Poverty Dynamics and Income Inequality in the Eastern Brazilian Amazon – A Multidimensional Approach

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Abstract Using household-level data from a representative sample of small farmers in the Eastern Brazilian Amazon, this paper analyses poverty dynamics and income inequality among smallholders along the Transamazonica Highway within Pará State, between 1997 and 2005. We compare and contrast two main groups of farmers - settlers and new owners. The main goal of our analysis is to measure the change in poverty level among these smallholders over time, contrasting traditional poverty indexes based on income insufficiency with a multidimensional index based on fuzzy logic. This multidimensional measure of poverty allows the analysis of the contribution of non-monetary income for poverty and inequality reduction. We believe that comparison between indexes will help to understand the role of social, political and environmental dimensions on poverty configuration and livelihood strategies of smallholders, and shed light on viable although not simplistic ways of alleviating poverty in rural environments.

Key words: Poverty; Inequality; Brazilian Amazon; Rural Livelihoods; Multidimensional Approach

Introduction

Despite being the strongest economy in Latin America, poverty is still widespread in Brazil. According to the United Nations (UNDP, 2003), over 72% of the Brazilian population live with less than U$ 500.00 a month. This national pattern, however, differs at the regional level. High levels of poverty are encountered mostly in the Northeast and North. The proportion of poor in 2007 is estimated as 36% of the Northeastern population (13% of extremely poor). In the Northeast, this proportion reaches 43% (18% of extremely poor) (IPEA, 2008a)[5]. The following maps illustrate the spatial concentration of poverty in these two regions (Maps 1 and 2).

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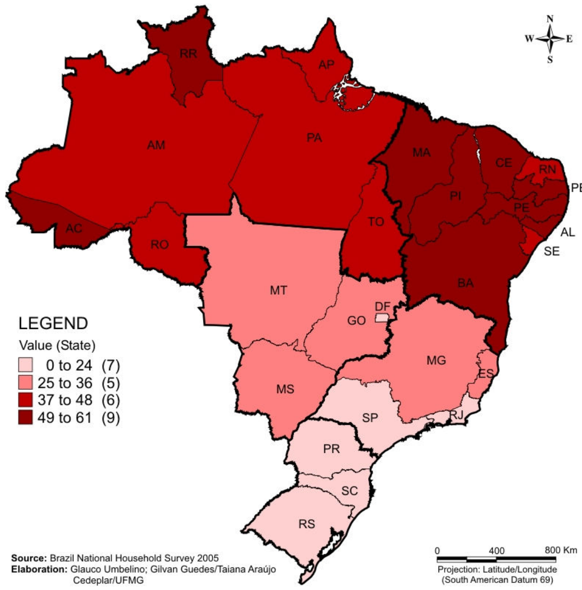
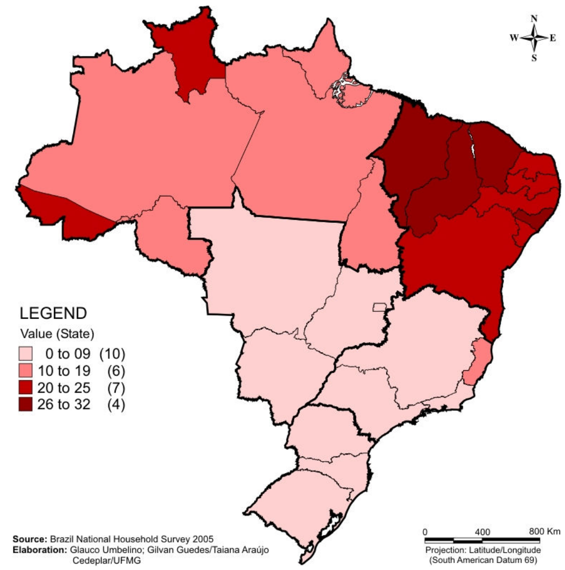
[5] Poverty in these regions are 56% (North) and 88% (Northeast) higher than the national average, and extreme poverty is 67% (North) and 122% (Northeast) higher than in Brazil (IPEA, 2008a).

Map 1: Head Count Ratio by State in Brazil - Poors, 2005



Map 2: Head Count Ratio by State in Brazil
Extremely Poors, 2005



Brazil has also one of the highest income inequalities in the world. In recent decades, however, there has been a decline in poverty and inequality for the country as a whole[6] (Manso *et al*., 2008; Ferreira *et al*., 2006). According to the Institute of Applied Economic Research (IPEA, 2008a), the number of poor[7] has declined almost 21% from 2002 to 2008. Among the extremely poor[8] such a decline has been even more accentuated (44%).

In this paper, we analyze poverty dynamics and income inequality among rural smallholders in a settlement area of the Brazilian Legal Amazon. This area is of particular interest because it was established by the Brazilian Government as part of a broader program of territory integration in the early 70's (Costa, 2002), and the land parcels were originally addressed to smallholders, for whom the main economic activity is agricultural production (Mahar, 1988). Although this paper is not a traditional public policy analysis, because a treatment and control groups are not possible to be identified, we compare and contrast two main groups of smallholders: settlers (the ones who received their land from the government agency and kept it by the time of interview) and new owners (the ones who bought land from a settler or other previous owner).

The main goal of our analysis is to measure the change in poverty level and income inequality among these groups of smallholders over time, and contrast traditional poverty indexes based on income insufficiency with a multidimensional rural poverty index. We believe that comparison between indexes will help to understand the role of social, political and environmental dimensions on poverty configuration, especially regarding rural poverty, and shed light on viable although not simplistic ways of alleviating poverty in rural environments of developing countries.

1. The Challenge of Defining Poverty

[6] The bulk of reduction was due to decline in poverty.
[7] Individuals whose income is equal or less than US$ 130, 00 per month.
[8] Individuals who received ¼ of the minimum wage (US$65,00)

Despite the wide and long literature on what it means to be poor, who defines it and what parameters should be taken into account (Atkinson, 1987; Sen, 1976; Hulme & Sphere, 2003), defining poverty is still a challenging enterprise. It is challenging because poverty has different meanings (Kulindwa, 2005; Sen, 1983) and multiple, hierarchical and complex causes which cannot be easily disentangled (Dunifon, 2005; DeFina, 2002; Sen, 1983).

Most frequently, poverty has been understood in terms of flows of consumption measured by individual and household income level (Foller, 2001). In this regard, the bulk of the economic literature on poverty has been devoted to devising ways of measuring it. Mainstream poverty research, however, even after accepting and recognizing the need for a multi-dimensional approach to poverty, has generally failed to address the dynamic, structural and relational factors that give rise to poverty (Harriss, in press), arguing in favor of cross-site comparability and objectiveness of income/consumption as a general way of accessing people's needs (Crespo & Gurovitz, 2002).

For the purpose of this article, poverty is defined as general lack of choices and opportunities that reflect in low or poor social network, land use tenure, income, access to natural resources, and portfolio of assets (see Fig. 3).

1.1. The nature of poverty: uni and multi dimensions

Poverty dynamics has been the object of an increasing number of studies, both in developed (Maggio, 2004; Antolin et al., 1999) and developing areas (Davis, 2007; Quinsumbing, 2007; Kay, 2006; Diniz, 2008; Justino et al., 2008). The quantitative development of those studies has been followed by a qualitative progress regarding its approach and measurement. The subject ranges from the one-dimensional poverty approach where a given monetary income defines the limits between poor and non-poor to multidimensional frameworks, which take into account information about individuals, households, and the society.

In the one-dimensional approach, income level has been the standard way of assessing whether an individual is above or below the poverty threshold. According to this perspective, an individual is poor if she does not have the minimum potential purchasing power to obtain a bundle of attributes yielding a certain level of well-being. The **money-metric approach** assumes fully operative markets for all attributes and uses market prices to aggregate different goods and services consumed by a given individual. Prices reflect the utility weights assigned by all households (Hoffman, 1998).

Nowadays, it is largely agreed that poverty is a result of multiple causes and encompasses multiple dimensions, ranging from lack of income to limited freedom to exercise human potentialities (Thorbecke, 2005). New approaches derived from the work of Amartya Sen (1983, 1985, 1999), such as the poverty analysis performed by Marta Nussbaum (see Nussbaum & Sen, 1996), attempt to overcome some of the limitations[9]

[9] The most important drawback of the money-metric approach is that it assumes fully operative markets for all goods, but in many circumstances some (non-monetary) elements cannot be purchased because markets may not exist for them, as in the case of some public goods, or simply because of market imperfections. Another import element in favour of more comprehensive approaches toward measuring poverty is, as this

from the one-dimensional approach. The so-called **social deprivation approach** (Boltvinik, 1999) involves a focus on 'multidimensional' poverty and on people's 'capabilities' and potentialities. According to Sen, the study of poverty should not focus solely on measuring income and expenditure, but on the underlying capabilities without which it is not possible to live a fully human life. Boltvinik (1999) argues that not just capabilities but human potentialities should be the focus of poverty elimination strategies. He develops a broader framework, shifting from a human needs and capabilities approach to a *human flourishing approach*[10].

According to the capability perspective (Sen, 1999), social arrangements should be primarily assessed by the plural functioning people value in the promotion of their freedom. Therefore, it follows that this perspective views poverty as a cumulated deprivation of those valuable freedoms (Alkire, 2007). By introducing the trilogy capability–freedom–functioning, Sen has moved the focus of poverty debate away from income and consumption measures to the more abstract consideration of the multiple dimensions of people's lives. What represents the end in the utilitarian approach – money, is only one of the possible ways to be followed in the pursuit of freedom (Sen, 1999).

Broader definitions of poverty, however, face natural measurement and data limitations and, as a result, some restrictions have to be made in the number and type of the attributes being analyzed. Some indexes were created in order to construct a scalar measure, which synthesizes all the relevant human poverty dimensions. Although the Human Development Index (HDI), proposed by UNDP in the 1990's, represents an attempt to capture poverty aspects that go beyond income levels, it only incorporates educational and life expectancy attributes (UNPD, 2003). Building on HDI, the Generalized Human Development Index (GHDI) is an attempt to expand well-being dimensions by including the contribution of additional attributes such as provision of public goods (Chakravarty, 2003).

UNDP indices face serious limitations to inform peoples' condition "on the ground" because aggregate measures at state and country level over glosses how people manage and create more or less local inequalities, injustice, conflict, politics, decisions, in many aspects tied to material hardship and poverty. Following Sen's work, many other multidimensional indices have appeared to better fit diverse national and regional realities. Brazilian researchers at IPEA (Research Institute of Applied Economy), for instance, have proposed an index designed for estimating the degree of multidimensional poverty of each family using commonly available household data surveys (Barros et al., 2006). These data, as they explain, is obtained by asking 48 "yes or no" questions to each family in six dimensions: vulnerability, access to knowledge, household assets, lack of resources, and infant development.

The adoption of household indices such as the one proposed by the current article as well as IPEA researches discussed before have much more potential and applicability

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research also attests for, the differences between rural and urban poverty. In rural contexts, income alone tells very little about people's livelihoods and dismisses its subjective aspects, such as people's level of self-consciousness about their socioeconomic condition, which greatly affects how poverty is experienced and dealt with (Shorrocks, 1995; Sen, 1999, 1976).

[10] Although theoretically stimulating and comprehensive, Boltivinik's conceptual framework is difficult to operationalize due to subjective components usually difficult to get in structured surveys.

to inform policy relevant research. The great advantage however lies in that these local indices can be associated and be informed by fine-rained and site specific ethnographic research on the daily life of the poor. These indices can be integrated with livelihoods research in general and more specifically with research on land use cover/change within political ecology and institutional frameworks.

Some scholarships are illustrative of this multidisciplinary approach to poverty. Focusing on rural poverty, they incorporate the relation between household traditional economic resources with other social forms of assets (such as social networks and remittances) along with natural resource provision (such as available forested land, quality of soil, topography, etc.). Some combined strategies, such as diversification across economic sectors and land use systems, are part of the complex system of rural livelihood strategies in facing income instability and in dealing with ecological pressures (Kay, 2006; Diniz et al., 2007; Murphy et al., 1997; Perz, 2005; Caviglia-Harris & Sills, 2005; German, 2003; Bahuguna, 2000; Reardon & Vosti, 1995; Wunder, 2001; Ribeiro, 1997). The next section broadens the discussion of how rural population faces hardships and how poverty is differently dimensioned among them.

1.2. The Uniqueness of Rural Poverty

Poor people living in rural areas generally have limited access to basic infrastructure and technology (Rocha, 2000; Braverman & Guash, 1986) and experience only partial integration to fully operative markets (Jones & O'Neil, 1993). As a result, they face limited opportunities to make the most of farm production or other income-generating activities (IFAD, 2007). In addition to structural differences between urban and rural environments, rural populations have been exposed to a process of agricultural modernization based on capital-intensive farming, especially in Latin America (Hakkert & Martine, 2003).

These structural changes brought about with the process of market internationalization along with a deficient process of land redistribution caused many of Latin American rural population to remain in poverty. The peasant economy was progressively squeezed out (Kay, 2006), giving place to a large-scale market oriented capitalist rural economy, such as monoculture production of soybeans and corn in the Southern Brazilian Amazon (Brandão *et al*., 2006). Furthermore, when integrated to the market, their well-being is usually more dependent on external factors of production, such as temperature, precipitation levels, water availability (Kulindwa, 2005), soil fertility (German, 2003; Meggers, 1995) and prices of technological inputs (Perz, 2003; Barbier & Burgess, 1996), which may influence their behavior towards production orientation and market integration.

The rural poor have been trying to develop rational mechanisms to face shortage of income and limited access to markets (Caviglia-Harris & Sills, 2005; Murphy, 2001; Murphy *et al*., 1997). Organizational membership, *clientelism*, and other forms of social capital, allow them to weather periods of scarcity (Pieterse, 2001), although this form of capital *per se* has limited effect in overcoming more structural causes of rural poverty, such as land concentration and lack of credit (Kay, 2006). As a response to larger sociopolitical and economic transformations, peasant workers or some of his/her family members are becoming increasingly involved in non-farm agricultural activities (Murphy, 2001). Off-rural migration has been one of the strategies adopted to generate income and bring about economic diversification. As a result, manyfamilies now rely on remittances as informal credit arrangements (Barbieri *et al*., 2009; VanWey *et al*., 2009; Guedes *et al*., n.d.).

1.2.1. Rural Poverty in Latin America, Brazil and the Amazon

In Latin America and the Caribbean, almost 44% of its population and 64% of the rural population are poor and this number has increased over the last two decades in rural areas (IFAD, 2007b).

Poverty in rural Latin America and the Caribbean is multidimensionally recreated. Rural poor suffer from social and economic exclusion, limited access to basic services such as health, education, and housing, and poorly organizational development (Hakkert & Martine, 2003). The lack of sustainable development strategies in these areas not only prevents rural poor from having equitable access to political and economic resources but is also accompanied by low levels of income that prevent them to afford basic private goods and services (Grossman, 1981). In addition, rural poverty in the region is often associated with geographical and institutional isolation (Hakkert & Martine, 2003). This setting propitiates the emergence and perpetuation of structural poverty, which generally affects illiterates, persons with limited portfolio of assets and low working skills, and is mostly found among indigenous communities, rural woman and ethnic minorities (IFAD, 2007a).

In Brazil, the incidence of rural poverty is particularly high. Almost 80% of the rural population, about 30 million people, lives in conditions of poverty, and in communities subsisting in difficult conditions and degrading environments (IFAD, 2007a). The poorest and most vulnerable groups among rural poor people are women, young people, and ethnic minorities such as Afro-descendants. Households headed by women account for 27% of the rural poor. Child labor is still common among poor households, and in some areas, especially the Northeast, the number of children between 10 and 14 years of age who work to supplement family income is still high.

One of the major causes of rural poverty in Brazil is the severe inequality of land tenure, especially in the Northeast and in the Midwest (IFAD, 2007b). Moreover, the lack of access to formal education contributes to its perpetuation over time. Poverty itself, along with imperfect capital markets, may increase the discount rate and reduce the time horizon of rural Brazilian smallholders, leading them to adopt low-technological agro-pastoral activities which contribute to decline in soil fertility (Barbier *et al*., 1997). This two-way relationship between poverty and production decisions in rural areas is an important dimension of poverty perpetuation and increase in income inequality in the country and elsewhere (Diniz, 2008).

According to Diniz and colleagues (2007), poverty in the Legal Brazilian Amazon is higher than the national average, although inequality is lower, which sets the basis for poverty homogeneity: a combination of high level of poverty with low inequality. The authors state that the region has been experiencing a process that reinforces its poverty structure. The Gross Domestic Product (GDP) and the headcount ratio[11] (proportion of poor) have shown a steady trend until the mid 90s. Between 1990 and 1992, the

[11] Both measures (relative and absolute) have shown the same time trend in the region (Diniz *et al*., 2007).

economic growth was actually followed by increase in poverty level. Since then, especially in a recent period (2002 to 2004), the economic growth benefited the poor by increasing the number of people migrating out of poverty.

The state of Pará, part of the Brazilian Amazon, has large areas of natural resources, including primary rainforest, despite the persistent deforestation driven by cattle ranching (Fearnside, 2005). As in Brazil, the state faces a very asymmetrical land tenure distribution, and some studies suggest that land consolidation due to large-scale cattle ranching is displacing smallholders to farther frontiers and to urban areas (Walker *et al*., 2000; Faminow, 1998). Poverty is widespread in rural and urban areas and the state remains as one of the poorest in Brazil. Almost 59% of its rural population lives below the poverty line (Verner, 2004).

These statistics reveal that reducing poverty is a central challenge in the region, especially because of its propelled impact on deforestation as represented by invasive forest mobility. As recognized by the emerging literature on multidimensional rural poverty, poverty and inequality scholarship in the Amazon must focus on its uneven spatial organization and on the livelihood strategies of rural households when proposing strategies for poverty alleviation. This can be done by addressing its dynamics over time and its singularity among rural poor, as they are representative of a considerable proportion of the poor population as a whole and has been proved to negatively impact their surrounding environment. In this paper, we use longitudinal primary data and cross-sectional secondary data for Pará State, in the Brazilian Amazon, in order to address poverty and inequality dynamics and environmental and social dimensions of poverty among smallholders along Transamazônica Highway, as described in the next section.

2. Rural Poor and the Environment

According to the International Fund for Agricultural Development (IFAD, 2008), 75% of world's poor live in rural areas of developing countries, which comprise approximately 800 million people, and this proportion could remain the same at least until 2040.

The alarming poverty level in rural areas of developing countries has been raising concerns about the synergistic interaction between rural poor and their surrounding environment (Wunder, 2001). As rural poor rely mainly on agriculture and related activities for their livelihood (Sherbinin *et al*., 2008; Netting, 1993) and as contemporary processes such as climate change, rising energy and food prices, agro-fuel production and increasing migration and urbanization are reshaping the face of poverty in rural societies, IFAD (2007a) suggests that domestic investments and external assistance should focus on rural areas and particularly on small-scale agriculturalists.

Some authors argue that the promotion of sustainable economic development in rural settings could increase employment opportunities, reduce regional income inequalities, prevent rural-urban migration, and ultimately reduce poverty (Anriquez & Stamoulis, 2007; Perz, 2000; Grossman, 1981). Rural development could also contribute to protection of indigenous cultures and traditions as well as conservation of rural landscape by reducing environmentally degrading anthropogenic activities, such as deforestation and low-technological land use systems (Salafsky & Wolenberg, 2000). At last, as suggested by Anriquez & Stamoulis (2007), rural areas may serve as a bumper for urban poor in periods of economic crisis.

As rural poverty is widespread in Latin America to date and as there is a considerable proportion of poor in forested areas, such as the Amazon, poverty alleviation in these areas might be an effective way of contributing to sustainable reduction of environmental degradation of tropical rainforests in the medium and long run.

3. Study Area

We make extensive use of data from the project *Amazonian Deforestation and the Structure of Households*. The project was conducted by the Anthropological Center for Training and Research on Global Environmental Change at Indiana University, and covers three research sites in the Brazilian Amazon: Santarém, Altamira e Lucas do Rio Verde. In this paper, we focus on Altamira only.

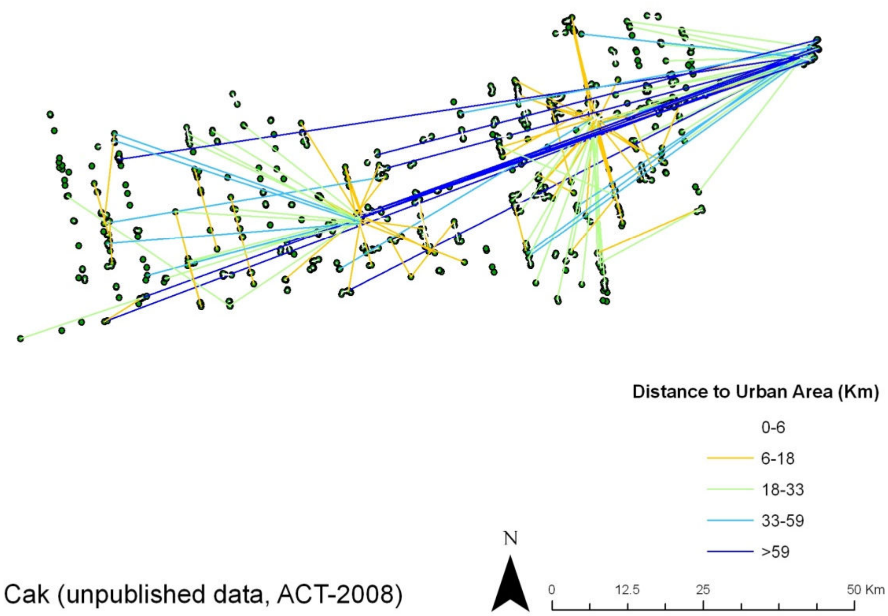
Altamira study area covers 404.700 hectares. The region is situated in the middle of the Amazon Forest and is located 740 Km away from Belém, the capital of Pará state, and is crossed by the Xingu River from north to south. The rural area under study has some important characteristics, which distinguish it from other settlement areas in the region. Altamira is a young settlement frontier; its colonization scheme started in 1970 and continued with family migrants arriving until the first half of the 80's. The Brazilian Government, by means of its National Institute of Colonization and Agrarian Reform (INCRA, in Portuguese), established a grid of small farm units (more or less 100 hectares) along the Transamazônica Highway. All the properties have their front to a feeder road (called *Travessão* in Portuguese), or to the Transamazônica Highway (VanWey et al., 2007). The small size units were designed to incentivize family agriculture and small-scale cattle ranching (Smith, 1982; Moran, 1981). The settlement project in Altamira region is considered an alternative to more radical land redistribution programs, such as a large scale agrarian reform, and differently from other Amazonian countries[12], was relatively common in the Brazilian Amazon (Murphy et al., 1997).

Altamira is characterized by high-fertility soil, known as *terra roxa*. Cacao production and cattle ranching are the main agro-pastoral production among farmers. Despite being a successful example of agrarian settlement in Brazil, the area is under influence of external forces, such as land consolidation by large capitalist ranchers and persistent high interest rates for credit (VanWey et al., 2005). Moreover, commodities price has declined in recent years, mainly because of increase in demand for soybeans and related by-products (Walker *et al*., 2000). Many international restrictions to Brazilian meat also contributed to worsen the agricultural/cattle ranching sector in Pará. As a result, families are adopting some strategies to minimize risk. Some farmers, for example, moved to the urban area or sent their children to study or work in the city (VanWey *et al*., 2009; Guedes *et al*., n.d.). This spatial diversification is a strategic way of reducing intra-family income variance, allowing smallholders to better deal with agricultural price oscillation and shortage of production due to climatic, economic or

[12] The Amazon rainforest region comprises six South American countries: Brazil, Peru, Colombia, Bolivia, Ecuador and Venezuela.

political factors. Figure 1 reveals that the rural-urban linkage is a very common strategy among smallholders in Altamira[13].

Figure 2: Rural Properties with Associated Urban Households in 2005



Source: Cak (unpublished data, ACT-2008)

4. Data Sources

This paper uses datasets from two different sources. Poverty and inequality indexes at Pará state level, used as reference[14], were estimated using microdata from National Household Survey (IBGE, 1997, 2005). At Altamira level, we used data from 1997/1998 and 2005 Altamira survey.

Data in Altamira region study area were first collected in 1997/1998 and a follow-up survey was conducted in 2005. In the first wave, 402 households in different pieces of land were sampled (see figure 2). The sample corresponds to a stratified sample of farm units by cohort of settlement and is representative of the farm units in the region. The survey interviewed the head of the household, the spouse and any other women in the property aged 15 and over. Males responded an economic and land use questionnaire, while females (spouses or property owners) answered the socio-demographic and reproductive history / contraceptive methods questionnaires. For all other women living

[13] In order to de-identify the sampled properties, all the geographical coordinates, roads and grids were dropped.

[14] It was not possible to estimate poverty and inequality indexes for rural Pará, because the rural areas of the states comprising the North region in Brazil were incorporated into the National Household Survey since 2004 (IBGE, 2005). For both years, we applied the household frequency weight factor and for 2005 data we estimated the indexes by using the *svy* commands in Stata 10.0 in order to account for complex survey design.

in the household aged 15 and over it was applied the reproductive history and contraceptive sections.

The 2005 follow-up aimed at three groups present by the time of the first wave: a) same couples interviewed in 1997/1998[15]; b) other households located in the same piece of land sampled in the first wave and; c) children of the couples interviewed in 1997/1998 who were living in the own households in 2005.

For poverty and inequality measures based on household income, we used data from both waves (1997/1998 and 2005). We restricted the longitudinal sample to the smallholders who were considered settlers and new owners in 1997/1998 and kept the property in 2005. The new property owners who acquired or inherited the land between waves were discarded. Thus, for poverty and inequality dynamics, sample size was restricted to 304 observations with valid cases for income. For measures based on the multidimensional factor, we restricted our sample to the 1997/1998 owners who had complete information on income and additional selected characteristics (as suggested by Figure 3). The final sample totaled 344 observations.

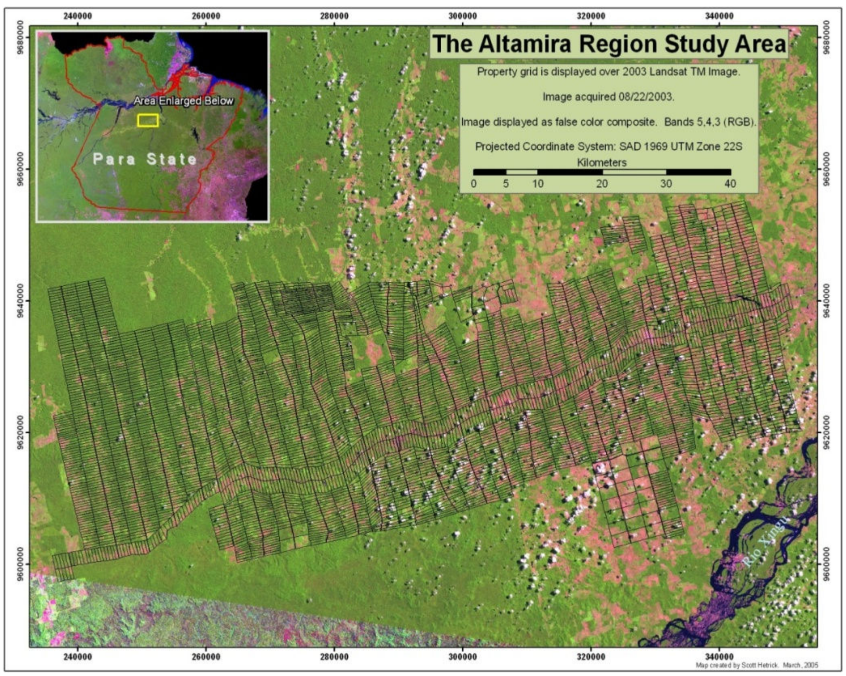


Figure 2: The Altamira Region Study Area

4. Method

This session describes both methods used to measure poverty in Altamira study area. The first group of indexes is based on a money-metric approach (although in this paper we apply it to a multidimensional factor) and is widely used in poverty analysis. The second method is based on fuzzy logic and generates individual degrees of pertinence to reference groups of elements based on selected characteristics. The multivariate fuzzy method is applied to the first wave of Altamira data only because of

[15] Approximately half of the 402 properties were interviewed in the end of 1997 and the other half in 1998.

the 1:1 correspondence between lot and owner[16]. Results are estimated for the whole sample and disaggregated into two groups of smallholders: original settlers and new owners.

Based on the literature about multidimensional poverty, specially the rural livelihoods approach, we summarize the relevant dimensions to rural families' livelihood into a multidimensional index based on six dimensions: social network, land use strategy, income formation, natural resources, community-based network, and portfolio of assets (Figure 3). The conceptual index suggested recognizes the external influences on poverty configuration at higher levels, although our empirical calibration for this paper takes them as given. This way, poverty and its dynamics are responsive to macroeconomic and social changes as change in levels are observed empirically.

[16] In 2005, some lots were divided due to selling or bequest, resulting in multi-property lots.

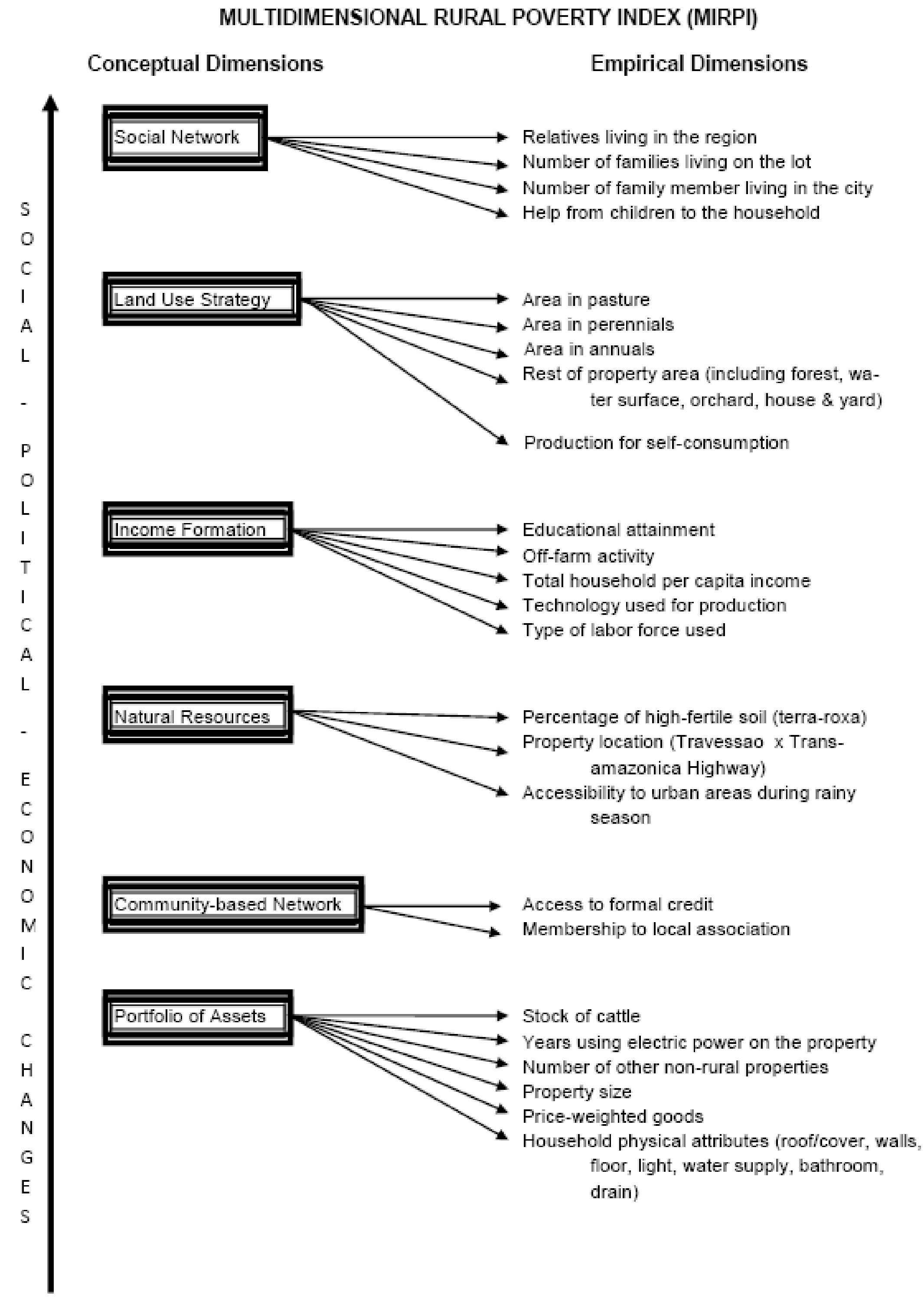


Figure 3: Conceptual Framework for Multidimensional Rural Poverty

4.1. The FGT Measures

The following poverty indexes are widely applied in poverty studies and used to measure several aspects of poverty such as proportion and intensity (Stewart, 2006). Therefore, instead of substitutes, they must be seen as complementary to each other since they respond differently to different aspects of poverty (Foster *et al.*, 1984).

4.1.1. The Headcount Index (HC)

The headcount index is the proportion of the population for whom income (or other measure of living standard) is below the poverty line.

$$HC = \frac{1}{N}\sum_{i=1}^{q} 1 = \frac{N_q}{N} \quad (1)$$

where N = total population; z = poverty line; y_i = household income I y_i , …, $y_q < z < y_{q+1} \ldots y_n$; N_q = number of poor in the population.

The headcount index does not take the intensity of poverty into account, that is, it is insensitive to differences in individual's poverty depth.

4.1.2. The Poverty Gap (PG) and Poverty Gap Index (PGI)

The poverty gap is the average, over all persons, of gaps between poor's living standards and the poverty line. It indicates the average extent to which individuals fall below the poverty line (if they do).

Using the same notation as before,

$$PG = \frac{1}{N}\sum_{i=1}^{q}(z - y_i) \quad (2)$$

The poverty gap index (PGI) is defined as the ratio of the Poverty Gap (PG) to the poverty line. It is the poverty gap expressed as a percentage of the line.

$$PGI = \frac{1}{N}\sum_{i=1}^{q}\frac{(z - y_i)}{z} \quad (3)$$

The PG and PGI do not capture differences in the severity of poverty amongst the poor and ignore inequality among the poor.

4.1.3. Squared Poverty Gap Index

The squared poverty gap index is a weighted sum of poverty gaps (as a proportion of the poverty line), where the weights are the proportionate poverty gaps themselves (like the PG, but with weights given to each observation).

The squared poverty gap index (SPGI) is defined as the average of the squared relative poverty gap of the poor.

$$SPGI = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{z - y_i}{z}\right)^{\alpha} \quad (4)$$

The squared poverty gap index has the advantage of taking inequality among the poor into account. A switch from a poor group to an even poorer would reduce the index; by contrast, a transition from a very poor to a less poor would increase the index.

4.1.4. Foster-Greer-Thorbercke class

The headcount index, the PG and PGI, and the squared poverty gap index all belong to the Foster-Greer-Thorbecke class of measures. Using similar notation

$$P_\alpha = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{z - y_i}{z}\right)^{\alpha} \quad (5)$$

The measures are defined for $\alpha \geq 0$, and α is a measure of the index sensitivity to poverty.

If α=0, we have the headcount index;
If α =1, we have the poverty gap index;
If α =2, we have the squared poverty gap index.

The “FGT family” indexes have the desirable properties of being decomposable and meeting the focal axiom, since they do not respond to the variation of non-poor’s income. The Headcount Index (P_o), however, does not meet the monotonicity axiom, since it is not susceptible to variations in the poor’s income, and the transfer axiom as it is insensitive to intra-group income redistribution. The Poverty Gap Index (P_1) does not meet the last property as well, although it satisfies the others ones. Despite being difficult to read and interpret, the Squared Poverty Gap Index (P_2) satisfies all three axioms.

As each index responds in different ways to different dimensions of one-dimensional poverty, it becomes insightful to consider the three all together in order to analyse poverty under distinct aspects and specificities (Foster *et al.*, 1984).

4.2. Inequality Measures: Gini and L-Theil

In our analysis, we apply two of the most common income inequality measures in the empirical literature: Gini and L-Theil. Gini coefficient can be derived from the income distribution or from the Lorenz Curve (Dorfman, 1979). Gini coefficient graphically represents the increase in the cumulated proportion of income ($\square_i$) due to the cumulated proportion of population (p_i) over the i-th person (Hofmann, 1998: 34). Thus, p_i is given by:

$$p_i = \frac{i}{n} \quad for \quad i = 1, \cdots, n \quad (6)$$

The cumulated proportion of income, by its turn, is given by:

$$\varpi_i = \frac{1}{n\mu}\sum_{j=1}^{i} x_j \quad for \quad j = 1, \cdots, i \quad (7)$$

In (6), x_j represents the income of the i-th person in a population of ‘n’ persons with μ as the average income.

As a salient summary statistics of the Lorenz Curve, L(u), which represents the proportion of the total income of the economy that is received by the lowest 100u% of income receivers, Gini coefficient corresponds to the difference between a specific Lorenz Curve and the Lorenz Curve of an economy where everybody receives the same income. This leads to:

$$G = 1 - 2\int_{O}^{1} L(u)du \text{ , (8)}$$

with the area under the Lorenz Curve defined as:

$$\int_{0}^{1} L(u)du = \frac{1}{2\mu}\int_{0}^{y^*} (1 - F(y))^2 dy \text{ (9)}$$

Replacing (9) into (8), we get to:

$$G = 1 - \frac{1}{\mu}\int_{0}^{y^*} (1 - F(y))^2 dy \text{ , (10)}$$

with increase in G representing larger differences between the area under L(u) where everybody receives μ and L(u) observed. In equation (9), 'u' represents the proportion of aggregate income that goes to the members of the population in the lowest 100u% of the income distribution, μ is the mean of the cumulated probability distribution of income, y* its upper limit, and F(y) the proportion of the population that receives incomes no greater 'y'.

L-Theil is defined as:

$$L = \frac{1}{n}\sum_{i=1}^{n} \ln\frac{1}{ny_i} \quad for \quad i = 1,\cdots,n \text{ (11)}$$

Let a population of 'n' individuals receiving a non-negative fraction of income and y_i be the share of the i-th person on total income:

$$y_i = \frac{x_i}{n\mu} \text{ (12)}$$

L takes the following limit values:

$$\begin{aligned} y_i &= \frac{1}{n}, \quad \forall i \Rightarrow L = 0 \\ y_i &= 0 \Rightarrow L = \infty \end{aligned} \quad (13)$$

Equation (11) and condition (13) imply that L is not applicable to households with no income.

4.3. The Grade of Membership Model

4.3.1. Model description

The Grade of Membership (GoM) model is a statistical methodology used to delineate clusters of elements within a heterogeneous and multidimensional dataset (Woodbury *et al*., 1978; Manton *et al*., 1994; Lamb, 1996; Portrait *et al*., 1999, 2001; Cassady *et al*., 2001). Differently from other clustering techniques, GoM does not impose individuals and objects to be organized in well-defined (i.e., 'crispy') sets (Woodbury *et al*., 1978).

The empirical application of GoM implies the identification of at least 2 extreme profiles, k, derived from non-observed association among variables categories in the model, and corresponding to crispy sets with the same mathematical properties. For each individual in the sample, *k* degrees of pertinence, g_{ik}, are estimated in relation to the extreme profiles. As an individual's degree of pertinence to the reference groups constitutes a fuzzy set, a larger number of variables will improve its delineation. These g_{ik} scores vary from 0 to 1. Zero indicates that the element does not belong to the set and one means that it entirely belongs to the set.

The model estimates two main parameters, g_{ik} and λ_{kjl}, by means of iterative process, maximizing the likelihood function defined by the distance of each variable category to the centrality of the sample (Woodburry, 1978). GoM assumes that the answers given by each individual are independent. The g_{ik} (k = 1, 2, ..., k) are moments of the random vector$\zeta_i = (\zeta_{il}, ..., \zeta_{ik})$ with distribution function H(x) = P ($\zeta_i \leq$ x). Thus, GoM scores are the result of random variables when an individual is selected in the population under analysis. The distribution of the samples of realization (the scores in the sample) gives the estimates of the distributional function H(x). If the degree of pertinence, $g_{ik,}$ is known, the answers to the questions Y_{ijl} by individual "i" are independent across categories for the same variable. The probability to answer "i", for the "j-th" question, for the individual with the "k-th" extreme profile, is λ_{kjl}. By assumption, there is at least one individual who is a well-defined ('crispy') member of the "k-th" profile. This assumption gives the probability that this individual has to answer each category for each question.

The probability of an answer at level "i", of the "j-th" question, by individual "i", conditional to the score g_{ik} is given by:

$$P(Y_{ijl} = 1) = \sum_{k=1}^{k} g_{ik}\lambda_{kjl} = 1 \qquad (14)$$

The probability model, based on a random sample, is the multiplication of the multinomial model by the probability for each cell, given by:

$$E(Y_{ijl}) = \sum_{k=1}^{k} g_{ik}\lambda_{kjl} \qquad (15)$$

where g_{ik} is, by assumption, known and $g_{ik} \geq 0$. The maximum likelihood model is, then, described as:

$$L(y) = \prod_{i-1}^{I}\prod_{j=1}^{J}\prod_{l=1}^{L}(\sum_{k=1}^{k} g_{ik}\lambda_{kjl})^{yijl} \qquad (16)$$

4.3.2. Empirical Strategy

In this paper, we follow literature suggestion on relevant poverty dimensions in rural areas (Diniz, 2008; Diniz *et al*., 2007; Key, 2006; Perz, 2005; Thorbecke, 2005; Maggio, 2004; Crespo & Gurowitz, 2002; Bebbington, 1999; Sen, 1985) by considering six groups of relevant characteristics: social network, land use strategies, income formation, natural resources, community-based network, and portfolio of assets (Figure 1). To understand the role of these groups of variables on poverty configuration, we compare the results obtained from the traditional FGT measures with the ones from the multivariate GoM model using a transition matrices approach. The use of transition matrices allows us to obtain an empirical measure of probabilities of migrating out of poverty when incorporating the non-monetary dimensions of smallholders' livelihoods.

Using the GoM model, we generate 2 extreme profiles of smallholders, the least (EP – Poorest) and the best well-off (EP – Richest), as presented in Table A1. These profiles are stratified by two main groups of smallholders: the settlers and the new owners. Then, we apply the transition matrices by calculating the probability of being located at least at 2/3 of median of $\sum_{g=0}^{1} g_{i2}$ (the cumulated pertinence to the best well-off extreme profile), given that a particular smallholder was classified as poor according to the FGT measures[17] (Iceland & Bauman, 2007; Iceland, 2005). We perform the same calculations for the transition from income-based non-poor to GoM-based poor.

We are particularly interested in evaluating the success of settlers, compared to the trajectory of the new farmers who bought the land from a previous owner or from a previous settler. As we know, however, the wealth status upon arrival in the region is an important determinant of smallholders' welfare trajectory (Perz, 2001; Murphy, 2001; Murphy *et al*., 1997). Thus, we add this additional attribute in the GoM model for both groups. Murphy and colleagues (1997) define initial wealth as reported possession of land and employment status before migration to the rural lot. In a more recent article, Murphy (2001) classifies a smallholder as well-off if possessing more than 10 hectares before migration[18]. Perz (2001) approximates the initial wealth index by means of a factor-weighted measure accounting for ownership of durable goods and initial housing quality. In another article (Perz & Walker, 2002), the initial wealth was slightly modified to account for agricultural capital index only (including possession of chainsaw, cocoa dryer and tractor). In this study, we perform a regression based index of wealth upon arrival (as suggested by ABEP, 2007). We regressed selected household assets and holdings upon arrival on the log of household total income[19]. This weighted factor was, then, cumulated and the classification of well-off smallholder was based on being at 2/3 or above the median of the distribution.

We created two additional weighted factors for agricultural technology and assets, using the same regression strategy as applied to the initial wealth factor. The agricultural technology factor combines information on manual/animal-based and motor-based technology and on type of fertilizer applied to farming, regressed on the log of total agricultural production[20]. The index was cumulated and categorized into below or above

[17] For the transition matrix approach, we recalculate the FGT measures using the same criterion: poor defined as located at below 2/3 of the median of cumulated income distribution and extremely poor at below 1/2.

[18] In her study area, the average property size is around 50 hectares. However, the initial wealth measured as an arbitrary land size without knowing the average size of the properties in the area of origin leads to a somewhat weak proxy of initial wealth.

[19] For the initial wealth index we included the following dummy variables (with weights in parenthesis): possession of refrigerator (1), radio (-1), sewing machine (-1), color TV (3), dish antenna (4), chainsaw (-2), tractor (3), commerce (-2), urban house (-2), urban land (7), rural house (-3), rural land (4), other assets (3). Index ranged from -6 to 13. Model statistics: R^2 = 60.70%; ρ (income; index) > 0 and significant at 1%. The model also controlled for current education of household head, current possession of the same referred assets, and if the house currently has bathroom.

[20] For production technology we included the following dummy variables (with weights in parenthesis): manual (0), draft animal (9), motor (10), chemical (-3), non-chemical (4). Manual technology was

the median, suggesting high and low productivity technology. For the assets factor, we gathered information on possession of selected household assets, and then regressed on the log of total household income[21]. The index was cumulated and categorized in quintiles of the cumulated distribution (0 – 20%, 21 - 40%, 41 - 60%, 61 - 80%, 81 - 100%). The advantage of the regression-based weighted factors is that the weights are derived empirically from the sample instead of arbitrarily assigned, and produces a closer description of sample heterogeneity along distributions (ABEP, 2007).

The land use/cover variables were transformed into proportion of lot size under specific classes (annuals, perennials, pasture and forest), and then cumulated and categorized into quartiles (0 – 25%, 26 – 50%, 51 – 75%, 76 – 100%). Other variables defined in terms of quantiles of cumulated distribution were: monetized value of agro-pastoral production for self-consumption[22], total household income, and cattle herd size. Dummy variables include: family members living on the lot, upward financial transfers, other relatives living in the region, family members living in urban areas, household members with off-farm activities, lot accessibility, and membership to agricultural association. Number of properties belonged to household head was defined as count variable. The additional variables have categories rearranged according to original categories and absolute frequency in each category.

4.3.2.1. Defining the Extreme Profiles

The number of extreme profiles can be established according to two different criteria: by means of theoretical orientation (as in Sawyer *et al.*, 2002), or by a technical criterion, comparing the Akaike criterion (AIC) statistics for models with different number of extreme profiles[23] (Manton *et al.,* 1994). Garcia and colleagues (2007) suggests the use of 2 extreme profiles when defining hierarchies. Thus, we departed from two reference groups (Table A1). Although somewhat arbitrary, the reference groups are not the core of the analysis, since they represent crispy sets, but in poverty and hierarchy analysis they are references for defining the ends of cumulated distributions, allowing for better establishment of multidimensional poverty threshold (Garcia *et al*., 2007). In this

constructed from use of grader/harrow, plough, or trailer/wagon. Animal-based technology was created from use of draft animal grader/harrow, plough, or trailer/wagon. Motor-based technology was created from use of chainsaw, grinder for manioc flour, or generator. Chemical inputs are the categorization of use of insecticide, fungicide, herbicide, chemical fertilizer or medicines. Non-chemical inputs are derived from use of organic fertilizer, mineral salt or irrigation. Model statistics: R^2 = 19.02%; ρ (production; index) > 0 and significant at 1%.

[21] Selected household assets with corresponding weights (in parenthesis): refrigerator (4), radio (-1), sewing machine (-1), color TV (3), dish antenna (1), chainsaw (4), tractor (2) and small truck (6). Model controlled for current holdings, education of household head and if the house has bathroom. Index ranged from -2 to 19. Model statistics: R^2 = 55.23%; ρ (production; index) > 0 and significant at 1%.

[22] We transformed production by crop and animal type into kilogram-equivalent. Then, we took price per kilo effectively get from selling among Altamira smallholders and multiplied it to total production for self-consumption. This way, we monetized the production not sold by making two assumptions: a) perfect market clearing; b) supply is price inelastic.

[23] A model with k+1 profiles can be compared to a model with k profiles, using the values of the Akaike criterion (AIC) for each extreme profile as the test statistics. A generalization of the estimated AIC of the maximum likelihood function allows the selection of the model with the smallest distance from the data, even in cases where the structural model is unknown.

study, we allowed GoM to first select the 2 elements of extreme profiles randomly. Then, we fed the model with estimates of λ_{kjl} from the previous round each time we performed a new run. This is an important procedure to assure that GoM estimates are in its global optimal (Junqueira & Machado, n.d.). We tried 20 rounds and analyzed the patterns of λ_{kjl} estimates over rounds. From round 7 to 8 λ_{kjl} converged to identical estimated values and were then used as final coefficients.

The final estimated values of λ_{kjl} represent the probability of a category "l" of a variable "j" to be part of the extreme profile "k". This value was divided by the percentage of observations in the correspondent category of the same variable in the whole sample. This ratio is known as the Lambda-Marginal Frequency Ratio (LMFR). Operationally, each λ_{kjl} (predicted probability) is divided by the relative marginal frequency for each variable used in the analysis. Every time the LMFR>=1.2 for one category of a variable, this category was considered to be "dominant" in that extreme profile. Using a higher RLFM increases the likelihood of a given variable not be selected as part of a given profile (see Machado, 1997). The threshold is arbitrary and depends on the degree of heterogeneity one wants to capture in the sample (Sawyer et al., 2002). The two extreme profiles thus was described according to the categories of each variable with the LMFR>=1.2 (Table A1).

4.3.2.2. Classifying Multidimensional Rural Poor

One advantage of GoM method over cluster techniques based on binary logic[24] is that it not only generates profiles of individuals clustered into similar characteristics but also produces a quantitative measure of individual heterogeneity, defining the degree of pertinence to each one of the extreme profiles. Both measures can be applied to poverty analysis: while the profiles somewhat overcome the arbitrariness of defining a poverty line, the individual-based heterogeneity measure can be used as a traditional continuous variable (such as income) when defining the level of poverty for each individual.

In this analysis, we used the estimated degrees of pertinence to the best well-off profile (g_{i2}) as our multidimensional welfare measure. Following the same strategy for income-based relative poverty measures, we defined poor and extremely poor as follows:

$$\begin{aligned} MIRPI\_Poor &= g_{i2} < \frac{2}{3} Median\left[\sum_{i=1}^{344} g_{i2}\right] \quad for \quad i = 1,\cdots,344 \\ MIRPI\_ExtremelyPoor &= g_{i2} < \frac{1}{2} Median\left[\sum_{i=1}^{344} g_{i2}\right] \quad for \quad i = 1,\cdots,344 \end{aligned} \tag{17}$$

Inequality measures used the same cumulated g_{i2} distribution applied to equations (8) and (11).

5. Results

Pará state was considered the poorest among the Legal Brazilian Amazonian states (excluding Maranhão, which has just part of its territory in included) in 1997,with 50% of

[24] GoM is an appropriate method for clustering when applied to categorical data. For continuous variables there are more robust alternatives, such as FANNY method (Kaufman & Rousseeuw, 1990).

its population classified as living below the poverty line[25]. In 2005, the Headcount ratio dropped to 44.0%, representing a reduction of 12% in 8 years. If the extreme poverty line is considered, the HC ratio dropped from 21.0% to 16.0% (a decrease of 23%). Over the same period, the percentage of poor in Brazil dropped from 35 to 31% (a reduction of 11%), while the percentage of extremely poor dropped from 16 to 11% (a decline of 31%). Despite the decline, contemporary poverty in Pará is still widespread.

Table 1
Headcount Ratio (HC) in Pará and Brazil - 1997 and 2005

Geographic Unit	Population Group	1997	2005	Δ (%)
		HC (Caloric Consumption Insufficiency)		
Pará	Poor	50.0	44.0	-12.0
	Extremely Poor	21.0	16.0	-23.8
Brazil	Poor	35.0	31.0	-11.4
	Extremely Poor	16.0	11.0	-31.3

Source: IPEADATA (2008)

FGT poverty measures are presented in Tables 2 and 3, for both relative and absolute poverty lines. If we consider the measures using the absolute criterion, the proportion of poor among Altamira rural smallholders was approximately twice the level for Pará state in 1997[26]. The difference is still higher among extremely poor (almost 5 times). Using the relative measures, the difference reduces significantly, suggesting that although poverty level is higher, inequality is closer to the state level. This is confirmed by smaller differences for inequality measures. Surprisingly, differences in poverty levels between settlers and new owners were virtually inexistent although inequality was significantly higher among settlers (13%).

[25] The poverty line estimated by IPEA (2008b) is based on the amount of money required to buy a basket of essential products in order to supply the needs for caloric intake. The poverty line is regionalized and estimated separately for rural, urban and metropolitan area. By 2001, for instance, the estimated poverty line in the metropolitan area of Belém (Pará state capital) was R$115,92 (U$47.70), while R$119,86 (U$49.32) for the urban area and R$104,88 (U$43.16) for the rural area.

[26] Poverty measures for Pará in 1997 were estimated based on per capita household income from PNAD (IBGE, 1997). As PNAD was not representative of the rural population for the Northern states of Brazil until 2003, the measures are basically based on urban population. This is why from 1997 to 2005 (tables 2 and 3) poverty levels seemed to have increased, although this has not proceeded. Poverty series from IPEA (IPEA, 2008a), only provide information on HC.

Table 2
Poverty and Income Inequality in Altamira Study Area according to the type of land acquisition - 1997/1998 (Estimates for Pará State in 1997 for comparison)

Indexes	Small holders	Settlers	New Owners	Pará State
	Absolute Poverty Line			
Poor				
HC	60.1	61.0	59.6	33.8
PGI	43.9	44.0	43.9	10.0
SPGI	37.7	37.8	37.7	7.3
Extremely Poor				
HC	45.7	46.3	45.3	10.0
PGI	34.9	35.5	34.6	2.6
SPGI	30.9	30.7	31.0	2.3
	Relative Poverty Line			
Poor				
HC	43.8	46.3	41.6	31.2
PGI	33.7	34.9	33.0	20.2
SPGI	32.0	30.2	29.8	6.4
Extremely Poor				
HC	40.1	43.9	37.3	20.2
PGI	30.9	31.5	30.7	5.7
SPGI	30.2	27.7	28.1	3.9
Income Inequality				
Gini	0.7465	0.7980	0.7071	0.5690
L-Theil	1.5806	1.9300	1.2937	0.6980

Source: Altamira Study Area Dataset (1997/1998); PNAD (1997)
Note: Poverty line = 1/2 Brazilian minimum salary (R$ 120.00/2 = 60.00 or U$30.00) in 1997. Extreme poverty line = 1/4 Brazilian minimum salary.

In 2005, poverty levels among smallholders in Altamira approached the state average and differences between settlers and new owners became more pronounced. The gap between settlers and new owners for HC ratio was 18% higher for settlers among poor and 11% among extremely poor. Inversely, income inequality in 2005 was 16% lower among them. Differences between settlers and new owners were even higher if considering relative poverty, especially among extremely poor (35% higher for settlers), despite their smaller inequality (Table A1). This dramatic change over time suggests that poverty homogeneity seems to spread among settlers, while new owners have successfully been reducing poverty, combining increase in average income with decline in inequality.

Table 3
Poverty and Income Inequality in Altamira Study Area according to the type of land acquisition - 2005 (Estimates for Pará State in 2005 for comparison)

Indexes	Small holders	Settlers	New Owners	Pará State
	Absolute Poverty Line			
Poor				
HC	36.8	40.7	34.6	45.7
PGI	18.0	20.0	16.9	16.3
SPGI	11.4	12.0	11.1	10.5
Extremely Poor				
HC	18.4	19.8	17.6	16.4
PGI	7.7	7.3	7.9	4.3
SPGI	4.9	4.3	5.2	3.0
	Relative Poverty Line			
Poor				
HC	35.0	40.7	32.0	30.5
PGI	16.1	17.9	15.1	7.9
SPGI	10.1	10.6	9.9	5.7
Extremely Poor				
HC	25.6	30.9	22.9	19.2
PGI	11.7	12.3	11.3	4.6
SPGI	7.2	6.9	7.3	3.4
Income Inequality				
Gini	0.5652	0.4910	0.5843	0.5135
L-Theil	0.6885	0.4370	0.7523	0.5367

Source: Altamira Study Area Dataset (2005); PNAD (2005)
Note: Poverty line = 1/2 Brazilian minimum salary (R$ 300.00/2 = 150.00 or U$75.00) in 2005. Extreme poverty line = 1/4 Brazilian minimum salary.

5.1. Comparing Uni x Multidimensional Poverty Measures among Smallholders

The virtually equality of poverty levels among settlers and new owners for 1997/1998 actually hides important well-being asymmetries between groups. Counter-factual simulations of the role of production for self-consumption on poverty alleviation (not shown) revealed a higher impact on poverty reduction among new owners, although less effective in reducing their inequality levels. This result motivated us to contrast levels of poverty and inequality in 1997/1998 approached by income and by our suggested multidimensional index. Table 4 suggests that differences between groups increase for poverty measures accounting for inequality within poor (PGI and SPGI). While income-based poverty (approached by SPGI) is 13% smaller among settlers, multidimensional poverty is actually 11% higher. Table 4 also suggests the importance of other dimensions to alleviate poverty. For SPGI, extreme poverty as income insufficiency can be 38% higher than multidimensional chronic poverty. These results add to the argument of Diniz & Arraes (2008) that one-dimensional poverty measures tend to overestimate poverty, especially among rural population.

Table 4
Money-Metric X Multidimensional Poverty (MIRPI) in Altamira Study Area according to the type of land acquisition - 1997/1998 (Income-based Estimates for Pará State in 1997 for comparison)

Indexes	Small holders	Settlers [A]	New Owners [B]	A / B	C / D	
					A	B
Money-Metric Relative Poverty Line [C]						
Poor						
HC	43.8	47.0	46.1	2.0	20.5	17.5
PGI	35.4	33.7	37.2	-9.4	9.2	27.0
SPGI	32.0	29.7	33.8	-12.1	7.5	33.1
Extremely Poor						
HC	40.1	38.0	42.2	-9.9	2.7	17.8
PGI	33.2	30.8	34.9	-11.7	7.5	31.0
SPGI	30.2	27.7	32.0	-13.4	7.1	37.5
Multidimensional Relative Poverty Line (MIRPI) [D]						
Poor						
HC	39.1	39.0	39.2	-0.6	-	-
PGI	29.8	30.9	29.3	5.3	-	-
SPGI	26.1	27.6	25.4	8.8	-	-
Extremely Poor						
HC	36.2	37.0	35.8	3.4	-	-
PGI	27.3	28.7	26.7	7.6	-	-
SPGI	24.1	25.8	23.3	11.1	-	-

Source: Altamira Study Area Dataset (1997/1998)
Note I: Poverty line = 2/3 median of cumulated welfare distribution. Extreme poverty line = 1/2 median of cumulated welfare distribution.
Note II: MIRPI = Multidimensional Rural Poverty Index. Sample restricted to valid income and multidimensional welfare index cases (304 observations).

The estimated probability of transiting away from poverty is a useful way to access the impact of non-income dimensions on poverty alleviation. Table 5 presents a transition matrix of estimated probabilities of transition from/to poverty according to both money-metric and multidimensional measures by groups of smallholders. Calculations reveal a striking reduction in the probability of being poor, as non-income dimensions of smallholders' well-being is incorporated into the analysis. The impact, in accordance to our counter-factual simulations (not shown), is higher for new owners, and even higher for out-migration from income-based extreme poverty. For example, the probability of transiting away from extreme poverty among settlers, given they were considered poor based on income insufficiency was 0,4722. This probability was 13% higher among new owners. The probability of becoming multidimensionally poor, given that he/she was considered income-based non poor is approximately half the estimates for migrating out of poverty and showed no significant difference among groups.

Table 5
Estimated Propabilities of Migrating out of and to Poverty in Altamira Study Area - Money-metric X Multidimensional Welfare

Per Capita Household Total Income			Multidimensional Welfare					
			Smallholders		Settlers		New Owners	
			Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
			2/3 Median					
Small holders	Poor	2/3 Median	0.5414	**0.4586**	-	-	-	-
	Non-Poor		**0.2749**	0.7251	-	-	-	-
Settlers	Poor		-	-	0.5897	**0.4103**	-	-
	Non-Poor		-	-	**0.2623**	0.7377	-	-
New Owners	Poor		-	-	-	-	0.5213	**0.4787**
	Non-Poor		-	-	-	-	**0.2818**	0.7182
			1/2 Median					
Small holders	Poor	1/2 Median	0.4836	**0.5164**	-	-	-	-
	Non-Poor		**0.2802**	0.7198	-	-	-	-
Settlers	Poor		-	-	0.5278	**0.4722**	-	-
	Non-Poor		-	-	**0.2813**	0.7188	-	-
New Owners	Poor		-	-	-	-	0.4651	**0.5349**
	Non-Poor		-	-	-	-	**0.2797**	0.7203

Source: Altamira Dataset (1997, 1998)
Note: Sample restricted to valid income and multidimensional welfare index cases (304 observations).

Concluding Remarks

What group of farmers did better?

Poverty among rural population in our study area is still widespread, but was significantly reduced in recent years, following the national trend (Cunha, 2009). However, the reduction was asymmetrically experienced by groups of smallholders. This difference in poverty and inequality reduction reflects the uneven distribution of non-income dimensions of well-being between groups. While both settlers and new owners reduced poverty and inequality levels over the years, poverty decline was more pronounced among new owners, in spite of higher inequality reduction among settlers. This dynamics of poverty and inequality measures among rural smallholders suggests that poverty homogeneity seems widespread among settlers, while new owners have successfully been reducing poverty, combining increase in average income with decline in inequality.

Estimates of multidimensional poverty and inequality combined with profile descriptions from GoM model also suggests that new owners developed more complex and functional social networks and were adopting more profitable land use strategies (specialization in perennials and perennials with pasture). As perennials are also more labor demanding, their portfolio of labor applied to agriculture was predominantly based on hired labor and use of sharecroppers (some of them living on the lot), in contrast to more family-based or other non-paid labor supply among settlers. The higher level of holdings and assets reflects higher ability to improve house quality and, as a consequence, experience higher overall level of well-being. They also adopted more efficient income diversification strategies, with higher number of family members with off-farm activities. These income generating activities is in accordance with their lower dependency on institutional credits and higher levels of land consolidation.

Although settlers have a longer average settlement time in Altamira frontier, their land use systems (some lots with specialization in annual production) combined with their more advanced stage in household life cycle reduce their chance of making the most of agricultural production. Even though older settlement cohorts benefited from better soils (Smith, 1982; Moran, 1981), their likely low-productivity trajectory of land use might have contributed to reduce their chances of migrating out of poverty, as low-technological intensive land use leads to soil fertility decline and impoverishment (D'Antona *et al*., 2006). Non-significant differences in wealth upon arrival add to the argument that contemporary differences in well-being are reflective of settlers' less efficient livelihood strategies over time.

Scale dependent consequences of smallholders' responses to rural poverty

Our results suggest that, although income is a general way of accessing goods and services, non-monetary dimensions of people's livelihoods in rural areas play an important role in poverty and inequality configuration. This is relevant insofar as operative markets may not exist for a significant number of goods and services or because access to them is experienced asymmetrically among different groups of smallholders.

Differences between settlers and new owners in our study area suggest that while settlers rely more often on social relationships, especially on family help on the lot, new owners are more market oriented, benefiting from or being a direct agent of recent capitalist penetration in various Amazonian regions (Caldas *et al*., 2007; Gianezini, 2003; O Liberal, 2003). These differences in livelihoods strategies have distributive consequences which vary by level of aggregation. While our quantitative evidences support that larger holdings are associated with higher probabilities of poverty reduction, land consolidation is known to increase inequality in higher levels of aggregation. This is also supported by significant correlations between larger holdings and smaller reduction in inequality measures (especially among new owners). Thus, more attention must be paid on the dynamics of interactive effects of land consolidation among new owners and poverty homogeneity among settlers.

As in our study area land consolidation is in tandem with cattle ranching and formation of pasture for speculative purposes (VanWey *et al*., 2007; Walker *et al*., 2000), and as larger pastures and cattle herds are associated with better welfare, especially among new owners, increase in pasture and cattle ranching would improve household welfare but decrease soil fertility and reduce areas for more environmentally sustainable systems, such as cocoa plantations. Pasture formation has also negative impact on local labor market. As cattle ranching demand little labor, diversification strategies of smallholders who are dependent on provision of labor to other farmers may be negatively affected (Walker *et al*., 2000). As a consequence, overall welfare of labor suppliers is deemed, creating a negative spiral of informal credit and income constraints (VanWey *et al*., 2009).

In all, as some well-being dimensions have diverse implications and consequences depending on the scale of analysis, push factors for households' out-migration from poverty face a natural limitation in terms of public policy potential. While larger properties and pasture formation benefit individual farmers, consolidation and land speculation produce negative externalities to the community of rural farmers as a whole, resulting in dynamic increase of social deprivation and inequality.

Central questions such as scale-dependent impact of non-monetary poverty dimensions on social welfare must be an important agenda for research on rural livelihoods and political economy of rural populations in developing areas. Mixed-methods approaches, such as the integration of participatory diagnoses of communities' constraints with structured / semi-structured household surveys, represent innovative and promising way of accessing structural and political causes of multidimensional poverty and inequality among rural communities. This research is part of a larger initiative towards mixed-methods approach of rural livelihoods in the Brazilian Amazon and represents a first step on the way of understanding local causes of smallholders' trajectories in the region.

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Annex

Table A1
Distribution of Households/Lots by Welfare Level and Description of the Extreme Profiles according to Dimensions of MIRPI

Group	Frequency	
Non-poor	Absolute	Marginal
EP - Richest	56	16.3
Residual	155	45.1
Poor		
Residual	70	20.3
EP - Poorest	63	18.3
Total	344	100.0

EP - Richest: Households with fully operative social networks (multi-family lots, family members living in urban areas of Altamira, Brasil Novo and Medicilândia and financial support from off-household children), land use systems specialized in pasture (and pasture with perennials), developed and diversified income strategy (family members involved in off-farm activities, highest total current and initial income levels, highest proportion of household heads with at least 5 years of completed education, diversified labor force used in agriculture, applying high productivity technologies), with the most adequate natural resources for productive agricultural production (best fertile soils, with good accessibility and located by the Highway), large scale supply of credit and with the most valuable portfolio of assets (largest lots [bigger than 100 hectares], with the biggest amount of durable goods and holdings, both urban and rural, largest cattle herds and concentrating the best physically structured houses [brick or hardwood walls, tile/wood floor, internal bathroom, septic tank, piped water, and own generator or public power supply]).

EP - Poorest: Households with inoperative social networks (single-family lots, no family members living in urban areas of Altamira, Brasil Novo and Medicilândia and poor relatives living in the region), land use systems specialized in annuals (and annuals with perennials), restricted income strategy (no family members involved in off-farm activities, lowest total income levels, illiterate household heads, labor force used in agriculture concentrated in family members and temporary labor, applying low productivity technologies), with the least adequate natural resources for productive agricultural production (lots without terra roxa, with no or precarious accessibility and located at the feeder roads), with no credit and with the least valuable portfolio of assets (smallest lots [smaller than 100 hectares], with the smallest amount of durable goods and holdings [just 1 rural lot], smallest cattle herds and concentrating the worst physically structured houses [mud or palm leaves walls, dirt floor, no or external bathroom, no drain or rudimentary tank, not piped water, and power supplied by oil lamps]).

Source: Altamira Dataset (1997, 1998)
Note I: MIRPI = Multidimensional Rural Poverty Index
Note II: EP = Extreme Profile (gik = 1)

Table A2

Poverty Gap Proportion between Settlers and New Owners (%) - Cross Sectional and Longitudinal Estimates for Altamira Study Area (1997/1998 and 2005)

Index	Settlers / New Owners (%)					
	Absolute Poverty		B - A	Relative Poverty		B - A
	1997/98 (A)	2005 (B)		1997/98 (A)	2005 (B)	
Poor						
HC	2.26	17.61	15.35	11.36	27.21	15.86
PGI	0.21	17.79	17.58	5.64	17.99	12.35
SPGI	0.25	8.50	8.24	1.25	6.60	5.36
Extremely Poor						
HC	2.20	11.93	9.73	17.80	34.92	17.11
PGI	2.69	-7.82	-10.51	2.78	8.66	5.89
SPGI	-0.85	-17.23	-16.38	-1.63	-4.94	-3.31
Income Inequality						
Gini	12.86	-15.97	-28.82	-	-	-
L-Theil	49.18	-41.92	-91.10	-	-	-

Source: Altamira Study Area Dataset (1997, 1998, 2005); PNAD (1997, 2005)

Note: Absolute poverty line (1997/1998) = 1/2 Brazilian minimum salary (R$ 120.00/2 = 60.00 or U$30.00) in 1997. Poverty line (2005) = 1/2 Brazilian minimum salary (R$ 300.00/2 = 150.00 or U$ 75.00). Absolute extreme poverty line (1997/1998; 2005) = 1/4 Brazilian minimum salary. Relative poverty line = 2/3 median of per capita household total income. Relative extreme poverty line = 1/2 median of per capita household total income.