Household demographic and socio-economic predictors of agricultural practices, land use and environmental degradation perception of the Paute catchment (Ecuador)

Raúl VANEGAS[1], Fabrice DEMOULIN[2], Sabine HENRY[2]

Summary

This paper seeks to improve the understanding of the household-level dynamics (life-cycle) and its relationship, through livelihood strategies, to adaptations (agricultural practices, land use change) & environmental perception focusing on long-settled communities in the Andes. In this research we have included migration as part of the household livelihood strategies (focusing on the sending place) as well as some agricultural practices and perception of environmental degradation variables considered as household adaptations.

A primary data generation (the 3-Paute survey) has been carried out obtaining 239 surveyed households. Gathered data have been analyzed by the Factor Analysis for Mixed Data (FMDA), the Hierarchical Clustering on Principal Components (HCPC); as well as Chi2 (test of independence), ANOVA & Kruskal-Wallis tests for measuring dependencies or relations among variables.

The presented findings advance our understanding of the complex dynamics in long-settled communities in the Andes region in five ways: 1) some household life-cycle variables influence the availability of the household labor force, that in turn may impact the diversification of economic activities and cropping, the type of agriculture and cattle (subsistence, transition, or large scale), and the use of intensive (inputs) and/or extensive agriculture (deforestation); 2) gender roles are well defined in function of the production scale of agriculture and cattle; 3) we argue that household access to hired labor force and focus on profit beyond subsistence; 4) migration (out and/or in) plays an important role on the different dynamics under study mainly on wealthy households; and 5) the local livelihoods, adaptations, and environmental outcomes extend beyond a focus on macro-level to those operating at the household life-cycle level.

[1] raul.vanegascabrera@fundp.ac.be
Facultad de Ciencias Agropecuarias, Universidad de Cuenca
Av. 12 de Octubre s/n
Cuenca, Ecuador
Tel. : 593 / 07/ 2810 706
Fax. : 593 / 07/ 2881 646

[2] fabrice.demoulin@fundp.ac.be, sabine.henry@fundp.ac.be
Département de Géographie, University of Namur
61, rue de Bruxelles
5000 Namur – Belgium
Tel. : 32 / 81 / 72 44 70
Fax. : 32 / 81 / 72 44 71

Theoretical Background

Soil erosion is the single most important environmental degradation problem in developing countries (Thampapillai & Anderson 1994; Grepperud 1995). Although land degradation is a physical process, its underlying causes are firmly rooted in the socio-economic, political and cultural environment in which land users operate (Stocking & Murnaghan 2001). Farmer decisions with regard to production (agriculture) and land use are strongly influenced by socio-economic factors (Boardman et al. 2003). Researchers often perceive land degradation as the consequence of existing social and economic conditions experienced by the farmers and widespread all over the world (Hammad & Tumezei 2010). In addition, the socio-economic situation of farmers affects their capabilities to implement environmentally viable soil and water conservation measures; including farm practices as well (Daba 2003). By consequence, an explanation which captures the essential features of the soil erosion problem in much of the developing world need to address the complete dynamics of the soil erosion problem, where the demographic and socio-economic factors are considered to be fundamental.

Debates have raged for centuries on the importance of human demography in environmental change (Ehrlich & Holdren 1971; Malthus 1989; Boserup 1981; Carr 2004). Much of the demographic world research has focused on the impact of population on environment, where the impact of population growth and population re-distribution (migration) has probably received the greatest attention. Some investigations suggest that out-migration plays a fundamental role on the socio-economic status of local population in the southern Ecuadorian Andes (Jokisch 2007; Jokisch & Pribilsky 2002; Gray 2009; Jokisch 1997, Jokisch & Kyle 2005). Nevertheless, much of the world research looks at migration at the aggregate or societal level, divorced from household livelihood strategies, and with a particular emphasis on impacts in destination (especially frontier) areas (de Sherbinin et al. 2008). Additionally, because the types of migration, intervening variables (including data quality), and environmental outcomes, it is also one of the most difficult to adequately assess (Curran, 2002).

One of the most influential socio-economic and demographic theoretical approaches on soil erosion is based on the Boserup's theory (Boserup, 1981). This approach argues that growing population causes rural people to migrate to forest areas where they clear the forest for establishing agricultural livelihoods, and even it has forced farmers to cultivate easily eroded hillsides. Thus, rural poor are dependent on natural resources for survival and hence poverty is a major source of soil erosion. However, Boserup also established that population growth may not necessarily lead to land degradation, but also it can promote more intensive agricultural practices and more favorable technological and organizational innovation that will not only increase productivity but improve environmental quality as well. For this, Boserup suggests a number of technology and investment paths, the "capital led" (substantial use of capital in agricultural inputs, land conservation infrastructure, and planting perennials) and the "labor led" (farmers add more labor to the production process) approaches (Ananda & Heralth 2003).

One of the most prominent research areas addresses the impact of population on land use and land cover change, where the most influential analyses have often focused on macro-level trends (Pebley 1998; Lambin et al. 2001; Perz & Skole 2003; Lambin & Meyfroidt 2010); while micro-level empirical research has concentrated on the characteristics of individuals and the influences of the "household life-cycle" on land use decisions mostly in the context of

new arrivals in the Amazonian frontiers (Marquette 1998; McCracken et al. 1999; Walker & Homma 1996; Walker et al. 2002; Perz 2002; Barbieri et al. 2005; Perz & Walker 2002; Perz et al. 2006).

A household has been described as ‘‘a site in which particularly intense social and economic interdependencies occur between a group of individuals’’ (Ellis 2000). The “household life-cycle” approach is based on the Chayanov’s peasant economy model (Chayanov 1966; Walker et al., 2002, 2004; Walker & Homma, 1996). Chayanov observed that peasant farming households possessed farms of different sizes, and that wealthy households with many family workers typically possessed larger holdings than those constrained by labor shortages. The household life-cycle is a combination of the Chayanovian approach with a household production model. In its basic form, this approach assumes that households have no access to capital or to hired labor, and that households focus on production to meet consumption needs (rather than to accumulate capital). The life-cycle begins with household formation, typically when a new residence is established by a married couple. Then, the household enter a frontier, in which land is abundant and labor and capital are scarce, and their land use decisions are determined by household demography in three ways: *first*, it represents the consumption needs of the household (positive effect of children and elderly dependents); s*econd*, household demography determines the amount of labor available for farming which, in the absence of capital and labor-saving technology, determines the amount of land that can be used (positive effect of the number of working age members, particularly males); and *third*, as the owners of land and their children age and as their children move to other properties or to urban areas, the time horizon of the owners change. Households with many small children have a short time horizon, seeing only the need to feed and care for the family for the next few years. As these children become able to help with farm work, and available labor increases beyond the minimum necessary to support the family, households begin to make investments in perennial crops or pasture. The life-cycle ‘‘ends’’ when the founding couple are no longer those that make key livelihood decisions.

Remarkable household life-cycle research focus on frontiers (Amazons) environments, while relatively few work has been done in long-settled smallholders rural areas (such as those in the Andes region). In spite that some empirical researches performed by Godoy et al. (1997) and McSweeney (2004) have found that even tough in long-settled contexts, younger households tend to deforest more and to extract more forest products than do ‘‘older’’ households, they may not be motivated by the same factors as young colonist households (in frontiers areas). The most important factors to consider here appear to be the ethno-social and institutional contexts. According to these authors, in indigenous long-settled smallholders’ households, risk is carried mostly by the community, rather than an individual household. A young indigenous family, therefore, may have less need to spread their agricultural risk through extensification; crop failure can be mitigated by the inter-household food transfers, and their risk is lessened as household members benefit from their own and their community’s agro-ecological knowledge. Further, the constraints of high child dependency can be somewhat loosened for young indigenous families through communal childcare support, on the one hand, and access to established systems of labor reciprocity on the other. In addition, land tenure is relatively secure in long-settled areas, obviating the need to clear land for appropriation claims afterwards, as it happens on Amazon frontiers (de Sherbinin et al. 2008).

OBJECTIVES AND HYPOTHESES

The objective of this study is *"to identify the demographic and socio-economic predictors of agricultural practices, land use and environmental degradation perception of the Paute catchment in Ecuador"*. This catchment is inhabited by long-settled Ecuadorian Andean communities. In this framework, we hypothesize that *"current household life-cycle (demographic) and livelihood strategies (socio-economic) induce some adaptations (agricultural practices, and land use change) and different household environmental perceptions"*.

According to the extensive literature, both the household life-cycle as well as the household livelihood strategies induces many complex direct and indirect effects mainly on household adaptations and environmental outcomes. Figure 1 attempt to sum up such effects, although the cause-effect scheme is very complex and includes other aspects which are out of the scope of this research such as feedbacks.

The household life-cycle is determined by changes in the household demography including gender and age of the household head; and number of children, and male and female adults. A male adult household head provides more labor force than their female counterpart. Number of children is positively related to the consumption needs of the household (including elderly dependents), while number of male and female adults represent the labor available for farming which, in the absence of capital and labor-saving technology, determines the amount of land that can be used. This argues for a positive effect for the number of working age members. As children become able to help with the farm activities, they are also considered an important source of labor force mainly for subsistence agricultural scale in the case of long-settled Andean communities (Walker 2003; Walker & Homma, 1996).

Among household livelihood strategies, some important socio-economic variables play a fundamental role such as agriculture (as main economic activity), and migration (external & internal). In order to engage in these activities, households strategically mobilize their assets such as natural, social (membership to organizations in this research), capital, human, physical and financial capital (de Sherbinin et al. 2008). Migration is considered to be one of the most successful livelihood strategies developed by households, as well as one of the most important demographic factors affecting the environment (Curran, 2002). The livelihood framework has not commonly been applied in studies of the determinants of migration, but it explicitly includes both contextual and environmental factors (Gray 2009)**.** One element of this theory is that migration can serve as a form of diversification against economic risk (Rosenzweig & Stark, 1989; Bilsborrow & Okoth-Ogendo, 1992), which could be extended to include the risk of environmental degradation (Gray 2009) and the associated declines in agricultural production.

Both the household life-cycle and the household livelihood strategies induce adaptations on agricultural practices such as land preparation techniques, inputs (fertilizers & pesticides) and irrigation methods. The type of farming system (subsistence, transition, or large scale) is influenced also by the labor force availability (Perz 2002, 2006; Bilsborrow 1992, Somda 2001). Gender roles in traditional farming system (including cattle) in the Andean communities in Ecuador are well defined. Such roles are in straight relation with the production scale (subsistence or trade purposes) (CGPaute 2006). Gray (2005) analyses the effects of household wealth status on agricultural practices arguing that wealthier farmers cultivate much larger areas (extensification), have fewer trees in their fields, and use higher levels of animal traction, resulting in higher levels of household wealth (feedbacks in thick

lines in Figure 1). Poorer farmers in instead may have agricultural practices that minimize environmental degradation at the expense of their economic development and well-being. Important household livelihood strategy such as out-migration according to Gray (2009) might be able to draw on natural capital to facilitate this costly migration, either through increased productivity of agriculture (intensification) or by using high quality lands (extensification) as collateral for a loan.

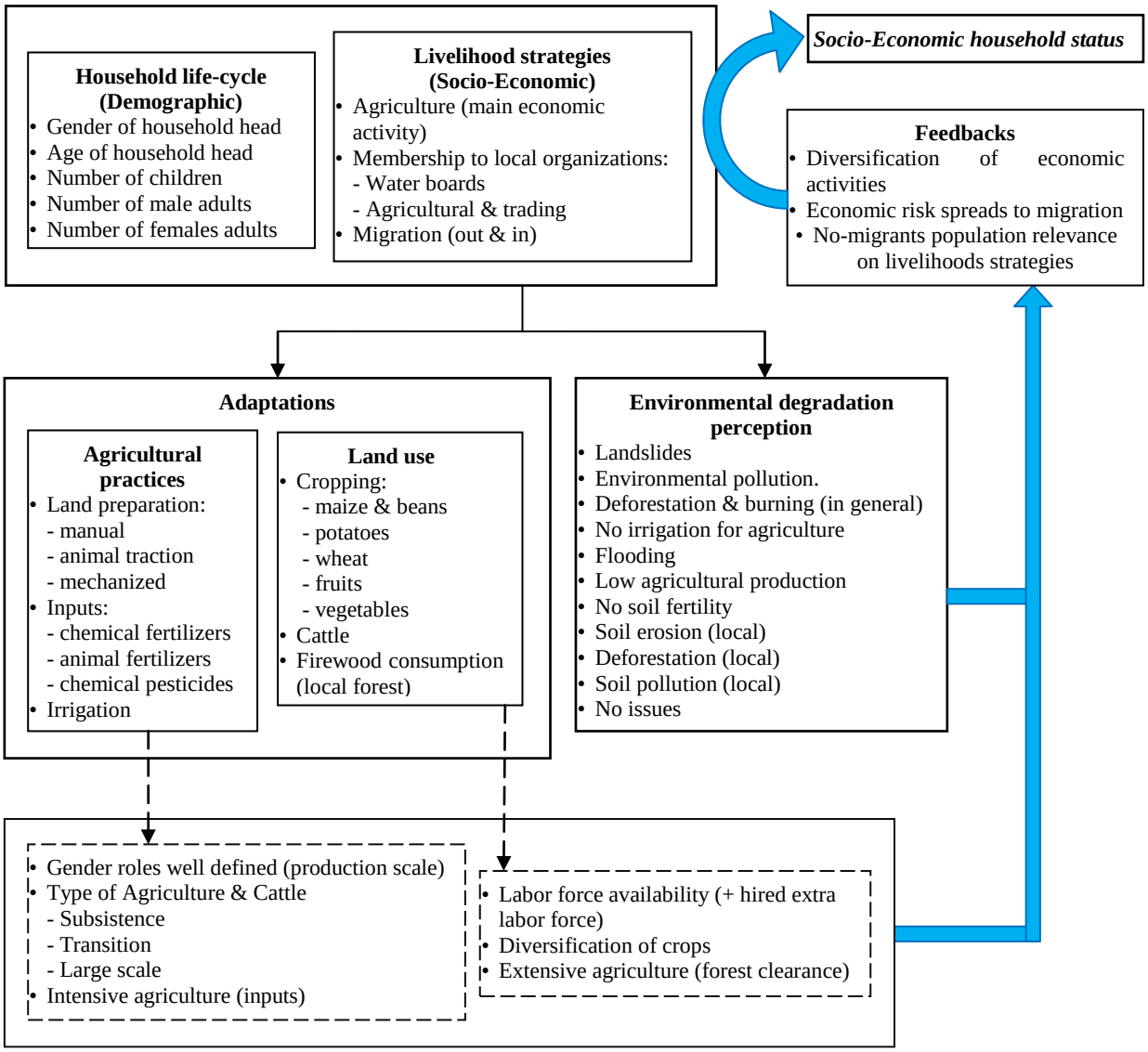


Figure 1. Influence of household life-cycle and livelihood strategies on adaptations and environmental degradation perception

In the adoption of natural fertilizers according to Somda (2001), the most important demographic & socio-economic characteristics are farmers' age, their annual agricultural income, and their comparative perception of yield with regards to other fertilizers. A second group includes livelihood strategies represented by the farmers' membership to organizations (extension workshops). A third group comprises the farmer's labor force availability, and the number of ruminants owned and farmer's gender. According to Nkamleu (2000) chemical fertilizers are adopted by farmers who are more highly educated, those with temporary land

rights and those who are more distant from the homestead; while chemical pesticides are adopted by male farmers, those who have contact with extension, those who have temporary land rights or those practicing continuous cropping.

Induced adaptations on land use dynamics suggest that land use change over time is based on changes in the demographic composition as the household ages. The family size is positively related to the amount of land cleared (Rudel & Horowitz 1993; Pichón 1997), as is number of adult males and females (Sydenstricker-Neto & Vosti, 1993). Other empirical research have analyzed the effects of time since arrival in the property, age of the household head, or number of adult males on land use and land cover (Marquette 1998; McCracken et al. 1999; Walker & Homma 1996; Walker et al. 2002; Perz 2002; Barbieri et al. 2005; Perz & Walker 2002; Perz et al. 2006; VanWey et al. 2007). One of the most important implications of demographic factors such as number of household members (working ages) is the labor force availability. This in turn will induce diversification of crops, and land use change through deforestation for extensive agriculture (Gray 2009).

Cattle grazing require little labor force and can be sustained on land that is too poor for crops (de Sherbinin, et al. 2008). Under traditional and subsistence farming systems in the Ecuadorian Andes, cattle is managed mostly by adult women with the help of children (as soon as they become able to help with the farm tasks). This argue for as positive effect of adult woman and number of children on labor force available. In this regard, Perz (2001) propose that children are in demand by parents because they first provide labor needed for early agricultural production and later, when children migrate out, they provide remittances needed for acquisition of cattle. Besides land, cattle are the second important form of physical capital for rural families worldwide (de Sherbinin, et al. 2008). They provide an important income (sometimes the most important in the Andes context) from dairy products; and they represent a status symbol (Loker 1998) as well. The effects of out-migration on environmental outcomes (such as land use) may be mediated by farming system, with impacts being less significant in cattle raising systems where labor demands are smaller (de Sherbinin, et al. 2008).

Natural resources in rural Andean areas such as firewood tend to be collected from local (communal or private) forests, and gathering is often left to women and children. Dasgupta (2000) propose that as these resources become scarce, each additional child provides a marginal benefit through his/her labor, which suggests in turn that resource dependency will result in higher household fertility. Some empirical evidence from Pakistan, Nepal, and South Africa (de Sherbinin, et al. 2008) support this hypothesis. Existing literature suggest that in rural population based on subsistence production, the returns to childbearing are higher than the net costs. For example, evidence from Zambia suggests that the age at which children become net producers is about age 12 (Barrett & Browne, 1998). In Pakistan such age for female children falls between 11 and 16, and by age 18 they effectively ‘‘repay’’ the time mothers spend for children care and household tasks (Filmer & Pritchett, 2002). These studies suggest that households begin to experience net benefits since children reach age 11, and in societies where girls marry early, the actual period of net contribution to the household’s income is relatively shorter.

According to Barber et al. (2003), the farmers’ perception of environmental degradation is influenced by some socio-economic factors such as neighborhood facilities (new schools, health posts, bus services, mills, dairies, and agricultural cooperatives). Such perceptions may

encourage participation in programs for environmental management, and influence environmental behavior. In addition, farmers' perception of environmental degradation has been considered relevant for the management of environmental hazards (Chanda 1996) as well as causal factors for the adoption of improved environmental practices. For instance Wei et al. (2009) suggest that such environmental perceptions are correlated to some socio-economic factors such as education level of farmers, the availability of extension services and whether farmers had participated in large and well-funded management projects that allow them to recognize degradation and adopt improved practices conservation.

Considering the farmers' perception–adoption of particular agricultural innovations, available research propose relations with some variables that are typically categorized into four demographic and socio-economic groups (Wei et al. (2009): farmer & household characteristics including age, education and farming/employment orientation of farmers; farm biophysical characteristics including farm size, area planted and farm fragmentation; farm financial/management characteristics including farm income, off-farm income and risk aversion; and exogenous factors such as input and output prices, extension services and program participation.

All causal dynamics under study and their respective outcomes will in turn induce some feedbacks (out of this research scope) such as diversification of economic activities (depending mainly on the household labor force available), and the economic risk spread to migration (depending on the household socio-economic status). In the case of the Andean population in the Paute catchment, it is expected those no-migrant households (currently the largest group) as the most influential group on their current livelihood strategies. All these feedbacks will induce in turn a effect on the general household socio-economic status.

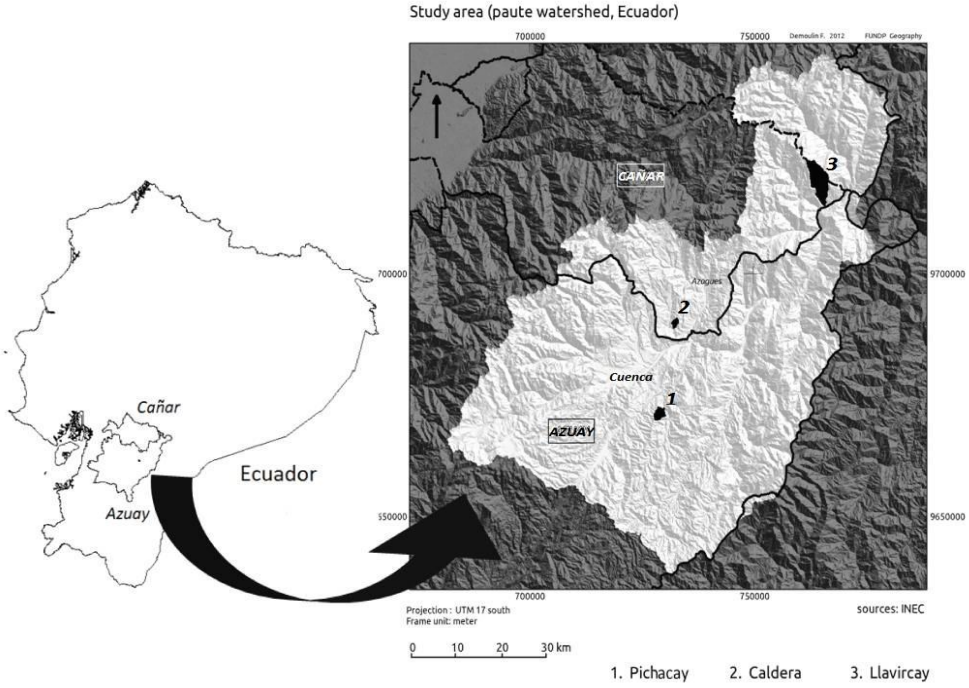
Feedbacks have been influential on explaining the sustained high human fertility in the face of declining environmental resources (O'Neill et al. 2001; de Sherbinin et al. 2007) proposing the following causal connections: poverty leads to high human fertility (demand for farm labor and insurance birth), human fertility then contributes to population growth which further increases demands for food and resources from an essentially static resource base; the declining per capita resource base reinforces poverty through soil fertility loss, declining yields, and poor environmental sanitation. Finally, poverty, in turn, contributes to land degradation by increasing incentives for short-term exploitation (versus long-term management) and because poor farmers lack access to costly fertilizers and appropriate technologies (vicious cycle model). Thus, this model suggests that households without access to other forms of capital seek to build their human capital (and social capital through the marriage and migration of children) in order to better exploit natural capital. On the other hand, Stokes & Schutjer (1984) argue that farm size and tenure are key indicators of the physical capital of households showing a positive relation with human fertility. These authors postulate that a larger farm size creates a demand for children as labor to keep land in production (and to retain use rights). This positive relationship has been observed in studies in Rwanda, Egypt, the Philippines, Iran, Peru and Ecuador (de Sherbinin et al. 2008).

STUDY AREAS

The Paute basin in the Ecuadorian context

In Ecuador, the Paute basin (Figure 2) is of primary importance for the countries' economic sustainability as about 45% of the national electric energy demand is produced in the Paute hydro-electric power plant. Total basin population is about 650 000 inhabitants in a total area of 5200 Km^2. In addition, the Paute basin is facing land degradation processes that could affect the countries' energy production in the long term (CGPaute 2006).

Improper land management, inequitable land tenure, steep slopes and the erosive climate are among the principal causes for the severe land degradation in the Ecuadorian Andes (Vanacker et al. 2003; Molina 2007). Land use in the Paute basin is highly dynamic and changes rapidly in response to demographic growth, political decisions, social inequalities and short-term economic pressures (Vanacker et al. 2000). More than half of the primary native forest is converted into agricultural land or replaced by secondary woody vegetation or more recently by exotic species. Clearings and settlements have affected particularly the central part of the Paute catchment. Remote parts of the catchment were largely left untouched and forested, but disturbance is now increasing rapidly as construction and utility roads around the Paute hydroelectric project have facilitated migration (Jokisch & Lair 2002).



Source: compiled by Demoulin, 2012

Figure 2. Location of the three study areas in the Paute

The productive structure of the Paute basin have dynamically changed as consequence of some internal and external factors, by consequence its social structure have been also modified. One of the most important influencing factors has been recognized to be the Agrarian Reforms (1966, 1976 and 1979) (Gondard & Mazurek 2007). In this context, in spite that every location within this basin show their own productive and social structures over time; two key elements have been identified playing a fundamental role: land tenure and land surface. Based on these two key elements, the socio-economic structure of the Paute catchment has been classified into five groups: landless, smallholders (< 1ha.), small land owners (1 up to 5 ha.), medium land owners (5,01 up to 10 ha.) and large land owners (>10 ha.) (CGPaute 2006).

Access to land is highly unequal. Over half of the landowners have less than 1 ha of land, often located on steep slopes so that cultivation occurs on slope gradients up to 70% (INEC[3], 1991). Due to rapid demographic growth and severe land degradation, both the quality and quantity of land available is rapidly decreasing. Overgrazing, and intensive cultivation of these poor soils has lead to severe land degradation and poverty. By consequence, the low agricultural production levels on degraded soils, and the lack of local livelihood alternatives are the main reasons for massive migration. Considering out-migration, estimations are that over a few hundred of thousands of inhabitants have left Azuay and Cañar provinces (where Paute basin is located) in the last decades. This factor is playing a fundamental role on the socio-economic status of the local population (Jokisch 2007).

Agriculture in the Paute basin is currently switching from cash crops (maize, beans, fava beans, potatoes, ulluco, vegetables) and sheep breeding into larger scale crops (tomatoes, tree tomatoes, vegetables, flowers and fruits) and cattle (milk trade). Small farmers face low productivity, no access to credits (no agriculture inputs, less land tenure), short land surfaces, and internal migration among other issues (CGPaute 2006).

The three pilot study areas

Three pilot study areas located across the Paute catchment (Figure 2) have been selected for this research: one located in Azuay province, the Pichacay site (Santa Ana parish), and two located in Cañar province, the Caldera (Javier Loyola parish) and Llavircay sites (Rivera parish). The main objective of such selection was to obtain a large panel of variables under study; assuring in this way to represent a diversity of demographic, socio-economic, agricultural practices, land use, and environmental degradation perception dynamics of the Paute catchment.

Some characteristics of the study areas based on official Ecuadorian INEC (National Institute for Statistics and Census) facts and figures from the last national population and housing census (2010) are presented in Table 1. Considering their total parish population; Pichacay and Llavircay sites represent relatively higher populated areas (27% and 37% respectively), while Caldera site represents lower populated areas (9%). Concerning the inhabitants age and gender composition, the three study areas show an important birth reduction as well as general aging of their population. Higher mortality rates are present for Pichacay and Caldera sites, but lower for Llavircay. Young population (31 years average) prevail for the three studies areas.

Considering economic activities, the proximity to large cities induce an important influence over the diversification of economic activities mainly for Pichacay (agriculture 23%, no agriculture 77%) and Caldera (Agriculture 34%, no agriculture 66%). Llavircay still concentrate their main economic activities on cattle, pastures and agriculture production (80%). Regarding out-migration and taking into account the total study areas population, Llavircay represents the lowest migration rate (2.77%), while higher rates are present for both Pichacay (3.22%) and Caldera (7.51%). Main destinations for migrants (Azuay and Cañar provinces) are USA, Spain, and Italy (INEC, 2010).

[3] INEC (National Institute for Statistics and Census). National Population and Housing Census, 1991.

Table 1. Some demographic and socio-economic facts and figures at study area level based on census data (INEC - 2010)

Study Areas	Pichacay	Caldera	Llavircay
Population			
Total	1427	586	578
Male	671 (47%)	266 (45%)	279 (48%)
Female	756 (53%)	320 (55%)	299 (52%)
Percentage *	27%	9%	37%
Age (Mean)	31	31	31
Economic activities[4]			
Agriculture	129 (23%)	99 (34%)	178 (80%)
No Agriculture	424 (77%)	195 (66%)	45 (20%)
Out-Migration[5]			
Male	40 (87%)	29 (66%)	13 (81%)
Female	6 (13%)	15 (34%)	3 (19%)
Percentage **	3.22%	7.51%	2.77%

* Out of total parish population
** Out of total study areas population

Regarding communitarian organizations, Pichacay site is represented by a strong "parish board" constituted by many local leaders and one parish chairman. Caldera site is represented by a strong "water board" that follows the same structure than Pichacay parish board. In Llavircay site there is a weak local organization represented by a "parish board". On the other hand, main environmental issues in Pichacay are soil erosion (badlands, landslides, deep and shallow gullies) and recent land abandonment. In addition, the operation of the Cuenca's (third largest Ecuadorian city located in the Paute catchment, in Azuay province) landfill in this area has brought serious environmental constraints on pollution and landscape changes. Caldera site is facing severe soil erosion (badlands, eolic erosion); while Llavircay site deals with soil erosion (landslides, flooding), burning of primary and secondary forest for agriculture purposes bringing some landscape changes. In addition, noise, air and light pollution, and flora and fauna depletion are present as consequence of the construction and operation of part of the Paute's hydroelectric power plant (3-Paute survey).

METHODS

Data collection

Primary quantitative as well as qualitative data at household level have been collected through the 3-Paute survey in the three study areas. Such technique has been widely successfully applied around the world for measuring, for instances, recent agricultural activities and retrospective migration histories (Grosh & Glewwe 2000; Massey & Zenteno 2000) among many other topics. In addition, considering the context of long-settled communities, some other investigations have also applied such field techniques for generating their own primary data (Gray 2009, Godoy 2001; McSweeney 2004). The main differences with such investigations is that the current research considers a wider range of demographic, socio-economic, and land use variables; and also it includes agricultural practices, and

[4] Only economic active population above 10 years old (INEC, 2010)
[5] A migrant is considered any person whom have migrated abroad since the last national census (November, 2010) and have not returned to Ecuador so far (INEC, 2010)

environmental degradation perception variables; aiming to understand the essence of the different dynamics taking place in the Paute catchment.

The field survey was performed in May and June 2011. The survey questionnaire consisted in seven parts covering housing characteristics, demographic variables (including migration & remittances), household characteristics (basic services, local organizations, belongings, consumption trends), local environmental issues (perceptions), agriculture practices (management), animal breeding (management), and land use change (past & present dynamics). The survey was intended to be administered to every household head[6]. The sampling frame constituted a complete list and maps of the houses located in the three areas under study (INEC, 2010). Then, every house was characterized by a unique code given by the INEC for performing the random houses' selection. In addition, for the sampling estimation, the same number of surveys (80) per study area was assigned considering further statistical comparison; as well as budget, labor force, and time availability. Table 2 gives the importance of the population and household surveyed by the 3-Paute data.

Table 2. Total population and total household data comparing the INEC census (2010) versus the 3-Paute survey (2011)

Study Areas	Total Population		Total Surveyed Population %	Total Households		Total Surveyed Households %
	INEC Census *	3-Paute survey		INEC Census*	3-Paute survey	
Pichacay	1427	390	27%	358	78	22%
Caldera	586	365	62%	165	90	55%
Llavircay	578	358	62%	133	71	53%
Total	2591	1113	43%	656	239	36%

* INEC: National Institute for Statistics and Census, Ecuador (2010).

The obtained sample includes 1113 individual biographies representing 239 surveyed households in the three study areas. These collected data highly represent both the total households registered (36%) as well as the total population (43%) of the three study areas. The data set includes five groups of variables: two "predictor" such as demographic and socio-economic; and three "outcome" such as agricultural practices, land use, and environmental degradation perception as presented in Table 3. In total, thirty-four household[7] variables have been tested in this research. As described in Table 3 most of tested variables are qualitative (categorical type with different levels), while a few are quantitative (edge of household head; and number of children, male and female adults). It is important to mention that all variables ("predictor" and "outcome") are time-varying (except gender).

[6] In the event that the individual identified as the household head was not in residence for part of the study interval, headship was assigned to the head's spouse, or to another adult relative in the case of absence by both the head and spouse.

[7] Even though "*gender*" and "*age of the household head*", and "*perceptions of environmental issues*" have been collected at the individual scale, they in practice represent the household context too.

Table 3. Definition and characteristics of tested variables

Variables	Type	Unit	Level	Definition
Predictor				
Demographic				
Household head gender	Categ.	Type	Ind.	Man or woman
Household head age	Numeric	Years	Ind.	Age in years
Children	Numeric	Number	HH	Number of residents ages 0-9
Male adults	Numeric	Number	HH	Number of male residents ages 20+
Female adults	Numeric	Number	HH	Number of female residents ages 20+
Socio-Economic				
Agriculture	Categ.	Yes/No	HH	As main economic activity
Migration (out & in)	Categ.	Yes/No	HH	Past & current migration experiences
Local water boards	Categ.	Yes/No	HH	Current membership
Local agricultural/trading	Categ.	Yes/No	HH	Current membership
Outcome				
Agricultural practices				
Manual land preparation	Categ.	Yes/No	HH	Past & current practices
Land prep. by animal traction	Categ.	Yes/No	HH	Past & current practices
Mechanized land preparation	Categ.	Yes/No	HH	Past & current practices
Chemical fertilizers	Categ.	Yes/No	HH	Past & current practices
Natural fertilizers (animal)	Categ.	Yes/No	HH	Past & current practices
Pesticides	Categ.	Type	HH	Past & current practices (Chem.,Nat., No)
Irrigation	Categ.	Type	HH	Past & current practices (Man., Pump, No)
Land Use				
Maize &Beans	Categ.	Yes/No	HH	Current land use
Potatoes	Categ.	Yes/No	HH	Current land use
Wheat	Categ.	Yes/No	HH	Current land use
Fruits	Categ.	Yes/No	HH	Current land use
Vegetables	Categ.	Yes/No	HH	Current land use
Cattle	Categ.	Yes/No	HH	Current activity
Firewood	Categ.	Source	HH	Current activity (Local forest, Purch., No)
Environmental degradation perception				
No issue	Categ.	Yes/No	Ind.	Current perception
Landslides	Categ.	Yes/No	Ind.	Current perception
Environmental pollution	Categ.	Yes/No	Ind.	Current perception
Deforestation/Burning	Categ.	Yes/No	Ind.	Current perception
No irrigation for agriculture	Categ.	Yes/No	Ind.	Current perception
Flooding	Categ.	Yes/No	Ind.	Current perception
Low agriculture production	Categ.	Yes/No	Ind.	Current perception
No soil fertility	Categ.	Yes/No	Ind.	Current perception
Soil erosion (local)	Categ.	Percep.	Ind.	Current perception (Not that serious, Serious, Very serious, Don't know)
Deforestation (local)	Categ.	Percep.	Ind.	Current perception (Not that serious, Serious, Very serious, Don't know)
Soil Pollution (local)	Categ.	Percep.	Ind.	Current perception (Not that serious, Serious, Very serious, Don't know)

Categ = Categorical; Percep.= Perception; HH= Household; Ind.= Individual; Chem.= Chemical; Nat.= Natural; Man= Manual; Purch.= Purchased

Regarding "predictor" variables, demographic characteristics represent the importance given in the household life-cycle theory to gender and age of the family head (individual); as well as to gender, age and number of family members (children, male and female adults). All of these demographic variables, except gender, vary over time. Socio-economic variables represent three important household characteristics that change over time such as agriculture (as main

economic activity), out & in-migration (past and current household experiences), and membership to local organizations (current situation). Concerning "outcome" variables, agricultural practices characteristics correspond to past and current household characteristics that are expected to vary over time such as land preparation methods (manual, animal traction, machinery), use of agricultural inputs (chemical and natural types for fertilizers and pesticides), and type of irrigation systems (manual, pump, no irrigation). Land use variables cover current household activities that change over time such as cropping systems (maize-beans, potatoes, wheat, fruits, and vegetables), cattle, and use of firewood for household cooking activities (collected from local forest, purchased, or not used). At last, the environmental degradation perception variables refer to current individual farmers' perceptions (representing the household) of important environmental issues such as landslides, environmental pollution, deforestation and/or forest burning (in general), no irrigation for agriculture, flooding, low agricultural production, no soil fertility; and local soil erosion, deforestation, and soil pollution. Such environmental perceptions are expected to change over time and they do not involve any measured field data.

Data analysis

Given the mixed type (quantitative & qualitative) and number of tested variables (34) we analyzed the data by applying multivariate statistical techniques available at the "FactoMineR" (Husson, et al., 2009) package in the R software (Version 3.0.0, R Team, 2007). In summary, we first balanced the weight of the mixed (quantitative & qualitative) collected demographic & socio-economic variables. Then we created demographic & socio-economic clusters ("predictor" variables). At last we searched for significant statistical relations between those built clusters and every tested agricultural practices, land use and environmental degradation perception variables ("outcome" variables) obtaining the final total households' typologies representing all dynamics under study. This three-step data analysis is described in details as follow:

1. Standardization of demographic & socio-economic mixed data

Given the mixed variables (quantitative & qualitative) collected, first we standardized (weight balancing) both demographic & socio-economic variables by applying the factor analysis for mixed data (FAMD) technique. The FAMD (Husson et al., 2009) can be seen roughly as a mixture between principal components analysis (PCA for quantitative variables) and multiple correspondence analyses (MCA for qualitative variables).

2. Building the demographic & socio-economic clusters ("predictor" variables)

Once mixed data is standardized, clusters were built by applying the hierarchical clustering on principal components (HCPC) technique. Given the high number of tested variables, HCPC reduce dimensions (minimizing lost of data) by combining the many correlated variables into a reduced number of principal components. Here, the optimal number of such components is automatically calculated by the HCPC technique. In this research, such components represent the different demographic & socio-economic dynamics under study. According to Husson et al. (2009) HCPC basically combines three methods: (a) the principal component analysis; (b) the hierarchical clustering on the obtained principal components and, (c) the hierarchical partitioning that agglomerates data for constructing clusters of households described by the tested variables.

3. Building the final household typologies

Significant statistical relations between every built cluster (demographic & socio-economic "predictor" variables) and every "outcome" agricultural practices, land use and environmental degradation perception variables were searched. As result, we obtained different household "typologies" representing all dynamics together under study. For the statistical relations, in the case of the qualitative variables, the Chi^2 test of independence (including analyses of residues) (Pearson, 1900) was applied. In the case of quantitative variables, first we tested their data homogeneity by applying a Barlett test of variance (Barlett, 1937). For the homogeneous typologies' variance, the ANOVA (Gelman, 2008) and post-hoc Tukey tests (Lowry, 2008) were considered. For the heterogeneous clusters' variance, the non-parametric Kruskal-Wallis test (Kruskal & Wallis, 1952) was applied. It is relevant to mention that data standardization is not applicable in this step. Statistical relations analysis is applied only on original field collected data[8].

Results and conclusions were based on the final obtained household typologies. Every single household typology represents different demographic, socio-economic, agricultural practices, land use and environmental degradation perception dynamics. Such typologies were described and compared among them (column analysis) aiming to identify differences and similarities that characterize each one. In addition, a transversal analysis was also performed allowing us to identify how every variable change along the different households' typologies. This two-steps analysis (column & transversal) provided full-view results representing all households' dynamics under study.

RESULTS AND DISCUSSION

1. Standardization of demographic & socio-economic mixed data

The FAMD results provide a graphic representation of tested qualitative & quantitative (demographic & socio-economic "predictor") mixed variables together in a single graph (Figure 3). The variables in red color represent the quantitative type (household head age, number of children, and number of female and male adults), while the variables in blue color represent the qualitative type (migration, membership to local agricultural or trading organizations, membership to local water boards, household head gender, and agriculture as main economic activity) both graphically represented in the same bi-dimensional space.

[8] Data standardization is necessary only for building the demographic & socio-economic clusters.

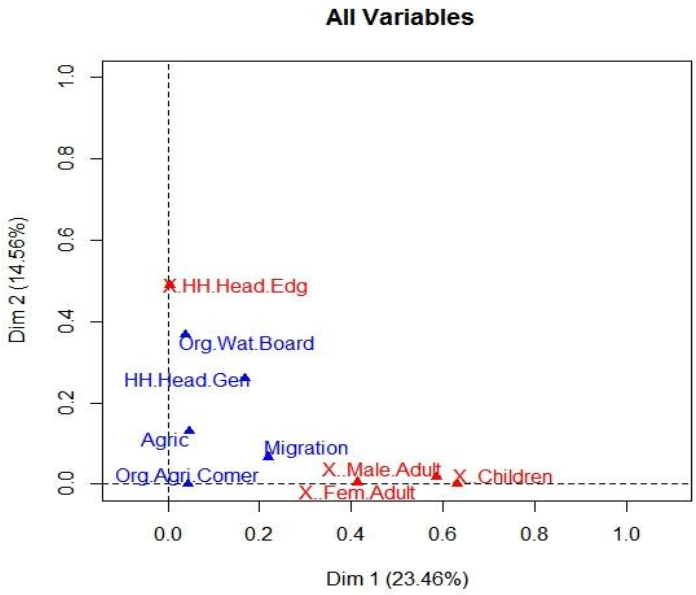


Figure 3. Demographic & socio-economic variables on the two first principal components

These two dimensions (Dim 1 and Dim 2) in Figure 3 graphically represent the two first principal components obtained by the clustering analysis[9]. FAMD results in dimension 1 are explained by a group of demographic related variables (number of children, and number of female and male adults) as well as by another group of related socio-economic factors (migration, and membership to local agricultural or trading organizations). Dimension 2 is characterized by a mixture of demographic and socio-economic related variables (household head edge, membership to local water boards, household head gender, and agriculture).

2. Building the demographic & socio-economic clusters ("predictor" variables)

The data frame for building the demographic & socio-economic "predictor" clusters constituted of nine variables (five demographic and four socio-economic) as mentioned in the previous step (standardization) and described in Table 3 as well. As it can be seen in Figure 4, the HCPC results provided three clear and strong clusters. This figure offers a bi-dimensional graphic representation of the three obtained clusters on the first two principal components or dimensions (Dim 1 and Dim 2). Such bi-dimensional figure provides also the data variance of every cluster, as well as the location of every household (every number represent one household) on the first two principal components.

[9] The FAMD package in R software offers only bi-dimensional graphics. Then, only the two first principle components (out of the three obtained by the HCPC technique, Figure 4) can be graphically represented.

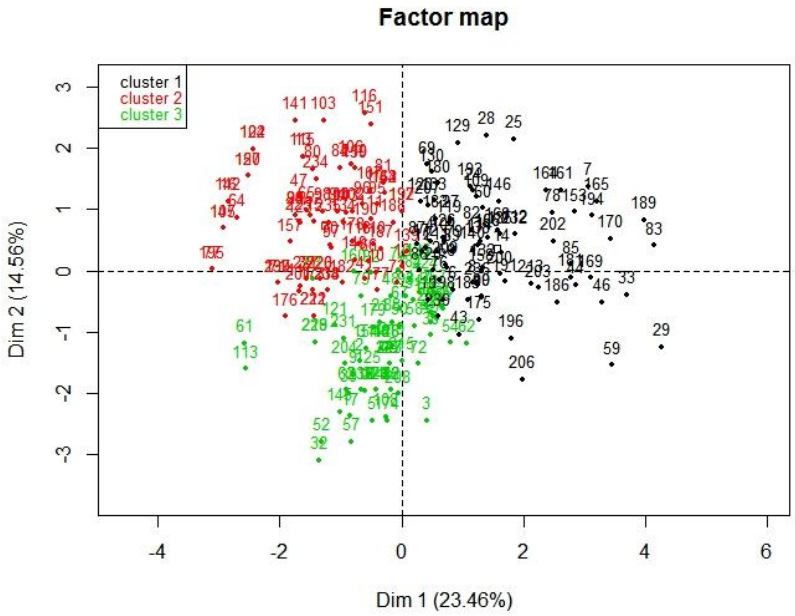


Figure 4. Households' demographic & socio-economic variance on the two first principal components

According to HCPC results (Figure 4) the three obtained "predictor" clusters explain around 38% of the total households' demographic & socio-economic data variance considering the first two principal components together. Cluster 1 shows a relatively higher data variance (less solid structure), while clusters 2 and 3 show a relatively more solid structure (lower variance). This proposes clusters 2 and 3 as demographically & socio-economically stronger than cluster 1. In spite of such differences in clusters' strength, they clearly represent three different demographic & socio-economic dynamics in the Paute catchment (see household typologies). In addition, as part of the preliminary data analysis it was possible to identify three variables that negatively affect the strength of the obtained demographic & socio-economic "predictor" clusters as follow: "housing" (type of house), "no agriculture" (as main household economic activity), and "household belongings" (pickup for daily activities). They have been excluded from the analysis, applying in this way some discriminant fundaments.

3. Building the household typologies

For building the final households' typologies representing all dynamics under study, the data frame constituted of 34 variables: 9 "predictor" (5 demographic and 4 socio-economic) and 25 "outcome" (7 agricultural practices, 7 land use, and 11 environmental degradation perception). Final results (including correlations, p values, and households' typologies) are presented in Table 4.

Table 4. Correlations and p values between the "predictor" clusters vs. the "outcome" variables, and final household typologies

Clusters vs.	**Correlation**	**p value**		**Typology 1**	**Typology 2**	**Typology 3**
Predictor						
Demographic						
HH head gender	42.73	5.26E-10	***	Men	Men-Women	Men
* HH head edge	139.9	<2e-16	***	47 years	55 years	29 years
* # Children	112.08	< 2.2e-16	***	4	~ 1	~ 2
* # Male adults	66.4	3.82E-15	***	~2	< 1	~ 1
* # Female adults	108.33	< 2.2e-16	***	~2	< 1	~ 1
Socio-Economic						
Agriculture	26.32	1.93E-06	***	+++	+++	+++
Migration	35.42	2.03E-08	***	++	<	+
Local water boards	30.28	2.66E-07	***	+++	+++	+
Local agricul./trading	11.32	0.003	**	+	<	<
Outcome						
Agricultural practices						
Manual land preparation	8.7	0.013	*	++	+	++
L.Prep. by animal traction	5.27	0.072				
Mechanized L.Prep	1.3	0.522				
Chemical fertilizers	1.69	0.430				
Natural fertilizer (animal)	1.3	0.523				
Pesticides	17.44	0.002	**	+ Ch	+++ Np	+++ Np
Irrigation	5.18	0.270				
Land Use						
Maize & Beans	4.32	0.115				
Potatoes	8.77	0.012	*	++	<	+
Wheat	0.17	0.680				
Fruits	18.43	9.94E-05	***	++	+	+
Vegetables	0.79	0.375				
Cattle	16.78	2.27E-04	***	+++	+++	++
Firewood	12.63	0.013	*	+++ Lf	+++ Lf	+++ Lf
Env. degrad. perception						
No issues	0.39	0.822				
Landslides	10.41	0.006	**	+	++	+
Environmental pollution	7.93	0.019	*	++	+	++
Defor./Burn.(in general)	0.82	0.665				
No irrigation for agricult.	1.34	0.511				
Flooding	1.55	0.462				
Low agric. production	1.45	0.484				
No soil fertility	3.88	0.144				
Soil erosion (local)	12.93	0.044	*	+	<	+
Deforestation (local)	10.89	0.092				
Soil Pollution (local)	11.54	0.073				

HH: household
* Quantitative variable
L.Prep: land preparation
Ch: Chemical
Np: No pesticides
Lf : local forest

0 '***' 0.001 '**' 0.01 '*' 0.05
+++ Very important
++ Important
+ Low importance
< No important

Final results in Table 4 confirm the research hypothesis *"the current household life-cycle (demographic) and livelihood strategies (socio-economic) induce some adaptations (agricultural practices, and land use change) and different household environmental perceptions*" as described in every household typology as follow:

1. "Large" (number of members) households representing the wealthiest families that depend on large scale agricultural & cattle for local and regional trade, where migration is playing an important role (typology 1). This typology is represented also by relatively old men as household heads and the highest number of household members. Membership to local "water boards" is considered to be very important; while manual land preparation, use of pesticides, and diversification of crops (potatoes & fruits) are relevant. Only "environmental pollution" is perceived as relevant issue. At last, the use of firewood is a very important household activity.

2. "Reduced" (number of members) households representing the poorest families highly dependent on subsistence agriculture & cattle, where migration is not playing any relevant role (typology 2). This household typology is characterized by the relatively eldest men or women as household heads and the lowest number of household members. The membership to local "water boards" and the use of firewood are very important activities, while "landslides" is the only environmental issue perceived as important.

3. "Growing" (number of members) households representing the middle class families highly dependent on transition (from subsistence into some local trade) agriculture & cattle, where migration is playing a relatively low important role (typology 3). Here, mostly youngest men are household heads, and the number of household members is increasing. The manual preparation of soils is important as well as the use of firewood. Environmental pollution is the only issue considered relevant.

A more detailed description of every household typology is presented below, providing more discussion and theoretical background for validating the research hypothesis.

Typology 1

Demographic results presented in Table 4 on households' typology 1 suggest the highest labor force availability and diversification of economic activities, which added to the household economic possibility of investing in extra labor force and agricultural inputs; this will directly affect household wealth. This typology is the most well demographically structured representing old traditional rural families of the Paute catchment, which appear to be also the wealthiest families. Such socio-economic status will allow these households to cover the costly illegal trip of their members, becoming in a fundamental factor to migrate abroad.

Water boards in the Paute catchment represent the main local organization ruling the use of irrigation water for agriculture. Given the high importance of agriculture & cattle in typology 1 according to final results (Table 4), the membership to these boards will assure a proper water supply. On the other hand, the relatively largest scale agriculture practiced in this typology pushes household heads to get involved with regional and even national level organizations for trading purposes, explaining the low importance given to their local counterparts.

Manual land preparation is considered relevant according to final results (Table 4) in this typology, which is in straight relation with the highest household labor force availability as well as economic feasibility to hire extra labor force. On the other hand, the wealthy household status in typology 1 as well as the necessity of maintaining their agricultural productivity levels for trading purposes will encourage heavy investments in agricultural inputs, as it is suggested by final results in the case of chemical pesticides. Gender roles are well defined in typology 1. Large and growing cattle herd requires more land for pastures as well as labor force for daily care. As the herd increases, daily care of cattle cannot be covered by household members (female & children in traditional and subsistence Andean agriculture) any longer. Then such activity is leaded by the household head himself who will hire extra labor force to cover all necessary daily tasks. This has pushed wives and children to be in charge mainly of cultivation & cattle activities for household consumption; leaving the largest production under the responsibility of the household head for trading purposes.

Cropping & cattle are considered very relevant land use activities in typology 1 (Table 4). These results represent typical wealthy households in the Paute catchment that practice large scale cattle breeding for milk and dairy products, as well as cropping for local and regional trading. However, some of the 3-Paute surveys results indicate that some wealthy households mainly invest in increasing their cattle herd, leaving cropping as a secondary income source. In addition, deforestation of primary and/or secondary forest of the Paute catchment must be considered, since according to final results, use of firewood is a very relevant activity. At last, environmental perception is weak (Table 4). It is clear that environmental concerns have been left behind large scale cropping & cattle production, which appear to be the most important households' objective. Further environmental analysis should consider the current intensive and extensive agriculture applied by this type of wealthy households for maintaining their profit; the indiscriminate use of agricultural inputs such as pesticides, as well as clearance of primary and secondary forest for expansion of the agricultural frontier mainly for cattle, and gathering of firewood, are expected to be strong environmental drivers in the Paute catchment.

Typology 2

This households' typology suggest low labor force availability, which facing the households' low economic possibility of hiring extra labor force; it will directly affect the household income, resulting in a general precarious socio-economic status in turn. Besides, migration is not influential as presented in Table 4. According to the official facts and figures (INEC, 2010) as result of previous (early 80's) male out-migration waves to the USA, women have been pushed to become in household heads until men returned home. However, much of these early migrants did not return to Ecuador, which helps to explain in part the importance given to eldest women as household heads. On the other hand, e.g. in Caldera study area, an important group of current inhabitants correspond to ages falling between 50 up to 84 years old. It is expected that such population correspond, in some proportion, to former migrants (early 80's) who did returned home, explaining in part the general aging of this population. In addition, the possible current male and/or female adults' migration (excluding those early migrants) has been discarded since INEC data (2010) confirms low migration rates for the three areas under study. Actually, this typology shows the lowest migration rate among all. The precarious economic situation is expected to be one of the main drawbacks for these households for not sending their family members abroad, leaving the no-migrant population as the most influential on the different current household dynamics under study.

Membership to local organizations provides different results (Table 4). On the one hand, membership to local "water boards" is considered to be very important; while the membership to "agricultural or trading organizations" is just relevant. Taking into account the high economic household's dependency on subsistence agriculture in typology 2; the membership to local water boards' at least assure water supply for lessening agricultural risk. In addition, these "reduced" families headed by "old" persons are expected to be less willing to search neither for technical assistance nor becoming member of trading organizations since they practice traditional and subsistence agriculture & cattle that might not rend any extra income from trading.

Results in (Table 4) show that some agricultural practices such as manual land preparation are considered to be no important. It is expected that the low socio-economic status of these households is pushing their population to diversify their economic activities to other non-agricultural livelihoods that will diminish labor force for agriculture in turn. Other characteristic of typology 2 (Table 4) is the no application of agricultural inputs such as chemical pesticides. Here the precarious household income is playing a decisive role.

Cultivation in general is considered a no important household activity in typology 2 (Table 4) since they practice a precarious subsistence cropping. Under traditional and subsistence agricultural practices in the Ecuadorian Andes, some high labor force demand crops such as potatoes and fruits, are generally under the main responsibility of male adults; while low labor force demand crops, such as vegetables and cattle are traditionally managed by female adults with the help of children. According to the results presented in Table 4, the most important activity is subsistence cattle in this typology. In addition, other land use factor considered as very important is the extraction of firewood from local forests, which is expected to be contributing to middle and long-term land use change in the Paute catchment. At last, environmental degradation perception in typology 2 is very weak (Table 4) in spite of the serious environmental issues occurring in the three study areas.

Typology 3

Results in Table 4 suggest households' typology 3 to experience higher labor force availability that will induce diversification of economic activities, improved household income and general socio-economic status in turn. This typology represents a traditional young and growing rural family that in turn it characterizes an important part of the current economic active population of the Paute catchment (middle class). Migration is still restricted in this typology (Table 4) since these growing families are facing high expenses and can hardly afford to send some of their members abroad. However, sometimes some of these households spread their economic risk by taking loans for paying the costly trip of the migrants. Considering this low migratory pattern in typology 3, the no-migrant population represents the highest influence on current dynamics under study.

Demographic characteristics are expected to influence the low importance given by households to local organizations (Table 4). Young households are expected to be more willing to search for technical assistance and alternative ways of trading even out of their parish if necessary. This may lessen the need of belonging to local organizations. However, it is also important to mention that such results may be influenced also by a very poor local organization that may not be even exists in some rural areas. According to the 3-Paute survey

results (Vanegas, et al. 2011), two of the three study areas are mainly represented by their "parish boards", while one parish is represented by its "water board".

Regarding agricultural practices, households' budget will be mostly invested in supporting such "growing" families in this typology, becoming manual land preparation fundamental as presented in Table 4. From time to time households can afford rental of animal traction or machinery, and purchase of agricultural inputs such as chemical pesticides. However, results (Table 4) show that cropping is still a secondary source of income, even under these relatively improved conditions that mainly may encourage cattle to go beyond subsistence reaching regional trade level impacting household's income. Households in this typology expand their economic risk to cattle more than cropping. Cattle are their main income source and physical capital for facing economic constraints. In addition, results (Table 4) show the important firewood extraction activity from local forest that is expected to influence the middle and long-term land use in the Paute catchment. However, results (Table 4) confirm the weak environmental perception in this households' typology as well.

Some authors (Godoy et al. 1997; McSweeney 2004) have found fundamental differences between long-settled and young colonist households. Such differences appear to be the ethno-social and institutional contexts that influence their household livelihood strategies, agricultural practices, agro-ecological knowledge, child dependency, and land tenure. According to de Sherbinin et al. (2008) better understanding of how these households relate to their environment might contribute to a more systematic understanding of why, despite high and growing population densities, long-settled indigenous households are found to be associated with much lower per capita rates of deforestation than non-indigenous settlers. In the past, indigenous peoples' light ecological footprint was explained by their low population densities, relatively low rates of market integration, and simple technologies. New data are showing that even when these conditions change, indigenous people can still be effective forest/resource stewards (Zimmerman et al. 2001; Guzmán et al. 2003).

As limitations and scope of the current research it is relevant to mention that we applied some theoretical approaches on soil erosion such as the Boserup's theory (Boserup, 1981) that propose population growth not only inducing land degradation, but also promoting intensive agriculture including technological and organizational innovations. However, according to Ananda & Heralth (2003) in many Asian, Latin American and African countries, Boserup's sequence was not observed. Here, severe erosion has occurred in areas where population growth has been very rapid, biologically vulnerable or fragile, and the socio-economic conditions prevented the implementation of conservation measures.

On the other hand, the household life-cycle also has several limitations. According to de Sherbinin et al. (2008), the assumption of a unitary household may be misleading in several contexts where different members of the household have divergent preferences regarding family size for instances. Also, this approach fails to take into account the complexity of the social, political, cultural and religious context of fertility. A household in a given social context may therefore choose to have high fertility because of prevailing social and cultural norms. Since these norms change slowly, there exists the potential for high fertility to be sustained even in the context of a declining resource base. In addition, the household life-cycle rely on short-term (usually one year) ''snapshots'' of rural livelihoods. Yet the family formation process is ongoing, and currently observed fertility rates are typically the result of prior decisions about a desired family size (Aggarwal et al., 2001). To get an accurate picture

of fertility determinants, then, requires longitudinal studies to better analyze the dynamics and the complex endogeneity issues that arise in empirical analysis.

Van Wey et al. (2007) propose to rethink the Chayanovian assumptions on which the household life-cycle is based: "households are unconnected to larger labor or capital markets relying only on household labor for farming". In fact, households strategically access cash from off-farm employment, primarily of women, and from government assistance programs, and they invest in cash crops. On the other hand, the classic work on household life-cycle has been challenged by the introduction of the property life cycle approach. Some researches argue that the effects of the time since arriving on the property reflect a different sort of cycle. Barbieri et al. (2005) argue that land is cleared at different rates depending on the duration of residence on a property. Van Wey et al. (2007b) argue for a learning process, where new arrivals in frontiers must clear large areas of land to experiment with different crops and inputs. Older residents of new frontiers and newer residents of old frontiers (where agricultural techniques and knowledge have diffused through the population) need not experiment in this way and instead can specialize in crops appropriate for their land.

At last, Stokes & Schutjer (1984) argue that land tenure can neutralize the relationship between farm size and family size (the "land-security hypothesis"). This approach suggests that land tenure security creates economic security that lowers the need to invest in large numbers of children. Greater security is associated with higher living standards, access to health care and greater educational opportunities, all of which promote lower human fertility. Some studies in Ecuador (Coomes et al., 2001; Carr et al., 2006) supported such hypothesis, with women in households with secure land title (usually the largest farms) having two-thirds fewer children than those without such titles (usually the smallest farms). Generally their findings confirm hypothesized links between poverty and fertility: households that are more centrally located, with good access to markets and services, choose to limit fertility more than poorer households.

CONCLUSIONS

Identified household dynamics are consonant with some expectations based on the household life-cycle approach, and household livelihood theories. However, in this research those identified household dynamics may not have the same expected effects because of the availability of hired labor and the focus of households on profit beyond subsistence (both unaddressed by Chayanov's theory). The final household typologies obtained in this research share four main common important characteristics: cattle and cropping are the most important household livelihood strategy, use of firewood as household energy source that might influence land use in the middle and long-term, and a strong weak environmental awareness.

The demographic structure of the Paute catchment is influencing mainly labor force availability that in turn will affect the household socio-economic status. "Reduced" households are highly dependent on subsistence agriculture (cattle) and diversification of economic activities is less likely to occur, contributing to their less wealthy conditions in turn. "Large" households are highly dependent on large scale agriculture (cattle) showing also a high diversification of livelihood strategies (agriculture & no-agriculture), which may continue improving their wealthy status.

Migration is playing an important role on the household dynamics under study of wealthy families mainly. This is in accordance with Gray (2009) whom proposes that households draw on natural capital (intensification and/or extensification) to facilitate this costly out-migration; and Brown et al. (1988) who proposes that out-migration increased with indices for long-standing settlement and modern socio-economic structure and decreased with indices for subsistence-oriented agriculture in the Ecuadorian Andes. The households practicing subsistence-oriented agriculture (no-migrant) represent the precarious as well as the growing socio-economic households' status (household typologies) that actually represent in turn to the largest population of the Paute catchment. Another important socio-economic factor is local communitarian organizations. Here, age of household head as well as number of family members, and type of agriculture are playing a decisive role. "Young" household heads are expected to be more willing to search for technical assistance than "old" ones. In the same way, "growing and large" families will encourage household heads to increase their income for covering family expenses more than "reduced" households. "Growing" and "large scale" agriculture production will also force household heads to find new ways to commercialize their products, which is not the case for the households under subsistence agriculture type.

Important agricultural practices such as "manual land preparation" and "pesticides" are also being influenced by demographic & socio-economic factors. "Reduced" families do not account with enough labor force, which is not the case for "growing and large" households. On the other hand, precarious and growing households' socio-economic status may not account with enough financial means for investing in agricultural inputs, while wealthy households will largely invest on such inputs for maintaining their large scale production and productivity. In general terms, traditional agriculture is still being practiced in the Paute catchment, since important factors such as land preparation methods, use of fertilizers, and irrigation have been proven to be no significant according to final results.

Concerning land use variables; number of household members and age structure are crucial for labor-intensive land uses and land allocation. The labor force availability influences the diversification of economic activities. Here "cattle" is the most relevant activity on which most of households are economically dependent. Cropping is important mainly for those households immerse in large scale agriculture; which is not the case for the "subsistence" neither "transition" agriculture systems. In addition, gender roles are well defined mainly for the "large scale" system where women and men play different roles based on production scale and trading.

Environmental degradation perception is considerable weak. Only two environmental issues (landslide and environmental pollution) out of eleven tested variables are considered to be relevant. Serious local constraints such as deforestation and forest burning, flooding, soil fertility, and soil erosion are not perceived as relevant. This phenomena may be influenced by both the rural idiosyncrasy and cultural background (rural population might be lacking some environmental concepts such as degradation as proposed by Wyn (2010) and the need of farmers to support their families by practicing agriculture on degraded soils. For this, farmers practice intensive and/or extensive agriculture with no any environmental considerations. Environmental awareness is still a big challenge in the rural Andes. In addition, all these household dynamics will induce feedbacks that in turn will affect the general socio-economic household status. According to Shivatoki et al. (1999) all these multiple and multi-level dynamics between population parameters and environmental variables and vice versa suggest

an important reciprocal relationships influenced by endogeneity processes, where each affects the others.

A focus on household dynamics does not imply that smallholders are necessarily neither the primary nor the ultimate agents of natural resource degradation or rural landscape change (de Sherbinin et al. 2008). Nevertheless, this focus on the micro-demographic dynamics of rural smallholders is based on recognition that they are important players in natural resource use and landscape change. From the environmental perspective, household demographic dynamics can affect local environmental outcomes and resource dependence, affecting in turn the natural resource management and biodiversity conservation.

While our research and many other studies focus on a "snapshot" of the current household generation, an intergenerational approach (children getting married, leaving home, and settling close to their parents; co-residence with older and younger relatives, inheritance, etc.) may improve the understanding of the long-term household life-cycle dynamics over time. On the other hand, the impact of fundamental livelihood strategies such as migration, remittances and off-farm employment on the household life-cycle need to be assessed in a more integrated approach.

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