educational level (measured in years of study) will lead to an increase of 2.7% on farm revenue, all other variables remaining constant.

And regarding the *dummy* variables, one observes that those families whose household head exerts some off-farm activity earn, on average, 42% less (farm revenue) than those families which the head does not have any off-farm activity, *ceteris paribus*. One can also see that the farm family that hires labor has, on average, farm revenue 57% higher than the farm family that do not hire external labor, all other variables remaining constant. The same trend can be seen to credit access. The farm family that received credit last year (in this case in the year of 2006) has, on average, farm revenue 33% higher than the farm family that did not

receive credit, *ceteris paribus*. Hereby one can perceive the importance of credit as well as external labor to the farm families regarding the total farm revenue obtained by them.

The coefficient of determination (R^2) was 0.32, i.e. 32% of the variation of farm revenue is explained by the variation of independent variables in the model. The low value of R^2 was as expect once the data is cross-sectional (GREENE, 2008; HILL, GRIFFITHS and LIM, 2008). The F-test point out that the overall model was significant.

FINAL REMARKS

The present study is based on farming systems economics, which is a holistic approach that focuses on human beings, the society, their needs and objectives, it deals with decision-making at family level and at the same time includes participation of the target groups and people concerned when defining their objectives, finding and assessing solutions for them. Furthermore, meeting rural families' needs and objectives should not be on the expenses of natural resources deteriorations especially land resources, neither the natural resources management should be on the cost of the living standards of families.

The results presented hitherto points out that the families in the *Ricinus Communis* non producers as well as the families in the *Jatropha Curcas* producers groups are those in better off conditions regarding the major part of living standard criteria (vectors). This outcome suggests, for instance, that the Brazilian program of biodiesel use and production (PNPB) which, by the way, has as one of its main targets the social inclusion and therefore the rural poverty alleviation, could not being effective in the case of *Jatropha Curcas* production, since the poor are not being included. A rationale behind it could be the risk aversion and the short horizon embedded in the poverty condition which should be tackled by public policies.

For the sustainability and development of natural resources and the living standards of families, future strategies should be formulated and assessed for meeting the society and familiy objectives such as natural resources management and higher living standards. Thus, similar studies using farming systems economics and living standard approach are strongly recommended not only in the north of Brazil but also in other regions aiming at integrating efforts towards the sustainability on the Brazilian family agriculture sector.

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