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Poverty and Inequality in the Rural Brazilian Amazon: A Multidimensional Approach

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Abstract

This paper analyses poverty and inequality dynamics among smallholders along the Transamazon High-way. We measure changes in poverty and inequality for original settlers and new owners, contrasting income-based with multidimensional indices of well-being. Our results show an overall reduction in both poverty and inequality among smallholders, although poverty decline was more pronounced among new owners, while inequality reduction was larger among original settlers. This trend suggests that families have an initial improvement in livelihood and well-being which tends to reach a limit later—a sign of structural limitations common to rural areas and maybe a replication of boom and bust trends in local economies among Amazonian municipalities. In addition, our multidimensional estimates of well-being reveal that some economically viable land use strategies of smallholders (e.g., pasture) may have important ecological implications for the regional landscape. These findings highlight the public policy challenges for fostering sustainable development among rural populations.

Keywords

Poverty; Inequality; Brazilian Amazon; Rural livelihoods; Multidimensional approach

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[2]In order to protect the identity of the sampled families and properties, all the geographical coordinates, roads and grids were excluded.

Introduction

In spite of having the strongest economy in Latin America, Brazil still has extremely high levels of poverty and inequality (Ferreira *et al.* 2006). According to Brazil's Institute for Applied Economic Research (IPEA), 21.4% of the population live below the poverty line and, as of 2009, the country ranked among the most unequal in the world (IPEA 2010). At the national level, however, poverty is spatially concentrated with significantly higher levels in the Northeast and North (Fig. 1).

While in the Northeast both poverty and inequality are high, in the North there are high levels of poverty but relatively low levels of income inequality. This is partially explained by a relatively high prevalence of smallholders in the rural areas (Aldrich *et al.* 2006; Brondizio *et al.* 2009) and the unique quality of Amazonian urbanization where city dwellers maintain a strong link to rural areas (Godfrey and Browder 1996; Padoch *et al.* 2008). Government sponsored Amazonian settlement projects and various types rural development programs designed to foster family-based agriculture have had limited impact in reducing poverty.

Often conflicts over land and forest resources with large capital enterprises and cattle ranchers have threatened the viability of smallholder agriculture (Walker *et al.* 2000; Aldrich *et al.* 2006). In some cases a lack of technical assistance combined with a disregard for rural infrastructure further add to the hardship of rural populations (Brondízio and Moran 2008; Ludewigs *et al.* 2009; Brondizio *et al.* 2009). At the local level, rural households react to these pressures by: (1) selling farm lots and migrating to marginal lands or new settlements (Walker *et al.* 2000), (2) moving to peri-urban areas or commuting to urban centers in search of off-farm employment (Murphy 2001), and/or (3) adapting their portfolio of economic activities to benefit from changing market opportunities (Brondízio and Moran 2008). For instance, smallholders contribute a significant share of the food commercialized and consumed in regional urban centers. While suffering from poor infrastructure and limited access to market and social services, rural small-holders do benefit from a rich natural capital in forest and water resources which can reduce their dependence on the cash economy (Murphy 2001; Perz 2005). As in other parts of the world, the ability of smallholders to adjust their livelihood strategies continues to be a key element in their long-term survival (Sherbinin *et al.* 2008).

This paper proposes a multi-dimensional criteria framework to analyze poverty and inequality dynamics among smallholders in rural areas of the Brazilian Amazon. Using data on livelihoods (Sherbinin *et al.* 2008) and portfolio of capital (Bebbington 1999), our framework examines six components of rural household well-being: income generation, portfolio of assets, family social network, community-based networks, land use portfolio, and biophysical capital. Using longitudinal household-level data, we propose three working hypotheses: (1) the ability of rural households to overcome poverty is hampered by limiting structural conditions (e.g., poor infrastructure, high cost and limited access to markets, limited health and educational services), i.e., a household's wellbeing improves during initial stages of settlement, but tends to level off as structural limitations create barriers to additional improvement at later stages of farm development; (2) the level of well-being as assessed in multidimensional terms is directly associated with the mix of livelihood strategies within the household; the portfolio of economic activities will vary with time of arrival in the region; households arriving at later stages of settlement occupation tend to rely more on market-oriented strategies; and, (3) the impact of changing livelihood strategies at the local level (e.g., increasing land allocation to pasture) has implications at larger scales, i.e., may benefit farmers at the household level, but contribute to the rate and pattern of regional forest change.

In order to situate and contextualize our working hypotheses, we compare income-only based and multidimensional estimates of poverty. We discuss the importance of different sources of non-financial forms of capital in providing flexibility for smallholders in coping with income variance over time and the implications of this for the regional environment. Based on a rural livelihoods framework we propose a multidimensional poverty measure that can be applied at the household and population level that accounts for the role of non-financial capital in poverty configuration. Two groups are compared: original settlers who received their land from the government agency and who still held it at the time of interview, and new owners who bought land from an original settler or other previous owner. Comparison of these two groups allows us to assess how poverty dimensions vary among subgroups of rural households and to consider links between economic strategies and wellbeing. We also examine whether smallholders who focus on market-oriented land use strategies are more likely to be better-off, and how limitations created by poor infrastructure, high cost of market access, low level of social services, and lack of credit with which to access technology limit upward mobility.

The Nature of Poverty: Two Approaches

Per capita income is the standard measure of poverty and serves as a proxy for wellbeing. The monetary-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 (Hoffmann 1998). Obviously, in certain contexts incomplete market functioning or absence of realistic pricing may distort income-based indices of deprivation (Bebbington 1999).

Another approach, derived from the work of Amartya Sen (1985, 1999), attempts to overcome some of the limitations of the income-only approach by focusing on multidimensional aspects of poverty including people's 'capabilities' and potentialities in dealing with deprivation (Kakwani and Silber 2008). Therefore, poverty is viewed as a product of a lack or deficiency in such instrumental variables as economic opportunities, political freedom, social facilities, transparency guarantees, and protective security (Alkire 2007).

This broader definition of poverty, however, faces measurement and data limitations and, as a result, some restrictions have to be made in the number and type of the attributes being analyzed. The Human Development Index (HDI), proposed by United Nations Development Program (UNDP) in the 1990s and reflecting Sen's approach, represents an attempt to capture non-monetary aspects of poverty, although it only incorporates educational level and life expectancy (UNPD 2003). Building on the HDI, the Generalized Human Development

Index (GHDI) expands the number of "wellbeing attributes" to include the provision of public goods (Chakravarty 2003). The UNDP indices, while essential for large-scale comparative purposes, are of limited utility 'on the ground' as they gloss over how people manage and respond to local social or political conditions related to material hardship and poverty.

Based on Sen's work, other multidimensional indices attempt to account for diverse national and regional realities. The IPEA, for instance, has proposed a multidimensional poverty index at the household and family level using commonly available household data surveys (Barros *et al.* 2006). The index is obtained from a questionnaire of 48 'yes or no' questions covering six dimensions: vulnerability, access to knowledge, access to job opportunities, household assets, lack of resources, and infant development. Although it represents an important advance to multidimensional poverty measurement, the IPEA's index (Family Development Index – FDI) is based on an urban concept of household so lacks important dimensions relevant to rural livelihood strategies as they may impact the environment.

Rural Poverty and the Environment

Poverty in general, and rural poverty in particular, has a synergistic relation with environmental change. Two general views about the relation between poverty and the environment dominate the literature. One, often criticized as simplistic (Lambin *et al.* 2001), tends to blame environmental degradation on the poor, stressing the positive feedback linkages between their extractive activities and conservation. A contrary view emphasizes the historical processes that have pushed the poor to inhabit 'marginal' areas where degradation is significant (Hakkert and Martine 2003; Kay 2006). Alternative frameworks have begun to recognize that under certain circumstances, conservation may actually reinforce the maintenance of local people under limited socio-economic development (Penna-Firme and Brondizio 2008). In any event, the intersection of conservation and poverty poses particular challenges for development planners (Tucker *et al.* 2011).

From a livelihood perspective, poverty in rural areas can be interpreted as the inability of rural households to select the mixed portfolio of capital that buffers exogenous threats to their wellbeing. In frontier settings, the source of this inability springs from structural factors as well as unequal distribution of resources (VanWey *et al.* 2011). Rural wellbeing at the local level is thus a direct function of both the level (composition) and return (utility) to capital and an indirect product of exogenous constraints at higher scales (both temporal and spatial) (Fig. 2). Our analysis builds upon studies of rural poverty that have attempted to incorporate the relation between household income and other forms of social assets and natural resource provision (Reardon and Vosti 1995; Murphy 2001; Wunder 2001; German 2003; Das Gupta 2004; Caviglia-Harris and Sills 2005; Kay 2006).

We define rural poverty as the general lack of choices and opportunities that are reflected in low levels of income, portfolio of assets, land use choices, land tenure security, access to natural resources, and social networks. While important, it is not our intent in this paper to address subjective measures of poverty and wellbeing. For the purpose of this analysis, we define wellbeing as the level of material conditions provided by a combination of livelihood strategies representing a portfolio of capital (financial and non-financial) and social relations structured and modified by their ability to increase household's satisfaction and security (Bebbington 1999). This highlights two important points: (1) the level of capital correlates with short term improvement in wellbeing, while the portfolio of capital, reflecting perceived utility for the rural household, is instrumental in building investment capacity over the long term; (2) contextual and temporal constraints may restrict some livelihood strategies. The first point can be interpreted as the immediate or micro-level determinants of wellbeing (VanWey *et al.* 2011), while the second reflects the historical processes that shape poverty and inequality in rural areas, inducing boom-and-bust cycles of frontier development (Rodrigues *et al.* 2009). Here we apply this general framework to an older settlement region between the cities of Altamira and Uruará along the TransAmazon Highway, in the Brazilian state of Pará.

Study Area

We make extensive use of data from the project Amazonian Deforestation and the Structure of Households conducted by the Anthropological Center for Training and Research on Global Environmental Change at Indiana University in collaboration with the University of Campinas and federal research agencies, such as EMBRAPA. The project includes three research sites in the Brazilian Amazon: Santarém, Altamira, and Lucas do Rio Verde. In this paper, we focus on the Altamira site only, which comprises 404,700 hectares and 3,916 rural lots along the Trans-Amazon Highway (BR-230) and secondary roads between the municipalities of Altamira and Uruará (D'Antona *et al.* 2008). The region is located 740 km away from Belém, the capital of Pará state, and is crossed by the Xingu River from north to south.

Our study area comprises mostly the rural areas of these municipalities where infrastructure accessibility is poor, which were part of a government-sponsored colonization scheme that started in 1970 and continued with migrant families arriving in large numbers until the first half of the 1980s. Colonists and land investors continue to arrive in adjacent settlements or by acquiring properties from colonist families. After nearly 30 years of development, population increased from about 1,000 people (Moran 1981) to about 58,000 (IBGE 2010), excluding the city of Altamira but including Brasil Novo and Medicilândia, two villages that have now developed into small towns.[1] The Brazilian Government, through its National Institute of Colonization and Agrarian Reform (INCRA), established a grid of farm units (average 100 hectares) along the Transamazon Highway designed for annual and perennial agriculture and small-scale cattle ranching (Moran 1981), all of which front onto the Highway or a feeder road (Fig. 3). During the initial phase of settlement, the government provided schools, roads, subsidized credit and technical assistance for agricultural production, but this initial support was subsequently interrupted, leading to farm failures and land abandonment (Almeida and Campari 1995). Some argue that the lack of on-going

[1]According to the 2010 Demographic Census, there are 186,882 people living in the region (including the municipalities of Altamira, Brasil Novo, Medicilândia, and Uruará), 33% in the rural area. The municipality of Altamira alone comprises 53% of the total population, and has the highest level of urbanization among the municipalities in the region (85%). In terms of basic infrastructure, all four municipalities rank far below the national average, with a very low proportion of households (both urban and rural) with access to water and sewage systems, and human development indices ranking below the national average (UNDP 2000).

governmental assistance was one of the main reasons for the high rate of property turnovers in the first decade of colonization (Moran 1981; Ludewigs *et al.* 2009).

The Altamira landscape is characterized by steep, but rolling topography. Accessibility in the region is precarious due to a combination of poorly maintained wooden-bridges, unpaved roads, low levels of government maintenance of transportation infrastructure, and intense annual rainfall creating swollen rivers and streams. Land cover is characterized by large deforested areas radiating from the main road (TransAmazon) to the feeder roads (*travessões*), and spreading westward over time from the area of initial settlement in the east. The area has unevenly distributed patches of high-fertility soils known as *terra roxa*. Cacao production and cattle ranching are the main agro-pastoral strategies, but are usually complemented by annual crops and horticulture. In some parts of the study area, sandy soils predominate and pasture and annual crop production are favored.

Farming systems in the area are diversified, including annual crops (53%, including rice, beans, and corn), perennial crops (72% including coffee, cocoa, and pepper), and pasture (95% of households raised cattle). Pasture is the dominant land use, ranging from a few hectares to an entire holding. Cattle-raising offers several advantages to small farmers in a context of uncertainty and high cost of market access; it compares favorably to annual crops and forest products, such as hardwood, which have low market price. Pasture formation adds value to the farm in an area with an active land market, and can be achieved at relatively low cost. Cattle raising represents savings that are easily convertible at the farm gate without need for storage, and has demonstrated consistently competitive prices. Yet, most farmers tend to set aside small forest areas dedicated to protecting water sources and in some cases as hunting grounds. Forests and fallow areas are also important in providing various raw materials needed for daily farm operations, such as wood, fibers, and roofing (Muchagata 1997; Brondizio et al. 2002; Campos 2006; Brondizio 2010).

While being a relatively successful example of agrarian settlement in Brazil, the area is also the scene of land consolidation by heavily capitalized ranchers and has high interest rates for credit. A significant technological and economic divide distinguishes small and large farmers in Amazonia. Access to technology is a recurrent problem among small farmers who usually have to rely on the use of fire and manual tools. Field data indicate that close to 80% of the farmers depend on axes, shovels, and machetes to clear and till their land. Moreover, commodity prices have declined in recent decades. The rate of property turnover has been around 75% since settlement (Ludewigs *et al.* 2009). Dual residency is also common (Fig. 4): many families have members living in the city where they work and/or study (VanWey *et al.* 2009). This spatial diversification of household members and activities limits intra-family income variance, allowing smallholders to better deal with agricultural price oscillation and shortage of production due to climatic, economic or political factors. The presence of family members in the city also facilitates access to services such as health, education, commerce, and banking. The rural–urban linkage is a very common strategy among smallholders in Altamira, and family networks are important for household livelihood strategies (Fig. 4).[2] This pattern of rural–urban connections and inter-dependency is increasing in the Amazon (Padoch *et al.* 2008).

Data and Methods

This paper uses datasets from two sources. We use, as reference, poverty and inequality indices for the state of Pará,[3] estimated from the National Household Survey (IBGE 1997, 2005). For the Altamira study site we use longitudinal data from household field surveys carried out in 1997/1998 and 2005.

For the first wave of Altamira survey, we used a sample of 402 households and farm properties (see Fig. 3) corresponding to a stratified sample of farm units by cohort of settlement and representative of the farm units in the region. Both heads of the household and any other women in the property aged fifteen and over were interviewed. Males responded to an economic and land use questionnaire, while females answered questionnaires covering family socio-demography, reproductive history, and the use of contraceptive methods. The 2005 follow-up survey was aimed at three groups present at the time of the first survey: a) same couples interviewed in 1997/1998, b) other households located on the same piece of land and sampled in 1997/1998, and c) children of couples interviewed in 1997/1998 who were living in their own households in 2005.

For poverty and inequality measures based on household income, we used data from both surveys (1997/1998 and 2005). We restricted the longitudinal sample to households considered original settlers and new owners in 1997/1998 and still kept their property in 2005. The new property owners who acquired or inherited farm units between surveys were discarded. In all, we lost 87 cases due to different sources of attrition (deaths, moves outside the study area and sale or family transmission of properties). Thus, for poverty and inequality dynamics, the sample size was restricted to 304 household observations with valid cases for income (Table 1). For poverty measures using multidimensional variables, we restricted our sample to the 1997/1998 owners who had complete information on income and additional selected characteristics (Fig. 2), thus losing 58 cases. The final sample totaled 344 observations (Table 1).

Analytical Tools to Measure Poverty and Inequality

We first briefly describe the baseline indices: the Foster-Greer-Thorbecke metric (FGT) class of poverty indices and the Gini and L-Theil indices of inequality. Then, we present the empirical strategy used to estimate our multidimensional wellbeing function, followed by the variables used to reflect each of the six dimensions presented in our conceptual framework (Fig. 2). The income-based poverty and inequality estimates were based on per capita household income. For *absolute poverty* measures, we set the poverty line[4] at ½ of the Brazilian minimum wage (¼ for extreme poverty line), following Hoffmann (2005). For *relative poverty* measures, the poverty line was fixed at 2/3 of the median along the income cdf [cummulative distribution function] (½ of the cdf median for extreme poverty),

[3]It was not possible to estimate poverty and inequality indices for rural Pará as a whole because these areas were not fully represented in the National Household Survey until 2003 (IBGE 2005).

[4]Absolute poverty line is set as a fixed reference value to compare per capita household income or any other wellbeing proxy. Relative poverty line represents a fixed percentage of the cumulated wellbeing function (e. g., income function). Some authors suggest predefined values for these lines, but the reference values vary according to the purpose of the study and the context (Hoffmann 1998; Iceland and Bauman 2007).

following Iceland and Bauman (2007). Estimates for the state of Pará excluded from the household income the share due to servants and their relatives living in the same unit because they do not participate in the expenditure and investment decisions of the household (Hoffmann 1998).

The FGT Measures—The FGT metric is a set of indices based on headcounts and poverty gaps widely applied in poverty studies and used to measure several aspects of poverty such as proportion, intensity and severity[5] (Stewart 2006). They are complementary since they respond differently to different aspects of poverty (Foster *et al.* 1984; Hoffmann 1998). The three FGT measures used in this paper are: the headcount ratio (HC), the poverty gap index (PGI), and the squared poverty gap index (SPGI). They can be calculated by means of the following formula:

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

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 ratio;

If α=1, we have the poverty gap index;

If α=2, we have the squared poverty gap index.

Although FGT measures are traditionally used to estimate poverty based on per capita income level, we applied them to our scalar measure of multidimensional wellbeing as well in order compare one and multidimensional poverty indices for the rural smallholders.

Inequality Measures: Gini and L-Theil—These are two of the most common income inequality measures in the empirical literature. The Gini coefficient can be derived from the income distribution or from the Lorenz Curve. The Gini coefficient graphically represents the increase in the cumulated proportion of income due to the cumulated proportion of population over the *i-th* person: the closer to 1, the higher the inequality of the population (Dorfman 1979). Interpretation of L-Theil is similar to the Gini coefficient, although it has a wider range of scalar variation and is bound to 0 and infinity. The closer to zero, the lower the inequality is. Unlike the Gini, L-Theil is not applicable to households with no income (Hoffmann 1998).

Measurement Strategy for Multidimensional Rural Poverty

The Grade of Membership Model: The Grade of Membership (GoM) model is a fuzzy cluster methodology used to estimate the degree of unobserved heterogeneity in a multidimensional dataset (Manton *et al.* 1994). Unlike other multivariate techniques, GoM does not require that individuals and objects be organized in well-defined (i.e., 'crisp') sets. The model estimates two parameters, g_{ik} and λ_{kjl}. The first parameter corresponds to the

[5]The headcount ratio, for instance, is insensitive to poverty intensity while poverty gap is insensitive to inequality among the poor. The squared poverty gap, however, accounts for both poverty intensity and severity, although is difficult to interpret (Hoffmann 1998).

probability of an answer at level ‘l’, of the ‘j-th’ question, in the extreme profile ‘k’, by individual ‘i’, conditional to the score g_{ik}. The second parameter corresponds to estimated individual heterogeneity, that is, for each individual in the sample, ‘k’ degrees of pertinence, g_{ik}, are estimated in relation to the extreme profiles (reference groups). Both parameters must sum up to one over ‘k’. The individual-level conditional probability for each individual ‘i’ to have a particular type of answer ‘l’ to variable ‘j’ is $P(Y_{ijl}=1)=\sum_k g_{ik} l_{kjl}=1$. The probability model, based on a random sample, corresponds to $E(Y_{ijl})=\sum_k g_{ik} l_{kjl}$, with g_{ik} a strictly positive known parameter, by assumption. Thus, the likelihood function has the following multinomial form (Manton *et al.* 1994):

$$L\left(Y_{ijl}\right)=\Pi_{i=1}^{I}\Pi_{j=1}^{J}\Pi_{l=1}^{L}\left(\Sigma_{k=1}^{K}g_{ik}\lambda_{kjl}\right)^{Y_{ijl}} \quad 2$$

GoM Model for Ordered Latent Variables: In this paper, instead of using Eq. (2), where both g_{ik} and λ_{kjl} are estimated iteratively, we restricted the probability of a specific category ‘l’ of a variable ‘j’ in the profile k=2 to be equal to 1, λ_{2jl}=1.000, in a model with K=2. This category must correspond to the highest level of wellbeing for that variable, and the opposite must be done to the profile k=1. This strategy is recommended by Garcia *et al.* (2007) when studying ordered latent variables and was used in empirical applications in the Amazon by Guedes *et al.* (2009). By informing a fixed matrix of λ_{kjl}, the estimated g_{i2} represents an empirical measure of the multidimensional wellbeing function. Once g_{i2} was estimated, we classified smallholders as poor or extremely poor according to the same relative poverty lines applied to the income-based classification explained above. Inequality measures use the same cumulated g_{i2} distribution applied to Gini and L-Theil indices to assure appropriate comparability to the inequality measures based on household income function.

The GoM model is applied only to the Altamira dataset collected in 1997/98. Results are estimated for the whole sample and disaggregated into two groups of smallholders: original settlers and new owners.[6] Our empirical multidimensional rural poverty scalar integrates six dimensions of livelihood relevant to rural families, as suggested by the conceptual rural livelihood framework (Sherbinin *et al.*2008): income generation, portfolio of assets, family social network, community-based networks, land use portfolio, and biophysical capital (Fig. 2). Table 7 describes all the variables used as indicators of each of the six dimensions. For details on the manipulation of variables and description of how the weighted indices were created, refer to the Annex.

Estimating the Transitional Probabilities—To evaluate the impact of non-monetary dimensions on poverty we use a transition matrix approach, comparing results obtained from the income-based poverty measures with those based on the scalar g_{i2}, derived from the multivariate GoM model. The use of transition matrices allows us to obtain an empirical

[6]We could have used both sets of Altamira longitudinal data to analyze the dynamics of multidimensional poverty. However, high levels of missing information on relevant dimensions made some distributions unstable for the second dataset. Thus, we opted for splitting the baseline sample between new owners and original setters, simulating the dynamics across different cohorts, assuming fixed returns of each livelihood across cohorts. This synthetic cohort approach to frontier regions is widely applied in rural demography with limited data (McCracken *et al.* 1999).

measure of probabilities of leaving poverty when incorporating the non-monetary dimensions of households' livelihoods.

The transition matrix was obtained by calculating the probability of being located at least at two-thirds of median of $\sum_{g=0}^{1} g_{i2}$, given that a particular smallholder is classified as income poor (Iceland and Bauman 2007). We perform the same calculations for the transition from income-based non-poor to GoM-based poor. Using the relative poverty line instead of an absolute value allows us to accurately compare one and multidimensional measures of poverty at the same relative level. Otherwise, we would incur in scalar bias when estimating the probability matrix.

Results

The state of Pará was considered the poorest among the Legal Brazilian Amazonian states in 1997 (excluding Maranhão, which has only a part of its territory included), with 50% of its population classified as living below the poverty line.[7] In 2005, the Head Count (HC) ratio dropped to 44%, representing a proportional reduction of 12% in 8 years. Among the extreme poor, the HC ratio dropped from 21% to 16% (a relative decrease of 24%). Over the same period, the percentage of poor individuals in Brazil dropped from 35% to 31% (a relative reduction of 11%), while the percentage of extremely poor dropped from 16% to 11% (a relative decline of 31%). In spite of this decline, income poverty in Pará continues to be widespread (Table 2).

FGT poverty measures are presented in Tables 3 and 4, using both relative and absolute poverty lines. We here define absolute poverty lines as a fixed proportion of the Brazilian minimum salary (i.e., ½ and ¼), while relative poverty lines are defined as a proportion of the median over a cumulated income or wealth distribution (i.e., 2/3 and ½ of the median). If we consider absolute poverty, the proportion of poor households among Altamira rural smallholders in 1997 was approximately twice the level observed for the state of Pará.[8] The difference is even higher for households considered extremely poor (almost five times). Using relative measures, the difference reduces significantly; suggesting that although poverty level is higher, inequality is closer to that of the state level. Surprisingly, in 1997 differences in poverty levels between original settlers and new owners were virtually nonexistent although inequality was significantly higher among old settlers (13%).

In 2005, poverty levels among smallholders in Altamira approached the state average, however differences between original settlers and new owners became more pronounced in favor of the latter. The gap for HC ratio between the two groups was 18% higher for original settlers among poor and 11% among extremely poor. Inversely, income inequality in 2005

[7]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 adequate 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), for the urban area, R$119.86 (U $49.32), and for the rural area, R$104.88 (U$43.16).

[8]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 continued. Poverty series from IPEA (2008a) only provide information on HC.

was 16% lower among them. Differences between original settlers and new owners were even higher if considering relative poverty, especially among extremely poor (35% higher for original settlers), despite their smaller inequality. This significant change over time suggests that poverty seems more homogenously spread among original settlers, while new owners have successfully been reducing poverty between 1997 and 2005, at the cost of increasing inequality levels. This is consistent with the evidences of social stratification along frontier development in the agricultural frontiers of the Brazilian Amazon (Aldrich *et al.* 2006).

Comparing Uni- And Multidimensional Poverty Measures Among Smallholders

The similarity in poverty levels among original settlers and new owners for 1997/1998 actually hides important asymmetries in wellbeing between groups. Differences between groups increase for poverty measures accounting for inequality among poor households (PGI and SPGI) (Tables 4 and 5). While income-based poverty among original settlers (approached by SPGI) was 13% lower than among new owners, multidimensional poverty was actually 11% higher. For SPGI, income-based extreme poverty was 38% higher than multidimensional extreme poverty (Tables 4 and 5). These results underline the argument of Diniz and Arraes (2008) that uni-dimensional approaches tend to overestimate poverty, especially among rural population.

Calculations reveal a striking reduction in the probability of being poor, when non-income dimensions are incorporated into the analysis (Table 6). This impact is higher for new owners, especially those considered extremely poor on income-based measures. For example, the probability of moving away from extreme poverty among original settlers, given they were considered poor based on income, was 0.4722. This probability was 13% higher among new owners. For those classified as non-poor in terms of income, the probability of being classified as poor based on multidimensional measures was lower (50%) than that of being considered non-poor and showed no significant difference among groups. In other words, it is twice as likely to observe upward mobility when multidimensional measures are considered.

Discussion and Final Remarks

As part of a larger initiative using a mixed-methods approach to study rural and urban livelihoods in the Brazilian Amazon, we have shown the value of multidimensional approaches to estimate poverty and inequality in rural areas of the Amazon. While unidimensional approaches are important and necessary, they do not consider a myriad of contextual and microlevel factors affecting livelihoods in rural areas. By glossing over on the role of local resource availability and allocation, and different forms of social networks, they also tend to overestimate poverty, especially among rural populations. Multidimensional approaches also require a suite of integrative methods and team-based fieldwork. Mixed-methods approaches, such as the integration of participatory diagnoses of communities' constraints with structured/semi-structured household surveys, and the use of geospatial analysis contribute to a more representative assessment of structural and political causes of poverty and inequality among rural communities and their contribution to environmental change.

Our analyses support our three working hypotheses. First, during the study period, smallholders in the study area were able to improve their economic conditions relative to the state and to the local population, but they are ultimately constrained by structural conditions such as limited access to new technology, better access to market, and decreasing social services caused by a high level of land holding turnover and land concentration. Second, farmers arriving later in the area were more successful than original settlers in terms of upward mobility by combining market-oriented activities such as cattle ranching and perennial crops (*vis-à-vis* annual crops) and urban-based employment. Finally, based on research published else-where (Ludewigs *et al.* 2009; Vanwey *et al.* 2007) we observed that these strategies have contributed to higher levels of deforestation and land aggregation; we observed higher levels of inequality within this group and between groups resulting from these strategies.

Poverty among rural households in our study area is still widespread but, following the national trend, it has been reduced in recent years (Cunha 2009). However, the reduction was asymmetrically experienced by different groups of smallholders, reflecting the uneven impact of non-income dimensions of wellbeing across groups. While poverty and inequality declined among all smallholders over the years, poverty decline was more pronounced among new owners, in spite of a higher reduction in levels of inequality among original settlers. This suggests that families experience an initial improvement in livelihood and wellbeing before reaching a limit, a sign of structural limitations common to rural areas in the Amazon. It is interesting to note that Amazonian municipalities seem to experience similar trends after they are established as part of a process of frontier expansion. Rodrigues *et al.* (2009) documented a pattern of boom and bust, as measured by the Human Development Index, for Amazonian municipalities suggesting higher levels of resource exploitation at the initial stage of occupation and formation, followed by a decline. In the case of municipalities, it indicates short-term benefit from resource and raw material export, but limited ability to develop productive activities that aggregate value locally, thus increasing the ability of municipalities to offer employment and to collect taxes needed to support social services such as health and education. These ‘boom and bust’ trajectories have important consequences for long-term local and regional development, as they contradict income convergence theories which predict an asymptotic upward growth path for local economies (Barro and Sala-i Martin 1992). At the household level, this process may be related the low profitability of agricultural production, to decline in forest resources (e.g., lumber) for commercialization, and to decline in agricultural productivity as fallow cycles decrease and households have limited access to technology. The vast majority of smallholders depend on manual labor and has limited ability to increase productivity and surplus for commercialization.

New owners seem to develop more complex and functional social networks and adopt more profitable land use strategies. As perennial crops are more labor demanding, they predominantly rely on hired labor and sharecroppers (some of them living on the property) in contrast to more family-based labor among original settlers. They also adopt more efficient income diversification strategies, with a higher number of family members in off-farm activities. These income-generating activities are in tandem with their lower dependency on institutional credits and higher levels of land consolidation, and reflect possible informal credit arrangements at the family level (Wouterse and Taylor 2008). Evidence from the study area suggests that out-migration of children, although a loss of labor, is outweighed by their remittances, which are used to invest in perennial plantations (VanWey *et al.* 2009).

Although original settlers have a longer average settlement time in Altamira, their land use systems and technology combined with the more advanced stage of their household life cycle seem to reduce their chances of getting higher rates of return from agricultural production. Even though older settlement cohorts benefited from better soils, barriers in access to technology and markets continue to impact their ability to improve economically (VanWey *et al.* 2007). Non-significant differences in wealth upon arrival add to the argument that contemporary differences in wellbeing reflect the limitations on original settlers to overcome poverty after an initial improvement in livelihood and economic conditions.

Differences between original settlers and new owners in our study area suggest that while original settlers rely more often on social relationships, especially on family help on the property, new owners are more market oriented and may include urban-based entrepreneurs (Ludewigs and Brondizio 2009). These differences have distributive consequences that vary by level of aggregation. While larger holdings are associated with higher probabilities of poverty reduction at the property level, land consolidation is known to increase inequality at the regional level. For instance, inequality is higher between groups of farmers with different property sizes, especially among new owners. Thus, more attention should be paid to the interactive effects of land consolidation and wellbeing dynamics at the regional level.

Land consolidation in the study area is in tandem with cattle ranching and formation of pasture for land speculation (Walker *et al.* 2000; VanWey *et al.* 2007; Ludewigs *et al.* 2009). As larger pastures and cattle herds are associated with higher levels of wellbeing, especially among new owners, the continuing increase in cattle ranching compounds to regional environmental and socioeconomic costs. Cattle ranching is also associated with increasing land holdings (in areas previously defined for agrarian reform) and social stratification. Expansion of pasture reduces other available resources (e.g., Non-Timber Forest Products, game, water, timber), increases deforestation, and threatens regional biodiversity. Pasture formation also has negative impacts on local labor markets. As cattle-raising demands less labor than perennial cropping, diversification strategies of smallholders who are dependent on the provision of off-farm labor may be negatively affected (Walker *et al.* 2000), creating a potentially negative spiral of income constraints (VanWey *et al.* 2009).

In all, livelihood options have different implications for wellbeing and environmental consequences depending on the scale of analysis, which poses a challenge for public policy interventions. While larger properties and pasture formation benefit individual farmers, they may produce negative externalities to the region as a whole, resulting in a dynamic increase of social deprivation and inequality. As farm sizes increase through land aggregation and families out-migrate, there is a proportional decrease in the availability of schools, transportation, health assistance, and public services in general, forcing the remaining families to sell their properties and move to the city or to newly opened settlements.

There are two general scenarios regarding the relation between forested areas and poverty in the Amazon. On the one hand, large tracks of forest co-exist with scattered, small poor households in non-frontier areas populated by native, rural and 'traditional' communities. In some areas, local populations benefit from an active market for agroforestry and forest products (Brondizio 2008) and there is widespread engagement of households in market-based livelihood strategies concomitant with increasing forest cover, but equally persisting levels of poverty and increasing inequality independent of the price of forest commodities (Brondizio 2010). Basically, households are confronted with structural issues similar to those discussed above and limited opportunities to aggregate value in their production at a local level; i.e., products are exported as raw materials with lower prices and high transportation costs. Second, in older frontier areas such as in Altamira, national and global demands for cattle and agricultural commodities have continually driven deforestation as well as attracted new settlers and private investors into areas where land and natural resources are still available at relatively low cost. This trajectory, common to several areas of the Amazon, has produced different degrees of socio-environmental externalities, including land struggles and social conflicts. Poverty levels in Altamira, as in other parts of the region, are sensitive to access, knowledge about, use, and control over natural resources. Based on current trends in deforestation, it is clear that few, small and scattered forest fragments will survive within the settlement area itself. On the other hand, farmers are progressively putting more efforts into reforestation and protection of key resources such as water springs and wood products used for farm operations.

The scale-dependent nature of monetary and non-monetary dimensions of poverty and wellbeing should be part of the research agenda aimed at understanding livelihood strategies, the political economies, and environmental impacts of rural populations in developing areas. While it is difficult to account for all of the interactions between historical and contemporary conditions underlying recurrent poverty in the region, it is a task central to any discussion of sustainable development and conservation policies for the Amazon.

Annex

Details on construction of weighted indices

Wealth upon arrival—Wealth status upon arrival was created based on a regression approach (as suggested by ABEP 2008). We regressed selected household assets and holdings upon arrival on the log of household total income and then used the estimated coefficients as weights to create a final index of possession of assets and holdings upon arrival. This weighted factor was, then, cumulated and the classification of well-off smallholder was based on being at two-thirds or above the median of the cumulated distribution. 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 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. Cronbach's alpha (scale)=0.6955.

Agricultural Technology—The weighted factor for agricultural technology was created 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. The index was cumulated and categorized into below or above the median, suggesting high and low production technology. 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 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 significant at 1%. Cronbach's alpha (scale)=0.5644.

Assets Factor—For the assets factor, we gathered information on possession of selected household assets, and then regressed on the log of total household income. 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 2008). 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 significant at 1%. Cronbach's alpha (scale)=0.5367.

Additional Information of Transformations of Variables Used—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,[9] 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 during the rainy season, and membership to agricultural association. Number of properties belonged to household head was defined as count variable. The additional variables used in our

[9]We transformed production by crop and animal type into kilogram-equivalent. Then, we took price per kilo effectively received by Altamira smallholders and multiplied it by 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.

multidimensional poverty index have categories rearranged according to the absolute frequency in each category.

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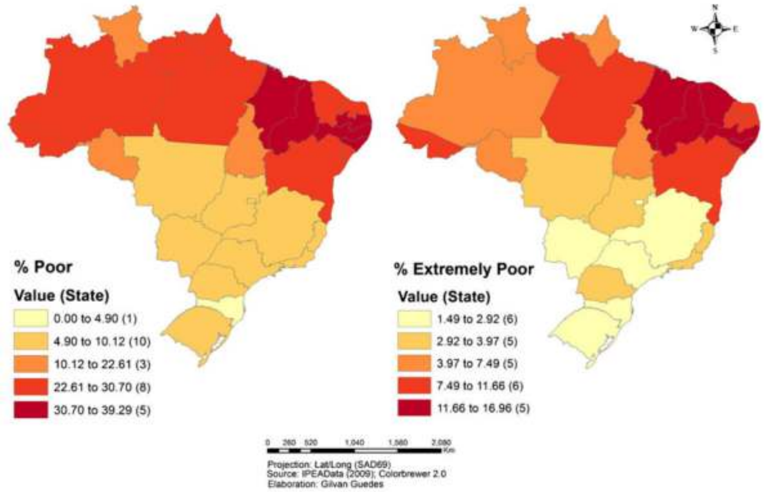

Fig. 1.
Head count ratio by state in Brazil, 2009 – poor and extremely poor

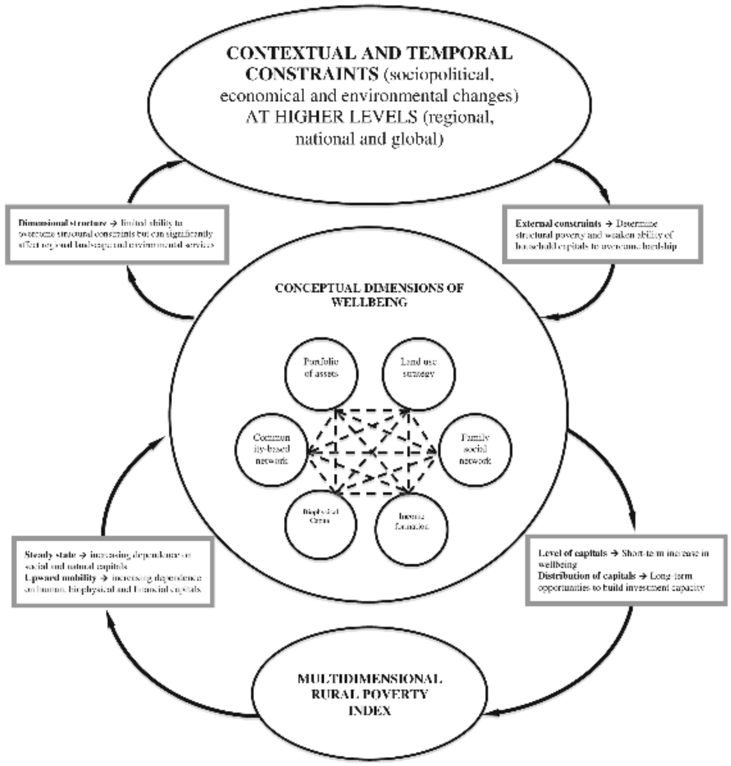

Fig. 2.

Conceptual framework for multidimensional rural poverty

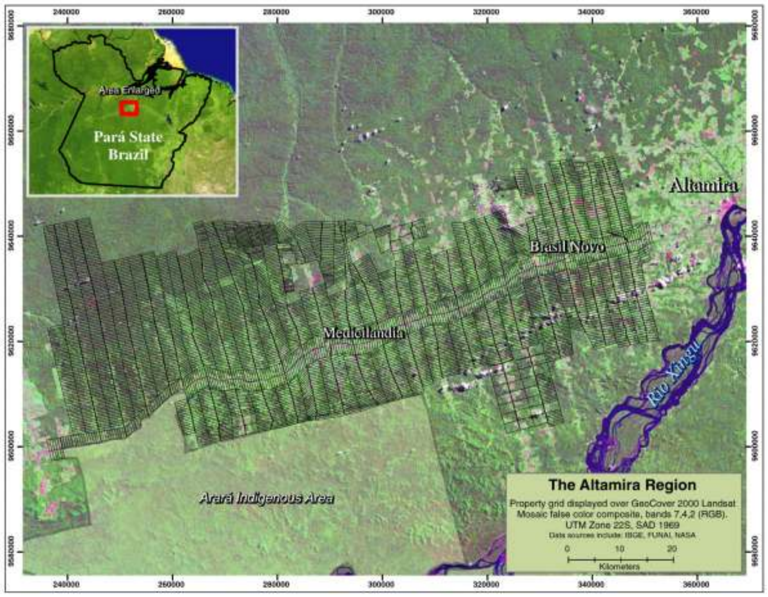

Fig. 3.
The Altamira region study area

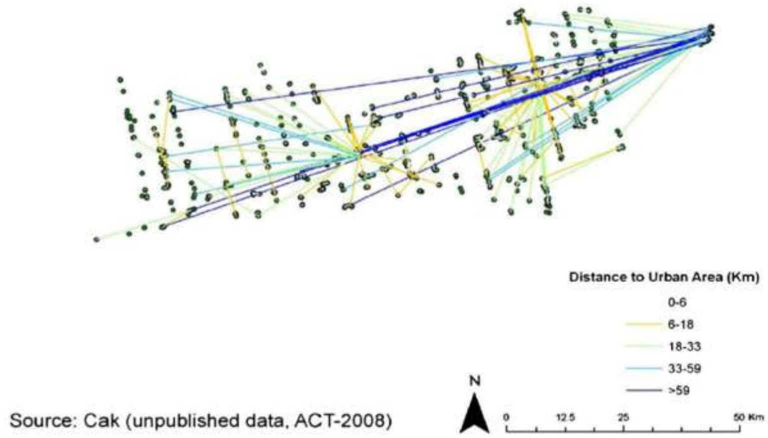

Fig. 4.

Rural properties with associated urban households in 2005

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Table 1

Sample size and composition – Altamira study area

Categories	Cross-sectional[a]	Longitudinal[b]
Original Settlers	234	208
New Owners	110	96
Total	344	304
Missing	58	11
Attrition	–	87
Original Sample	402	402

[a]=1997/98;

[b]=1997/98 and 2005

Altamira Study Area dataset (1997/98, 2005)

Table 2

Headcount ratio (HC) in Pará and Brazil - 1997 and 2005

Geographic unit	Population group	1997 HC (Caloric Consumption Insufficiency)	2005	Δ (%)
Pará	Poor	50.00	44.00	−12.00
	Extremely Poor	21.00	16.00	−23.81
Brazil	Poor	35.00	31.00	−11.43
	Extremely Poor	16.00	11.00	−31.25

IPEADATA (2008); PNAD (1997, 2005)

Table 3

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	All settlers	Original 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

Altamira Study Area Dataset (1997/1998); PNAD (1997) 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

Table 4

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	All settlers	Original 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

Altamira Study Area Dataset (2005); PNAD (2005) 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

Table 5

Income-based X multidimensional poverty in Altamira study area, 1997/98

Indexes	All settlers	Original 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	–	–

Altamira Study Area Dataset (1997/1998) Poverty line=2/3 median of cumulated welfare distribution. Extreme poverty line=1/2 median of cumulated welfare distribution

Table 6

Estimated transitional probabilities on poverty in Altamira study area, 1997/98 – income-based vs. multidimensional measures of poverty

Per capita household total income			Multidimensional welfare					
			All settlers		Original settlers		New owners	
			Poor	**Non-Poor**	**Poor**	**Non-Poor**	**Poor**	**Non-Poor**
2/3 Median								
All Settlers	Poor	2/3 Median	0.5414	**0.4586**	–	–	–	–
	Non-Poor		**0.2749**	0.7251	–	–	–	–
Original 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								
All Settlers	Poor	1/2 Median	0.4836	**0.5164**	–	–	–	–
	Non-Poor		**0.2802**	0.7198	–	–	–	–
Original 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

Altamira Dataset (1997, 1998)

Sample restricted to valid income and multidimensional welfare index cases (304 observations)

Table 7

Variables used in the multidimensional well-being scalar for Altamira study area (1997/98)

Income Formation
Educational attainment of the household head
Number of household members with off-farm activities
Total per capita household income
Weighted-index of wealth upon arrival on the property
Type of labor force used on the property (family, sharecropper, temporary, permanent)
Portfolio of Assets
Stock of cattle
Years using electric power on the property
Number of other properties owned (rural or urban)
Property size
Price-weighted goods
Household physical attributes (roof/cover type, wall material, floor type, electric power, water supply, type of bathroom, type of drain)
Family Social Network
Relatives living in the region
Number of families living on the property
Number of family members living in any city within the study area
Help from children to the household in the last 12 months
Land Use Strategy
Proportion of the property in pasture
Proportion of the property in perennials
Proportion of the property in annuals
Proportion of the property in primary forest
Proportion of the property in other land use/cover classes (secondary succession, water, orchard, house & yard)
Monetized production for self-consumption
Weighted index for agricultural technology
Biophysical Capital
Proportion of the property in high fertility soil (*terra-roxa*)
Property location (feeder road vs. highway)
Accessibility to the property during the rainy season
Community-based Networks
Access to formal agricultural credit
Membership to local association/union/cooperative