POPULATION, LAND USE CHANGE, AND CHANGING FORTUNES OF MIGRANT SETTLER HOUSEHOLDS IN THE ECUADORIAN AMAZON

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Abstract. The Northern Ecuadorian Amazon, the principal region of colonization of migrants in Ecuador since the 1970's, has been experiencing major changes in recent years, including a growing rapidly population, fragmentation of agricultural plots, changes in land use, and increased off-farm employment, all of which are affecting farm household incomes and well-being. This paper draws on research based on data from a longitudinal survey of migrant settlers gathered in 1990 and 2000 by the University of North Carolina and collaborators in Ecuador. Based on detailed data, we estimate farm household incomes, show the components of on-farm and off-farm incomes, and estimate Gini coefficients for both land distribution and household income. We consider factors responsible for changes in household income but do not estimate a formal model. The paper has sections on data collection, methodology for estimating household income, results, and implications for policy and further research.

INTRODUCTION

In the past decade or so, there has been a surge in research on the expansion of the agricultural frontier, especially into tropical rainforests. Many studies have documented the importance of the rainforests for local, regional and global climate including global warming, preservation of biodiversity, and hydrology (Myers, 1989; Shukla et al., 1990; Wilsno, 1992; Adger and Brown, 1994; Brown, 1994; O'Brien, 1995; Fearniside, 1996; Tinker et al., 1996; Dale, 1997;. Laurance and Williamson, 2001. There is also evolving a modest but growing body of work on the linkages between people and the environment in frontier contexts in all regions of the tropical world, but especially Brazil, focusing on the effects of human populations on deforestation and land use (Panayotou and Sungsuwan, 1994; Walker and Homma, 1996; Pichón, 1997; Rudel and Roper, 1997; Rosero-Bixby and Palloni, 1998; Perz, 2002; Walker et al., 2002; Carr, 2004, and on the effects of that in turn on human health, especially malaria (e.g., Singer and Sawyer, 1992; Barbieri et al., 2005). Despite the considerable attention to the environmental implications of the extension

of the frontier into rainforests, there has been very little study on the consequences of this process for the people themselves, often viewed as little more than agents of destruction. Without a better understanding of these consequences, the picture painted by the literature is woefully inadequate, since policies for achieving sustainable development in these contexts cannot be successful if they do not take into account the aspirations and economic activities of the people themselves, the migrant settler families.

This paper attempts to address this gap in understanding, based on data from a rare longitudinal data set on migrant colonists in the Ecuadorian Amazon. The study site, in the northern three Amazonian provinces, is one of extraordinary biodiversity (Myers, 1988; Myers et al, 2000), which has been undergoing deforestation at the fastest rate of any country's Amazon region (FAO, 2001). It is also a region where oil was found, in 1967, near what has since become the largest city in the Ecuadorian Amazon, Lago Agrio. The discovery of oil led to an influx of migrants seeking land, mainly from the Sierra or Highlands region characterized by a latifundia-minifundia agrarian system in which most rural families have little or no land. Families poured into the region, establishing farms along roads built by the oil companies during the 1970's and 1980's (Pichón, 1997; Pichón and Bilsborrow, 1999). Data were collected from a representative sample of farms in 1990, which was followed by a follow-up survey in 1999. Detailed data were collected on income in both years, permitting both a comparative statics analysis of the distribution of income and its sources in both years as well as a longitudinal analysis of changes over time in household incomes. Results on income from the 1990 survey were published by Murphy et al (1998), and will be summarized below. This paper significantly extends that work by providing not only the first results from the 1999 survey on income, but also on changes over time. It also shows the associations between income and land, household size and other key household characteristics, and land and labor allocation strategies.

HOUSEHOLD INCOMES AT THE FRONTIER: SOME PREVIOUS STUDIES AND CONCEPTUAL ISSUES

Published research on the incomes or welfare of people searching for land who establish farms on the frontier is found mostly in the historical economics literature, and has focused, at least in English, on England and the United States. Research on the developing world is much more limited, but does share one commonality in being based almost totally on incomplete data on household incomes. Instead, a host of proxy measures have been used, such as quality of housing,

amount of land owned or used, agricultural productivity, access to electricity, etc. With the burgeoning interest in the environmental aspects of the expansion of the agricultural frontier in many areas of Latin America, Africa and Asia, one would expect there to be a growing body of literature on the economic status and livelihoods of migrant farmers at the frontier. A major reason for the lack of such research is the lack of appropriate data sets, which is due to the considerable effort and time required to collect, process and analyzes the necessary data.

Although a number of studies have touched on the economic situations of frontier migrants in the Amazon basin region, including Henriques (1988), Schmink and Wood (1992), and Walker et al (2002) on Brazil, Aramburu (1984) and Loker (1993) on Peru, Uquillas (1984) and Rudel (1993) on Ecuador, and Painter (1987) on Bolivia, none of these is based on detailed household income data. Among the few published studies on frontier families based on micro-level or household survey data are Almeida (1992) on the Brazilian Amazon and Murphy et al (1997) on Ecuador. Almeida studied levels of income, wealth and investments on the farm based on a sample of households in the Brazilian Amazon, finding settlers on government-sponsored schemes were better off years later, and that some even had high household incomes but had accumulated large debts.

In the Ecuador Amazon, most farms are semi-commercial, growing annual crops for own-consumption (mainly corn, rice, and plantains) as well as coffee and cattle for cash. Settler colonists have generally a strong market-orientation and preference for cattle ranching as the main farming activity (Pichón, 1997; Murphy, 1998). There has been limited research on the effects of demographic factors on deforestation and land use, focusing on life cycle factors. One example is Walker *et al* (2002), who examine relationships between land use and the domestic life cycle in Brazil, as Marquette (1998) did for Ecuador. While they do not formulate a formal model, they discuss how a household welfare function, portfolio theory, and attitudes towards risk-taking lead to hypotheses about price and labor effects. They review a number of statistical studies, and note that most models are not fully specified and incorporate endogenous variables (Walker *et. al*., 2002, p. 183). They then perform cluster analysis to characterize all (261) farm households in their sample into seven types of farm systems (e.g., cattle specialization, perennials with annuals, etc.), and estimate how household demographic variables and distance affect the likelihood of being in one system or another. They find demographic factors and market accessibility important (p. 193), which provides support for studying roads and access to markets. The authors' review of empirical studies also indicates that factors such as family size and composition, education, and health status may affect household agricultural decisions.

Murphy *et al* used data from the same study area on which the present paper is based, estimating income from detailed data in the 1990 household survey, but there is little discussion of the methodology and the focus is on the factors determining (variations in) household incomes and wealth of the migrant settler families. They found that more land, larger families, higher education, and background factors such as ownership of land and other assets in the previous place or residence had significant positive effects on migrant settler household incomes. This present paper builds on the earlier one by estimating incomes from more comprehensive data for 1999, estimates Gini coefficients and plots Lorenz curves to show land distribution and income distribution, and compares changes over time in household incomes, during a period of great economic and political instability in Ecuador. We do not in this paper formulate and test formal models of the determinants of household incomes or of the factors responsible for changes over time, which is left for future research.

Although this empirical paper does not pretend to advance the theory of the determinants of rural household incomes, much less on the frontier, several aspects are worth mentioning since its estimation is complex and has several dimensions. These farm households are neither pure subsistence (per Thorner et al., 1986 on Chayanov) nor purely market-oriented households but rather a combination, since they produce for both the market and their own consumption, which has been referred to as mixed (economy) households (see, e.g., Walker et al., 2002). These frontier households have essentially no capital, so their incomes depend on the amount and quality of land they possess and the number and quality of workers. The earnings capacity or quality of individual workers has been investigated by an extensive body of research in labor economics, and has been found to depend on education, work experience, occupation, age, and gender. The relevance of these factors in the Amazon context has not been carefully studied, though education must have less effect on farm incomes in these contexts, and previous work experience and occupation are mainly relevant only for similar jobs. Nevertheless, education may affect both the likelihood of a person choosing to work off the farm, where earnings may be better, and the level of earnings perceived in that employment. Therefore, all of this usual cast of character attributes at the individual level may still be expected to influence household income, and so must the number of such individual workers.

The other main factor affecting household income is the quantity and quality of landholdings. In this context, it is useful to draw on the neoclassical theory of the agricultural farm household (Singh et al, 1986, Strauss, 1986; Walker et al., 2002). Thus the small mixed household is seen as attempting to maximize household utility, which depends on household consumption and

leisure time. It thus allocates land, labor, and technology (choice of methods, intensity of land use) to achieve this goal, subject to constraints on information, market prices, and total household labor. Then a series of factors can be found from the first and second order maximization conditions that affect production and therefore income from the farm, and from the off-farm allocation of part of the household labor supply, which has rarely been considered in these farm household models. Nor has the fact that these farmers generally have little education and high risk avoidance, and hence are oriented to satisficing rather than maximizing behavior (Simon, 1976). In any case, in this study we will examine some of the factors likely to be linked to farm household incomes only descriptively, following our description of the study area and the methodology for estimating household incomes in this special frontier context.

STUDY AREA

The Northern Ecuadorian Amazon is part of the western Amazon rainforest, characterized by very high biodiversity (Myers et al, 2000), considerably higher than the less wet areas to the east in Brazil (Figure 1). It constitutes 45% of Ecuador, but is sparsely populated, containing only about 5% of the population. This region, the Pacific Coast lowlands, and the Highlands or Sierra represent the three distinct landscapes of the country. The Amazon region ranges from the Andean foothills to about 200 meters above sea level at the eastern border with Peru, with the study area 350m to 250 m, straddling the Equator, with high annual rainfall of 3-5 m and no distinct dry season.

[Figure 1 here]

Since the 1970s, the region has become increasingly occupied by agricultural settlers, and continues to be seen as an "open frontier", attracting migrants from other parts of Ecuador, especially the rural Sierra, characterized by high rural poverty linked to extremely concentrated landholdings, or "minifundia". The initial colonization process was facilitated by oil extraction activities, especially the establishment of a network of roads by oil companies following the discovery of significant deposits of oil near Lago Agrio in 1967. The construction of roads to lay oil pipelines led to massive in-migration, agricultural colonization and high rates of deforestation. The forest cover on sample farms fell from essentially 100% in 1970 to 59% by 1990 and 45% in 1999.

Hiraoka and Yamamoto (1980) estimate as 8,000 the number of farm households that had been settled in the Napo and Sucumbios provinces by the late 1970s. They also investigated how the prominence of spontaneous colonization rather than planned agricultural settlements in the NEA, and the usual transition from slash-and-mulch polyculture to cattle ranching after some years of settlement has caused important threats to the ecosystem. Bromley (1981) described the *respaldo* pattern of agricultural settlement and deforestation in the NEA, in which migrants first settle lands along the roads, and subsequent settlers occupy parallel plots of land 2 km farther from the road, then 4 km, 6 km, 8 km and so on. Settlers were provided provisional land titles by the National Land Reform and Colonization Institute (IERAC) once they proved they had cleared land for agriculture (Murphy, 1998). Plots of land were usually 50 ha (250 m wide and 2 km long). Unfortunately, land tenure insecurity in the Ecuadorian Amazon increased drastically after 1993. Bilsborrow *et al.* (2004) describe how IERAC, which had existed since the original agrarian reform law was passed in 1964 and which had been especially active in land titling in the Amazon region, was terminated in 1993 by the neo-liberal government and replaced by a weak agency, INDA, which has done little to provide land titles to settler colonists in the Ecuadorian Amazon since 1993.

Recently urbanization has become an important process in the Ecuadorian Amazon. By 2001, the level of urbanization (proportion of population living in urban areas) was 36%, compared to 26% in 1990 and under 5 % in 1970 (INEC, 1992 and 2002). High natural growth resulting from high fertility, a continuing influx of migrants, and prospects of further expansion of the oil industry (following recent discoveries of large new deposits and the completion of a second trans-Andean oil pipeline in 2003) point towards increasing in-migration, pressures on land, and urbanization in the spatial configuration of the Ecuadorian Amazon in the future. Findings of our 1999 survey support this, showing high population growth, increasing farm subdivisions, and the formation of *solares* – small household residential plots--along main roads and near the main towns. Rural residents are increasingly engaging in off-farm employment, in great part due to the growing importance of urban labor markets as well as rural employment in the Amazon, and doubtless also out of economic exigency due to the decline in the price of their major cash crop, coffee.

DATA

A representative probability sample of farms was selected covering the main rural settlement area in 1990, providing data on demographic composition and behavior, agricultural production and

inputs, assets, earnings from off-farm work, remittances, etc. The sample frame in 1990 was based on lists of agricultural plots allocated to families moving to the region, provided by the government land reform and colonization agency, IERAC. The sample frame consisted of a large map listing each of the areas opened to settler occupation, called "sectores", together with the number of plots originally allocated for settlement in each sector. Agricultural plots were selected with a two-stage sampling strategy. In the first stage, sectors were selected from the IERAC list using systematic sampling, and in the second stage a number of (contiguous, for ease of fieldwork) "fincas" or agricultural plots of about 50 hectares were sampled using PPS (probabilities proportional to size). The two-stage sampling procedure led to a sample of 64 sectors (from the 297 in the region), sample "takes" of 5 to 10 fincas randomly selected from each of the sample sectors, and a total 416 farm households. This sample was thereby representative (accounting for 5.9%) of the entire rural settler population of the study region in 1990, such that the results can be taken to be representative of that population, unlike many other samples of households in the Amazon basin, which have usually been along roads.

During the 1990s many changes occurred in the in Ecuador in general, and principally in our research area, where many owners of the original plots subdivided them by 1999 to accommodate land use pressures due to high family size - by giving part of their land to a marrying son or daughter, or by selling a plot to a new settler. As a result, in 1999, 767 farm households were found on the same sample plots of land. The 1999 survey also found that, besides the many new subdivisions for farming, there were a large number of subdivisions occupying small-size plots (under 0.5 ha.), called solares. To understand the implications of these changes for land use and settler welfare, a follow-up survey was undertaken in 1999, involving revisiting the same plots of land or fincas as were visited in 1990 (the new project was funded primarily by NASA). Then, in 1999, 950 questionnaires referent to 950 plots of land had to be administered to all heads of household living on the *finca madres*. Of these, 823 are farms (defined as having at least one hectare of land), 111 represented *solares,* and 16 were for other diverse uses (such as a school or store). Given the response rate of 93%, the total sample is 767 *farm plots* of 708 independently managed farm owners (708 owners had one *finca*, 56 owners had two, and 3 had three *fincas*), albeit some of them do not provide complete information on all sections of the survey questionnaire. These questionnaires were administered to the heads of households. There are also 658 questionnaires with demographic and socioeconomic information on *households*, collected from the spouse of the head of the household (a 97% response rate). Overall, combining useful

information to analyze income and population characteristics in 1999, a total of 658 *farm households* are used in the analysis for 1999 in this paper.

METHODS

Many surveys of households that collect data on many topics either do not ask about income, or ask one or more comprehensive questions like, "altogether, how much income did you make last year (or month), from your work, business, farm, etc." This will never lead to reliable data, even if everyone in the household above some age is asked the same question, and the results are added together. The only chance of collecting reasonably reliable data on household incomes in developing countries is to ask detailed questions about all possible sources of income from each household member. This includes income from wage work, temporary or permanent, full-time or part-time, and from any secondary job as well as the primary one; plus income from any own-account economic activities such as cooking for others, street hawking, street cleaning, etc.; plus income from any individual proprietorship professional activities, such as that of a doctor, engineer, accountant, consultant, etc.; plus income from any type of owned business, including a store, restaurant, farm; plus income from other sources, such as savings accounts or other financial assets, rent from property, gifts, government transfers, remittances from migrants, etc.[1] The number of questions and time required to collect income this way is such as to make it almost never happen in a multi-purpose survey.[2] Even having a chance at collecting usable income data requires, besides well-trained interviewers who gain the confidence of the respondent and convince them of confidentiality and anonominity, a well designed questionnaire. Such a questionnaire will not only cover all the possible sources of income with multiple questions, but collect as much as possible indirectly or based on quantities sold, for example (such as farm crops, bottles of beer, haircuts, without actually asking incomes. In such cases, prices may be asked separately or not at all, if they are available or can be approximated from other sources, such as market price data.

Another issue, especially for farm households, is the fact that they are often consumers of their products as well as producers, so that collecting data on sales of farm products will lead to

1 An entirely alternative way of estimating household income is to ask a detailed series of questions about consumption purchases. For a general discussion of alternative ways of measuring household income from surveys, see Bilsborrow et al (1997).

2 One major exception to this is the World Bank's Living Standards Measurement Survey, but this requires multiple visits, something like 9 hours per household in a year, and is accordingly far too expensive for almost all organizations, including LDC governments, or research studies.

underestimates, which is likely to be the case more for the poor (who may sell little, being mainly subsistence producers) than the rich, who are likely to have larger landholdings and engage in monoculture production for the market. This means it is necessary to ask about total production and not just market sales. In the case of the Ecuadorian Amazon, most farm households engage in multiple farm activities and also produce some crops and fruits that they do not sell. The value of all such products should be estimated or *imputed*, and will often constitute an important part of household income, especially for small farm households. Without including the imputed value of farm production, incomes will be underestimated differentially for low-income households, and therefore measures of poverty and inequality exaggerated.

With these preliminary remarks, the estimation of household income was based on standard procedures, for both farm and off-farm sources of income. The former is more complicated and is based on the amount of production (with units) of each crop including minor fruits and vegetables, in the past 12 months (with separate questions on each plot or parcel of land in each crop, number of harvests and months of harvests, to aid recall). Questions about income in the past 12 months from the sale of large and small animals (such as cattle, in the man's questionnaire, and pigs, chickens, etc., in the woman's) are supplemented by asking about sales of animal products, such as milk or eggs. Though very few have such sales, that is not a good pretext for not asking. Other sources of income from the farm include renting out land or large farm animals, such as a horse or ox; cutting trees to sell wood; and income from the sale of animals, fish, and non-wood forest products. The estimation of income from the sale of timber is fraught with difficulty in the study setting, and we wager in general in the developing world, since those extractive activities are often illegal.[3] This was likely the case here too, despite our best efforts to probe with detailed follow-up questions about which species were sold (with the interviewer reading off examples of common local trees, from the most valuable to the most pedestrian), to whom/type of buyer, and in what units and quantities. The problem is that there is nothing to make the respondent answer the *initial* screening question honestly if he does not want to: "Have you sold any timber or wood from your farm in the past 12 months?" Note that we do not try to estimate the imputed value of wood used in house construction or repairs of for fuelwood, nor the amount or value of animals hunted or fish

3 In the case of Ecuador, the sale of timber from valuable tree species such as mahogany, even from one's own farm, requires first obtaining and paying for a permit. This has usually required long delays and some cost, so most farmers do not obtain permits and instead engage in illegal sales, usually to passing trucks that serve as intermediaries. Government officials have often been implicated in looking the other way, or taking bribes. Except for a brief period in 2002 under the "Vigilancia Verde" program of the Ministry of the Environment, this has traditionally been the case, including at the time of both surveys.

caught and eaten. Based on informal talks with colonists and the limited questions on these topics in the surveys, we are confident these latter items are all very small or non-existent for colonist households, in contrast to indigenous households (Lu et al 2004).

Off-farm income primarily consists of wage income of any member of the farm household who worked for pay away from the farm in the 12 months prior to the survey, whether agricultural or non-agricultural work, such as running a small store or *tienda* or teaching school in the local community (about the only non-farm work available in the smaller communities), or working in a nearby town, which may involve a wide range of occupations. Wage work is quite common, with even 40% of the households having someone in the household engaged in off-farm work in 1990, when farms were almost all intact (mean of 45 ha), which rose to 60% by 1999. Other, extremely rare sources of off-farm income of farm households include income from financial assets such as savings accounts, renting out vehicles or farm equipment (rare since technology is low), sales of fuelwood, and giving tours to tourists on their land. Finally, remittances from former household members who migrated away, whether to start their own farms, work in towns in the Amazon, or to more distant destinations, are included in off-farm income. However, remittances from migrants are rare and small in this region, despite the fact that by 1999 fully a quarter of farm households had one or more out-migrants. Few migrants sent anything back home, according to the farmers who would be the receivers of such remittances. While they could well be underestimating remittances, we have no way of knowing by how much. In any case, it is very unlikely that they were ever important sources of income among colonist households.

Several special, supplementary procedures had to be used to improve estimates of household incomes in the Ecuadorian Amazon. One was to obtain income from other, non-sample farms, since as much as 25% of the farmers in the sample have other farms, usually contiguous or near their sample farm, and some have three or four additional farms. Since it would have been extremely time-consuming to administer the same detailed questions on those farms as was done on sample farms, we did inquire about the total amount of land in each use (coffee, rice, pasture, etc.) and assumed the same per-hectare income as from hectares in that form of land use on the sample farm.

A more general imputation issue was what to do when the data provided by a farm household were incomplete. For example, if data were provided on quantities (e.g., production or sales of coffee but not price), then the mean price reported by others in the same community or *sector* was used. If the amount of land in a particular use was reported but not the production, then output was imputed to be the same per ha from other parcels of the same farmer, or neighboring

farmers. While such imputations were often necessary, they rarely concerned significant portions of farm household incomes. Note that as long as we had data on the amounts of land in each form of land use—which was the case since the main focus of the NASA-funded survey was land use--then such imputation procedures could always be used to estimate income from that parcel in that form of land use.

Income data invariably involve outliers, which in turn often means median values are preferred to means as measures of central tendency. However, this was not found to be a significant enough overall problem to not use means, for example, mean household incomes per land size strata. Two extreme cases do exist in the 1999 data, however, of a farm in the 90+ ha category and another of 20-30 ha, which were largely cleared and devoted to African palm, which has a high per ha earnings profile, though also requires heavy use of herbicides and environmental damage.

Once total household incomes were estimated for farm households from both the 1990 and 1999 surveys, it is of considerable interest to compare them, to see if households experienced improvements or declines over time, and why. This required adjusting for the high rate of inflation during the decade--the decline in the purchasing power of the currency, the sucre. Appendix A describes the procedures used, and the conversion to dollars to make the final numbers more meaningful for the reader.

Since we are also interested in the distribution of income, the Appendix also briefly describes the procedures for computing Gini coefficients.

The next section presents the results for the estimation of income of farm settler households in the northern Ecuadorian Amazon based on the 1999 data, with some comparisons to 1990. Relationships between 1999 household income and several key factors likely to affect those incomes, such as farm size, household size, education of the head, etc., are also indicated. The section after that examines changes over time in household incomes and some likely correlates.

RESULTS

Population characteristics

Table 1 provides comparative demographic data for the study site in 1990 and 1999. Data refer to farm households, defined as separately managed agricultural units or subdivisions with over 0.5 ha

of land[4]. In 1990, the average farm household size was 6.6, and the population was typically young, with 40.6% below 13 years of age. The dependency ratio– 0.79 – reveals the high fertility regime prevailing up to 1990, and the age composition indicates the working age population relative to the high number of child dependents (and a small proportion of older persons). The dependency ratio in 1999 is almost the same, showing little change in the worker-dependent proportions, but the average household size is smaller – 5.9. These indicators show a young age structure in the study area, what is particularly relevant in the case of land subdivisions after 1990 that are mainly occupied by younger couples. Furthermore, younger women at their initial or intermediary reproductive ages probably did not achieve the desired family size. Thus even if contraceptive use continues to rise and a dramatic fertility decline occurs in the next decade, *population momentum*, based on the current age distribution with a large proportion of young women, will ensure that the number of births continues to be high.

[Table 1 – here]

The mean age of the head and spouse shows little variation between 1990 and 1999, reflecting the fact that the effect of the aging by nine years of the (majority of) the 1990 heads who remained on their farms is slightly more than compensated by the change in the composition of household heads, which in 1999 also include their sons becoming new heads of households and new in-migrants arriving who are certainly younger than the 1990 heads who are now nine years older. There is also a substantial educational improvement in the population: the percentage of the population above age 6 in 1990 with at least complete primary education is more than half, compared to 44% in 1990. Furthermore, there is a substantial increase in the proportion with some secondary education – 19% in 1999 against 12% in 1990. These numbers reflect, at least in part, the increasing accessibility to schools constructed in the communities in the northeast Amazon during the 1990's.

Table 1 shows a small decrease in the sex ratio, leading to more balance in the proportions of men and women. This is typical of the change over time that occurs in frontier areas in the Amazon and elsewhere. In the north of Mato Grosso, Brazil, for example, the existence of different forms of land use besides agricultural colonization, such as mining, large-scale logging and large cattle ranching activities, leads to a situation of predominant male labor. Furthermore, in contrast to other areas facing agricultural colonization, such as Rondonia, in Ecuador it was rare for males to move to the region first to live alone only to later be joined by their families. While males often

4 *Solares* are excluded since they reflect a type of household distinct from those surveyed in 1990: they are non-farm households who support themselves by off-farm work.

indeed made a visit to the region to assess the situation prior to the move, once they decided to move, the whole (nuclear) family moved together (Bilsborrow, 2002).

One last issue on demographic changes in the northeast Amazon, as reflected in Table 1, refers to fertility patterns in 1990 and 1999. Based on the 1990 survey data, Thapa and Bilsborrow (1995) conducted a preliminary analysis of fertility among *settler women* (i.e., the spouse of the head of household) and explored possible changes in fertility over time prior to 1990. They found the total fertility rate (TFR) for settler women, estimated using indirect methods, to be extremely high in 1990, at 8.0 children per woman. Similar estimates based on the Brass indirect method yield a TFR of only 5.0 for 1999. Both estimates may be distorted to the extent that fertility was not constant in the years prior to the surveys, which is being further examined. The data for 1999 may be compared with those for the Amazon region as a whole from the latest National Demographic and Health Survey carried out in 1999, called ENDEMAIN III (CEPAR, 2000). The latter estimates a TFR of 5.5 for the region, in contrast to 3.4 for the country as a whole (4.4 rural, 2.8 urban). This was the first national demographic survey to include the Amazon region.

Farm income

Tables 2a and 2b show the results for household incomes respectively for 1990 and 1999. This includes the absolute values of farm incomes for 10 land size categories and for all farms together, as well as the overall breakdown of percent of farm household income from on-farm sources (annual crops and perennials, livestock and small animals, and wood) and off-farm sources (mostly income from off-farm employment, but also including remittances from migrants and income from renting out of land). The tables also show the mean household income for each land size category and its breakdown, and mean household size, and the resulting mean household income per capita in US 1999 dollars. Table 2c presents results on changes over time (%) between these two years of analysis. The results are presented, as above, according to ranges of farm land size in ha.

[Table 2a here]

[Table 2b here]

[Table 2c here]

Overall, the tables show important differences in farm income and household size between the two years. The mean household income and income per capita in 1999 are respectively 30.5% and 21% smaller than in 1990, despite the slightly smaller household size in 1999. There are also

important differences in sources of farm household income. Overall, farms in 1990 had most of their income from on-farm sources (74%), while in 1999 this percentage decreases significantly (to 56.6%), with a growing importance of off-farm sources of income. We assume that this is explained by two major changes in the Northern Ecuadorian Amazon over the 1990s. First, international commodity prices became very unfavorable to the main farming products in the Ecuadorian Amazon – coffee and beef, leading most farms to look for alternative, off-farm sources to complement farm income. Second, and as discussed previously, the study area has faced an increasing process of land subdivision, mostly to accommodate endogenous farm population pressures (sons and daughters of first generation settler colonists reaching adult ages and demanding their own land) or exogenous farm population pressures (land being sold for in-migrants continuing to come to the region (Barbieri, 2005). As shown in Table 2c, there is a huge increase in the proportion of smaller farms (until 30 ha) and a proportional decline in higher ranges of farm sizes.

The process of land fragmentation over the 1990s has profound impacts in the way that farm colonists make their living. The results show that, overall and as expected, the smaller the farm the higher the proportion of income from off-farm sources in 1999. The opposite is also valid – the larger the farms, the highest the proportion of on-farm income in 1999. However, this expected relationship is not evident in 1990. In fact, while farms below 2 ha in 1999 had 85% of their incomes from off-farm sources, the same farm range in 1990 was responsible for only 14%. This is also valid for most of the farm ranges in analysis. Nonetheless, for fewer hectares of land, the mean income per capita is much higher in 1990 compared to 1999. The results possibly reflect the fewer off-farm employment opportunities early in the decade, and perhaps more importantly, that the then favorable commodity prices acted in a way to improve rural livelihoods and retain farm labor.

The results for 1990 shows that farm sizes in intermediate ranges (10-20, 30-40) are more likely to have a higher income from off-farm sources compared to smaller or larger farms. This results support evidences from Pichón and Bilsborrow (1999) and Marquette (1998) about the higher income diversification by farms of intermediate size.

Tables 3a, 3b and 3c show the results by income category instead of farm size. The tables show that the poorest farm households tend to have smaller declines, or even increases, in mean household size, probably indicating an association between fertility, household size and poverty. But the main factor explaining lower incomes is their smaller resource base (farmland). It is interesting that even the richer farms have a high proportion of income from off-farm sources, both

in 1990 and 1999, suggesting this source as a desirable way of diversifying sources of household income even for households with plenty of land.

[Figure 3a here]

[Figure 3b here]

[Figure 3c here]

It is also useful to examine the disaggregated data on sources of household income. Given the similarity of results when controlling for farm size and income categories - given their close association - we focus here on disaggregated information only by farm size. Tables 4a and 4b show, respectively for 1990 and 1999, the percentage of farm income by source (coffee, other crops, livestock, small animals, wood, and off-farm) by farm size. Unfortunately, data are not available on income from small animals (chickens, ducks, guinea pigs, etc.) in 1990. Table 4c shows the change in the sources of farm household income between 1990 and 1999.

[Figure 4a here]

[Figure 4b here]

[Figure 4c here]

Overall, and as expected, the percentage of household income from coffee declined over the decade, from 24% in 1990 to 16% in 1999, with the highest declines for smaller (and poorer) farms, followed by some intermediate farms, indicating frailty to changing economic conditions. These smaller forms were much more likely to switch to off-farm sources as an alternative to coffee and also to livestock (which is severely constrained due to small plot sizes). Only farms 10-20 ha and above 60 ha had increase in land in coffee in the decade.

As a result of the process of land fragmentation and declines in the market price of beef, there was a large decline in the proportion of farm income coming from livestock (28% in 1990 to 15% in 1999). Perhaps surprisingly, there was an increase in livestock as a source of income for some relatively small farms (101% for farms 10-20 ha), and a much smaller increase for farms (8% for farms 30 -40 ha). But these are the only two cases of increases in the percentage of income coming from livestock; at the same time, there are no increases in income from cattle for larger farms. In any case, the two categories experiencing an increase in the proportion of their income coming from livestock represent only a small part of all sources (with most income being from off-farm sources).

The source of income with the highest percent increase between 1990 and 1999 is wood, from less than 1% in 1990 to 13.4% in 1999. This may be related to the dramatic process of land fragmentation in the study area, with new farms being settled and forests cleared to initiate farm production on new farm subdivisions. The single most important source of farm income in 1999 overall is off-farm employment, whereas in 1990 sources of income were more balanced, off-farm employment becomes increasingly more important over time, rising from 26% in 1990 to 38.3% in 1999.

Income and land inequality

Did poverty increase or decrease in farm households in the Northern Ecuadorian Amazon between 1990 and 1999? Have they become better off in term of land size and farm income? These were two principal questions before our analysis, and the answers differ depending on the measure used. Although income is not a complete measure of economic welfare, most assessments of poverty and inequality around the world are based on income (Robeyns, 2005). We therefore use Lorenz curves and Gini coefficients of farm size and farm household income to examine changes between these two years (Figures 2a and 2b).

[Figure 2a – here]

[Figure 2a – here]

In this approach, households were ranked by farm size in 10 categories, using the same categories in both 1990 and 1999. Thus, total on-farm income and total off-farm incomes were used. Due to the process of farm subdivisions mentioned above, the total number of farm households were 418 in 1990 and 658 in 1999.

To compute the Gini index of income inequality, the cumulative percent of households by farm income is matched with the cumulative percent of households (see Appendix Table A-1). The results show that the Gini coefficient (G) remained essentially unchanged between 1990 (0.554) and 1999 (0.551). Corresponding to these two Gini coefficients are the Lorenz curves, which may illustrate changes that are obscured in the overall Gini measures of inequality. The Lorenz curves show that there was a slight increase over time in the percentage of very poor households, as well as in the few rich households, though overall inequality did not change.

It is not surprising that the proportion of very poor households increased given the extraordinary process of fragmentation of farms, which led to a substantial rise in the Gini coefficient of land distribution from .271 in 1990 to .448 for 1999. This increase in such a short

period of time is striking, and would be expected to lead to a significant increase in the measure of income distribution inequality.

How is it possible that this did not happen? The answer is found by looking at the major components of farm household incomes in the two years. Thus, although on-farm sources of income constituted the majority of farm household incomes in both years, their share declined from 74% overall in 1990 to 57% in 1999, falling by almost half in monetary terms. Meanwhile, off-farm sources of income rose by about 17% overall, becoming 43% of farm household incomes in 1999. More important for reducing inequality, the off-farm shares rose from about 20% for the few households with under 10 ha. in 1990 to over 60% in 1999. It is thus this off-farm income, predominantly from wage labor, that smoothes over the dramatic increase in land inequality so that overall income inequality did not rise. Notice, from Table 2b, that the absolute amounts of off-farm income reported by those households with small farms in 1999 differed little from those reported by households with medium size or large farms, in stark contrast to on-farm incomes.

CONCLUSIONS AND POLICY IMPLICATIONS

This paper uses a rich set of longitudinal data on migrant farm households who have expanded the agricultural frontier eastward into the Ecuadorian Amazon. The data provide information on farm household income, population characteristics, land size and use, and many other aspects of these households, facilitating a comparison of household incomes in 1990 and 1999. The results show that, overall, farm households suffered a decline in incomes. While exogenous contextual factors, such as a decline in the international price of coffee and the internal price of beef may play fundamental roles, income changes between 1990 and 1999 are also partially due to the limited possibilities for land extensification as colonist expansion is circumscribed by titling of indigenous lands and national parks. Unlike elsewhere on the Amazonian frontier, population pressures on the Amazonian frontier are continuing to increase, due to both past high fertility and continuing substantial in-migration. Thus households are still large due to high fertility, despite fertility decline in the 1990's. The effect of past high fertility is seen in many of the original plots being subdivided among sons and daughters as they reach adulthood. Furthermore, many of the 1990 farm owners sold off part of their land to new in-migrants, perhaps to acquire cash to confront an emergency or for investment in the farm or to cope with declining on-farm incomes.

During the 1990 there was correspondingly a significant increase in income from off-farm employment, which has come to play an increasing role in household income generation. This has also contributed to diversify the "household portfolio", spreading risks and diversifying sources of income.

Another, even simpler consequence of the decline in fertility along with out-migration *from* the original settler households by sons and daughters as they reach adulthood is a striking decline in household size between 1990 and 1999. This has considerably attenuated the decline in *per capita* incomes of households compared to their mean incomes. Despite this demographic "dividend" and efforts of settler households to diversity sources of income, poverty has only increased.

Changes over time in inequality have also been examined in this paper. A large increase in land inequality occurred, as elsewhere in the Amazon, but for the opposite reason: The Gini coefficient measuring the distribution of landholdings rose from 0.271 to 0.448 in less than a decade, not from consolidation of landholding as in the Brazilian Amazon (Schmink and Wood, 1992) but instead from a fragmentation of farms, a parcelization of plots, resulting from both inheritance by children of settlers and in-migration. Thus it is not just a land invasion by migrants that has led to the rise in inequality of landholdings but the lagged impacts of previous high levels of fertility. The latter is virtually never even mentioned as a factor in land use change on the frontier, though it must be becoming important in other areas of the world beyond Ecuador.

It is intriguing, however, that despite the sharp increase in land inequality, *income inequality* did not change at all among rural farm families in the Ecuadorian Amazon. This is in turn due to two factors, the declining fortunes of farm production due to price declines in the two principal farm cash products and the effects of increasing off-farm employment, especially among those with little land, that ameliorated the consequences of the change in land distribution. Our long involvement in research on Ecuador leads us to wish to provide policymakers with information useful to achieve more sustainable development in the region. While remedial policies such as better extension of Ecuador's welfare program can alleviate impoverishment in the short run, other policies such as family planning, technical assistance for changing land management practices from coffee and pasture to other higher-value forms of land use, and further expansion of urban employment are much more likely to be effective as well as sustainable.

This paper has shown that the effort to collect detailed data to measure household incomes in frontier regions can yield useful information and research findings, as well as provide the generally recognized best estimate of farm household welfare. Nevertheless, the data are not

without flaws: Some farm production figures may be too low, due to concealment or memory recall problems. And it is doubtless true that the value of wood (mostly illegally) sold from settler farms is too low, though we have no way of knowing how much this underestimate is or its form: Is it mainly underestimated for those families that report income from wood sales, or from families failing to report having income from sales of wood? And we have not conducted multivariate analyses here to investigate, for example, the determinants of farm household incomes in 1999 (as Murphy et al [1997] did for the 1990 sample in the same study region) or of changes in those incomes over time. While this could provide further findings useful for policy consideration, we think the key changes in land size, prices, and both fertility and migration are the main factors involved, as described here.

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Table 1 – Comparison of Selected Demographic Characteristics in the Northeast Amazon, 1990 vs. 1999

Indicators	1990	1999
Population (N)	2,761	3,835
Households (N)	416	652[a]
Average Household Size	6.6	5.8
Age Groups (%)		
Age < 12	40.58	40.37
12<=age<65	55.92	56.92
Age>=65	3.50	2.71
Dependency Ratio[b]	0.79	0.76
Mean Age of Head of Household (years)	44	43
Mean Age of Spouse of Head (years)	39	37
Sex Ratio[c]	1.22	1.19
Education (%)		
None	7.23	6.48
Incomplete Primary	48.43	41.02
Complete Primary	32.60	33.69
Incomplete Secondary	8.38	14.25
Complete Secondary or Higher	3.36	4.57
TFR	8.0	5.0

[a] Not including 109 *solares*
[b] Rate of population below 14 and over 64 to the population between 14 and 64 years old.
[c] Males/females.

Table 2a – Percent of farm household income from on-farm and off-farm sources, according to range of farm size in 1999 – Northern Ecuadorian Amazon

Farm size (ha)	N	Mean Household Income $ US	Mean household size	Income per capita $ US	On-farm Income %	Off-farm Income %
0 - 2	38	482.2	5.2	92.4	14.6	85.4
2 - 5	128	778.7	5.0	155.4	38.0	62.0
5 - 10	74	1017.2	5.1	197.9	51.3	48.7
10 - 20	62	995.8	5.7	174.4	70.4	29.6
20 - 30	69	1275.4	6.2	205.1	57.6	42.4
30 - 40	81	1402.1	6.4	219.4	58.9	41.1
40 - 50	146	1640.6	6.1	267.6	58.2	41.8
50 - 60	34	2161.7	6.7	325.1	69.8	30.2
60 - 90	18	4013.7	6.7	597.3	61.0	39.0
More than 90	8	2126.6	6.3	337.6	63.8	36.2
Total	658	1305.2	5.8	225.0	56.6	43.4

Table 2b – Percent of farm household income from on-farm and off-farm sources, according to range of farm size in 1990 - Northern Ecuadorian Amazon

Farm size (ha)	N	Mean Household Income	Mean household size	Income per capita	On-farm Income %	Off-farm Income %
0 - 2	8	840.4	6.6	126.9	86.1	13.9
2 - 5	13	887.5	5.2	169.7	69.8	30.2
5 - 10	9	439.5	4.3	101.5	87.4	12.6
10 - 20	23	801.4	5.5	145.2	59.3	40.8
20 - 30	38	1137.3	6.5	175.0	76.5	23.5
30 - 40	78	1719.4	6.2	275.5	60.1	39.9
40 - 50	166	1842.1	6.5	282.5	75.2	24.8
50 - 60	53	2346.3	7.7	306.3	78.2	21.8
60 - 90	12	2692.4	6.7	404.3	83.1	16.9
More than 90	18	5685.2	8.9	640.2	83.8	16.2
Total	416	1877.8	6.6	285.8	74.3	25.7

Table 2c – Variation (%) in farm household income from on-farm and off-farm sources, according to range of farm size, between 1990 and 1999 - Northern Ecuadorian Amazon

Farm size (ha)	N	Mean Household Income	Mean household size	Income per capita	Mean income from on_farm sources	Mean income from off-farm sources
0 - 2	375.0	-42.6	-21.1	-27.2	-90.3	-83.1
2 - 5	884.6	-12.3	-4.2	-8.4	-52.3	-45.6
5 - 10	722.2	131.4	18.7	94.9	35.8	-41.3
10 - 20	169.6	24.3	3.4	20.1	47.6	18.7
20 - 30	81.6	12.1	-4.3	17.2	-15.6	-24.8
30 - 40	3.8	-18.5	2.4	-20.4	-20.1	-2.0
40 - 50	-12.0	-10.9	-6.0	-5.3	-31.1	-22.6
50 - 60	-35.8	-7.9	-13.2	6.1	-17.8	-10.8
60 - 90	50.0	49.1	0.9	47.7	9.5	-26.6
More than 90	-55.6	-62.6	-29.1	-47.3	-71.5	-23.9
Total	58.17	-30.49	-11.72	-21.26	-47.08	-23.87

Table 3a – Percent of farm household income from on-farm and off-farm sources, according to range of annual farm income in US dollars in 1999 – Northern Ecuadorian Amazon

Annual Income (U$)	N	Mean Household Income	Mean household size	Income per capita	On-farm Income %	Off-farm Income %
Less than 100	44	32.4	5.4	6.0	70.2	29.8
100 - 400	142	250.4	4.6	54.0	72.1	27.9
400 - 700	133	559.3	5.5	101.5	67.4	32.6
700 - 1000	80	847.1	5.9	144.8	72.1	27.9
1000 - 1500	87	1216.9	6.8	179.0	56.0	44.0
1500 - 2500	90	1926.3	5.9	324.3	57.1	42.9
2500 - 3500	37	2973.4	6.3	472.7	54.7	45.3
3500 - 5000	22	4129.8	6.4	645.3	52.4	47.6
5000 - 6500	14	5735.8	8.8	653.3	42.3	57.7
More than 6500	9	13256.8	9.4	1404.3	50.3	49.7
Total	658	1305.2	5.8	225.8	56.6	43.4

Table 3b – Farm household income from farm and off-farm sources, by income category in 1990 - Northern Ecuadorian Amazon

Annual Income (U$)	N	Mean Household Income	Mean household size	Income per capita	On-farm Income %	Off-farm Income %
Less than 100	17	38.3	5.0	7.7	88.4	11.6
100 - 400	53	269.1	5.2	52.3	90.7	9.4
400 - 700	76	548.7	5.9	93.6	83.6	16.4
700 - 1000	58	819.3	6.0	137.0	83.0	17.0
1000 - 1500	66	1229.2	7.5	163.2	82.6	17.4
1500 - 2500	72	1881.5	7.1	265.7	81.1	18.9
2500 - 3500	26	2921.4	7.1	413.2	70.3	29.7
3500 - 5000	24	4183.4	7.6	551.9	76.9	23.1
5000 - 6500	10	7422.2	9.6	773.1	76.5	23.5
More than 6500	16	13115.0	8.1	1615.2	61.1	38.9
Total	416	1877.8	6.6	285.8	74.3	25.7

Table 3c – Percentage change in farm household income coming from on-farm and off-farm sources, by income category, between 1990 and 1999 - Northern Ecuadorian Amazon

Annual Income (U$)	N	Mean Household Income	Mean household size	Income per capita	Mean income from on_farm sources	Mean income from off-farm sources
Less than 100	158.8	-15.2	8.2	-21.6	-32.7	-20.6
100 - 400	167.9	-7.0	-9.9	3.3	-26.1	-20.6
400 - 700	75.0	1.9	-6.0	8.4	-17.8	-19.4
700 - 1000	37.9	3.4	-2.2	5.7	-10.2	-13.1
1000 - 1500	31.8	-1.0	-9.7	9.6	-32.9	-32.2
1500 - 2500	25.0	2.4	-16.1	22.0	-27.9	-29.6
2500 - 3500	42.3	1.8	-11.0	14.4	-20.8	-22.2
3500 - 5000	-8.3	-1.3	-15.6	16.9	-32.8	-31.9
5000 - 6500	40.0	-22.7	-8.5	-15.5	-57.3	-44.7
More than 6500	-43.8	1.1	16.3	-13.1	-16.8	-17.7
Total	58.2	-30.5	-12.0	-21.0	-47.1	-23.9

Table 4a - Mean farm household income and percentage according to source of income (coffee, other crops, livestock, small animals, wood and off-farm) in 1999 – Northern Ecuadorian Amazon

farm size (ha)	Mean Household Income	Number of farm households	Household Income (%)					
			Coffee	Others crops*	Livestock	Small animals	Wood	Off-farm**
0 - 2	483.56	38	6.74	2.82	0.49	4.80	0.00	85.16
2 - 5	1191.43	128	8.36	9.26	2.11	4.11	35.63	40.54
5 - 10	1132.73	74	19.83	11.04	5.89	9.04	10.43	43.77
10 - 20	1089.43	62	29.47	15.57	8.49	9.75	9.64	27.09
20 - 30	1511.66	69	15.30	18.96	7.16	5.00	17.77	35.81
30 - 40	1452.52	81	17.27	12.12	22.54	4.14	4.25	39.68
40 - 50	1795.59	146	16.80	11.07	19.18	3.82	10.94	38.19
50 - 60	2220.25	34	10.06	15.74	35.48	5.87	3.45	29.40
60 - 90	4475.56	18	10.13	12.10	27.69	1.30	13.78	34.99
More than 90	2289.99	8	38.33	9.82	11.18	2.97	4.07	33.62
Total	1481.48	658	15.76	12.40	15.32	4.87	13.38	38.28

* Includes income from all crops and perennials except coffee

** The difference between the total mean income in this table and the result presented in Table 3a is due to the no incorporation, in the last, of on-farm income fromsmall animals

Table 4b - Mean farm household income and distribution by source of income (coffee, other crops, livestock, wood, and off-farm) in 1990 - Northern Ecuadorian Amazon

Farm size (ha)	Mean Household Income	Number of farm households	Household income (%)				
			Coffee	Others crops*	Livestock	wood	Off-farm
0 - 2	840.35	8	37.68	45.46	1.98	0.99	13.89
2 - 5	887.52	13	44.54	19.50	5.47	0.29	30.20
5 - 10	439.53	9	53.39	26.42	7.54	0.00	12.64
10 - 20	801.35	23	23.83	19.63	14.98	0.72	40.79
20 - 30	1137.25	38	33.78	19.81	21.50	1.40	23.51
30 - 40	1719.35	78	24.82	16.88	17.69	0.67	39.94
40 - 50	1841.73	166	26.00	26.95	21.51	0.74	24.80
50 - 60	2346.31	53	20.86	19.53	37.14	0.66	21.79
60 - 90	2692.42	12	15.60	20.17	46.10	1.19	16.94
More than 90	5685.20	18	12.64	16.77	53.38	1.03	16.17
Total	1877.38	416	23.67	21.86	27.95	0.80	25.72

* Includes income from all crops and perennials except coffee

Table 4c – Change in the distribution of farm household income according to source (coffee, other crops, livestock, wood, and off-farm) and farm size category, US dollars, between 1990 and 1999 - Northern Ecuadorian Amazon

Farm size (ha)	Mean Household Income	Number of farm households	Household Income (%)				
			Coffee	Others crops*	Livestock	Wood	Off-farm
0 - 2	-42.5	375.0	-89.7	-93.8	-85.84	-100.00	252.90
2 - 5	34.2	884.6	-74.8	-52.5	-48.36	16482.03	119.02
5 - 10	157.7	722.2	-4.3	-58.2	101.30	-	730.54
10 - 20	35.9	169.6	68.1	-20.7	-22.95	1713.47	695.63
20 - 30	32.9	81.6	-39.8	-4.3	-55.76	1587.69	98.90
30 - 40	-15.5	3.8	-41.2	-28.2	7.65	433.91	4561.28
40 - 50	-2.5	-12.0	-37.0	-58.9	-13.07	1339.81	1171.28
50 - 60	-5.4	-35.8	-54.4	-19.4	-9.60	394.64	158.64
60 - 90	66.2	50.0	8.0	-40.0	-0.14	1830.64	242.30
More than 90	-59.7	-55.6	22.1	-41.4	-91.57	59.84	-16.30
Total	-21.1	58.2	-47.5	-43.3	-56.74	1221.13	485.44

Figure 1 – Study area in the Northern Ecuadorian Amazon

Figure 2a – Lorenz curve and Gini Coefficient for distribution of farmland in the Northern Ecuadorian Amazon, 1990 and 1999

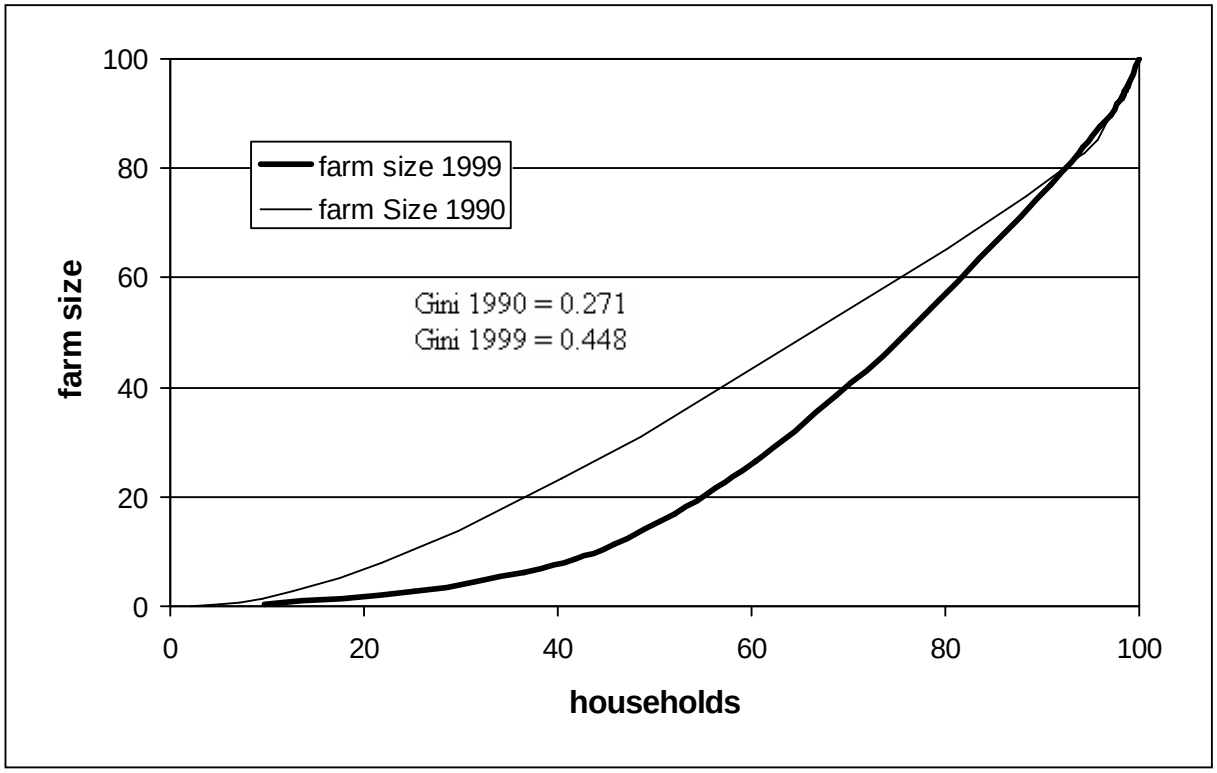
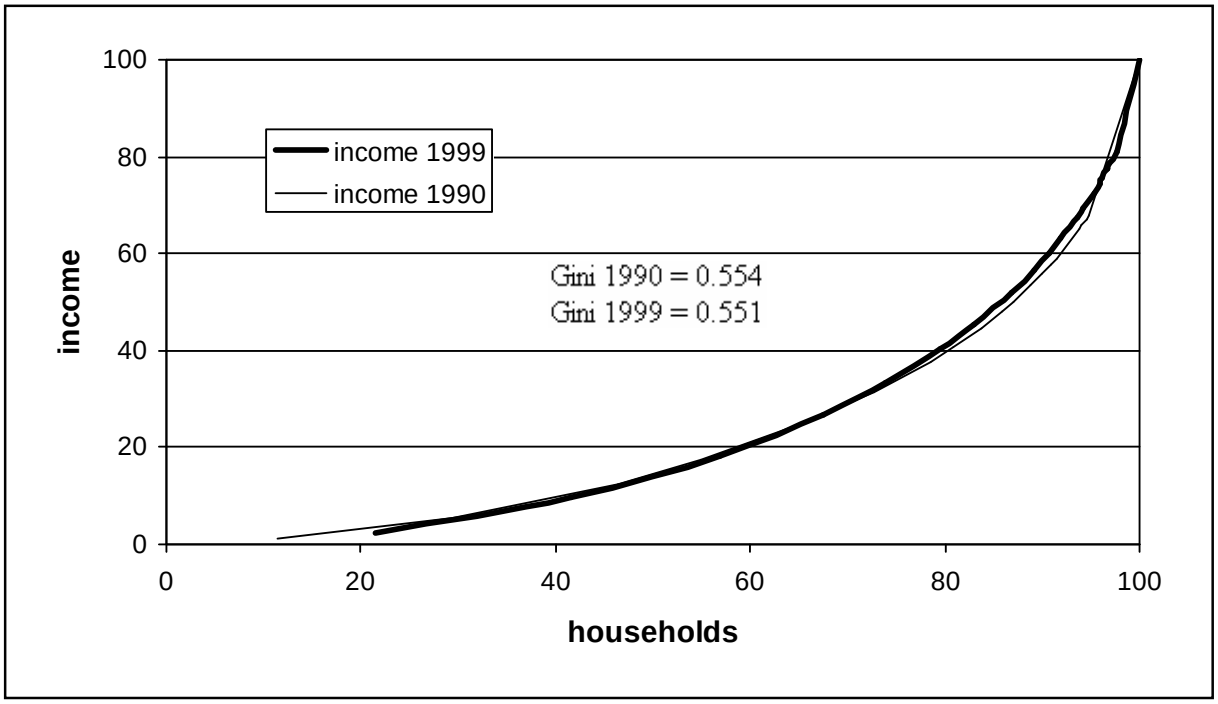


Figure 2b – Lorenz curve and Gini Coefficient for distribution of income in the Northern Ecuadorian Amazon, 1990 and 1999



Appendix A

There are three principal issues for consideration in the present study. The first issue concerns the farm household income analysis based on the socioeconomic, land use and demographic surveys developed in 1990 and 1999. We provide below additional information on the method of estimating farm income. The second issue is how to achieve a comparability between 1990 and 1999, which involved then use of Index Prices and conversion to dollar. The third issue is the comparison of measures of land and income inequality in 1990 and 1999. The second and third issues are also discussed below.

Procedures to estimate farm household income

The 1999 household income data involve information from both the head of household and spouse questionnaires, regarding on farm agricultural and cattle production, extraction of natural resources, income from consumption and sale of small animals, income from off-farm employment, out-migrant remittances, and other sources of income such as rents. The income from farm production includes both the share of production for household consumption and for sale.

Income in 1999 is estimated based on data provided mainly by the male head of the household (the "jefe questionnaire"), with additional information from the female spouse of the head (the "esposa questionnaire"). The estimation of farm household income in the two periods 1990 and 1999 is comprehensive, and based on data on crop production for sale and home consumption, consumption and sales of cattle, extraction of natural resources (especially wood), consumption and sale of small animals (mainly chicken and pigs), earnings from off-farm employment, rental income, and remittances from out-migrants. Note that farm income includes both production for household consumption and for sale, where the income value of food and other products produced and consumed on the farm is imputed based on market prices. However, the estimation of income also involved further data cleaning and data adjustments, imputations for missing items, and corrections where clearly incorrect data were evident. Complications also had to be dealt with such as cases in which a household head owns other plots of land in the sample, for which detailed data are available to yield income (but these cases must not be considered separate households), and cases when he has other farm plots outside the sample. Fortunately, this possibility was anticipated in the questionnaire design, which had a battery of questions to inquire about any such additional farms, size in ha, and main use in crops or in raising cattle. This provided the basis for estimating incomes from those other farms, which nearly a quarter of the

sample owned. Otherwise, household incomes would be woefully underestimated. In general, if information were available on a certain source of income but the monetary value was not provided, it was imputed based on the mean values for the sample.

Currency exchange consumer prices index and inflation

In order to assure comparability between 1990 and 1999, some procedures were necessary in order to adjust the 1990 data for its value in 1999, thus correcting for the rampant inflation in Ecuador in the period, and then converting all the comparable values from the Ecuadorian currency in the 1990s (sucres) to dollars.

Ecuador has adopted the US Dollar currency since March 2000 (BCE), but during the survey period (1990-1999) the currency was Ecuadorian Sucres. According International Monetary Found 1999, the average exchange market rate during the period of data collection (second and third quarter of 1990 survey), was 1 078 Sucres for one Dollar, and the variation among the quarters in that year were not significant. While the variation during the 1999 survey period was extremely high, in February of 1999, at the beginning of the survey, the exchange principal rate was of 7 807 Sucres for one Dollar, and at the end in September of the same year 12 116 Sucres for one Dollar. In spite of that problem, was necessary to consider the Dollar reference in our analyses, either making a conversion of all the economic values, such as, sales prices of the products, cost of productions, different economic revenues of the households, etc.

The only use of exchange rate Sucre to USA Dollar, to compare income for a long the time period (1990-1999) was not enough, even in Ecuador, when the fluctuation of the exchange rate Sucre to US Dollar, suffered high variation during this period. For these reason was necessary to use other economic indicator such as consumer price index (CPI), as another relating economic that supports the results of the present analysis.

In Ecuador, the inflation is measured statistically through the consumer index prices of urban area (IPCU), and it is carried out, starting from a basket of goods and demanded services from consumers of medium and low strata, established through a households survey of revenues and expenses, that the Central bank of Ecuador publishes monthly. (Central Bank of the Ecuador, http://www.bce.fin.ec, 2005). Regrettably, Ecuador only has consumer index prices for urban areas of principal cities, having not consumer index prices for rural areas, and the Amazon region. All the 1990 values were converted to 1999 values using the CPI in order to get the same value of both data. Then, all these data (1990-1999) were converted to 1999 US Dollars, using as exchange rate 10 000 Sucre to one Dollar, see table 1 in annex 1.

The inflation factor was computed for the period of 1990 and 1999, obtained a factor result of 16.67, which mean that, the cost of market basket of good and services rose 16.67 times during the period from 1990 to 1999. To compute this factor, we took into account the Consumer Index Price (CIP) base periods of: (1990 = 100)[5], (1995 = 100) and 1999 index. Thus, In Ecuador the mean of the market basket of good and services that cost $100 in 1990, in 1995 cost $521.5 (rising 5.21 times), and the market basket of good that cost $100 in 1995, during the survey period in 1999, February, March, April, May, June and September, the cost was 319.7 (rising 3.19 times); so computing this factors 1995 CIP (521.5/100) time CIP 1999 (319.7/100) we got a factor of 16.67. see table 2 in annex 1.

Measure of income and land inequality

In order to determine income inequality between 1990 and 1999, we estimated Gini coefficients and plotted Lorenz curves (Atkinson, 1970; Kolm, 1969, Bishop el al, 1997). We use our data for the two periods to construct Lorenz curves, which may be used for comparisons with the 2001 Ecuadorian agricultural census.

Although, the Lorenz curve allows an unambiguous inequality comparison of income distributions (Creedy, 1998), the same information can be summarized in Gini coefficients. The Gini measure is defined as the area in between the diagonal 45 degree line and the plotted Lorenz curve, expressed as a proportion of the area below the diagonal (Creedy, 1999). A coefficient close to 1 means extreme inequality, while one of zero indicates complete equality.

The Gini formula has been presented in many forms, but can be calculated from the Lorenz curve as the ratio represented in this equation: G = Area A/(Area A + Area B), in our study we used the formula:

$$G = 1 - \sum_{i=0}^{N} (\sigma Y_{i-1} + \sigma Y_i)(\sigma X_{i-1} - \sigma X_i),$$

where Ïf X and Ïf Y are cumulative percentages of X's and Y's (in fractions) and N is the total number of farm households. Tables A-1 and A-2 show the results.

[5] The average of consumer price index during the 1990 survey was exactly the same than the average of CPI in whole year.

Table A-1 – Gini coefficient for Income,
Northeast Ecuadorian Amazon, 1990 vs. 1999

Inequality of farm household Income				
	1990		1999	
Percentile Income	Income Mean (U$)	Household N = 418	Income Mean (U$)	Household N = 658
0.05	156.9	48	153.1	141
0.10	458.0	75	455.1	133
0.15	745.8	71	735.4	100
0.20	1050.0	36	1046.6	70
0.25	1321.7	40	1343.0	42
0.30	1638.2	34	1634.6	37
0.35	1958.2	24	1941.4	23
0.40	2302.3	10	2237.8	25
0.45	2544.5	12	2548.5	16
0.50	2852.9	9	2881.1	10
0.55	3126.0	5	3156.8	8
0.60	3506.7	7	3471.2	11
0.65	3727.7	5	3742.8	4
0.70	4032.3	4	4044.3	7
0.75	4242.5	2	4368.2	4
0.80	4646.3	10	4753.3	2
0.85	5084.4	1	4990.8	3
0.90	5320.7	2	5226.8	2
0.95	5524.4	1	5582.0	4
1.00	11187.9	22	10108.2	16
Gini Coeff.	**0.554**		**0.551**	

Table A-2– Gini coefficient for land size.
Northeast Ecuadorian Amazon, 1990 vs. 1999

Inequality of Land size				
	1990		1999	
Percentile Income	Farm size Mean (Ha)	Household N = 418	Farm size Mean (Ha)	Household N = 658
0.05	1.50	9	1.32	64
0.10	4.04	12	4.05	102
0.15	8.66	9	8.01	74
0.20	14.05	10	13.10	35
0.25	18.19	13	17.88	27
0.30	24.40	20	23.89	40
0.35	28.33	18	28.48	29
0.40	33.36	33	33.71	26
0.45	39.32	45	38.65	55
0.50	43.09	34	43.28	46
0.55	48.89	132	48.82	100
0.60	53.16	34	52.65	22
0.65	58.63	19	58.50	12
0.70	63.25	4	62.58	6
0.75	68.00	2	68.80	5
0.80	73.00	2	74.16	3
0.85	80.00	3	78.50	2
0.90	90.00	1	82.00	1
0.95	153.83	18	90.00	1
1.00			115.50	8
Gini Coeff.	**0.271**		**0.448**	