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Benefits of international migrations for socio-ecological resilience of rural households in the home country

Empirical evidences in two Ecuadorian provinces

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Introduction

This research aims to link two themes yet understudied: the consequences of international migration at the home country and the analysis of the social ecosystem resilience at household level. These two topics share several common perspectives being complementary issues as well

Consequences of international migration

The impacts of the international migrations on the development of the sending countries are often reduced to its economic and social aspects (Giuliano and Ruiz-Arranz, 2009). 200 million people currently live outside their country of birth (United Nations, 2009) and their remittances contribute largely to the economy of their home country. Considering only the developing countries, remittances reached 235 billion dollars (Ratha et al., 2009). It is hundred times more than the budget freed by the EU for the Cooperation in the Development in 2009 (European Commission, 2009). Migrants and migration networks are seen as a powerful level for the development of his/her village (Beauchemin and Mezger, 2009; Mazzucato and Djamila, 2009). Social remittance are widely acknowledged as an important resources for promoting immigrant entrepreneurship, community and family formation, and political integration (Levitt, 1998). Migration is one of the numerous livelihood strategies developed in several developing rural regions (Henry et al., 2004) and can make important poverty-reducing contributions to household incomes, with multiplier effects in community (Durand et al., 1996). Nevertheless, a few micro economic analyzes point some negative effects of remittances, such as squandering in conspicuous consumption (Binford, 2003; Reichert, 1981). In terms of social aspects, positive and negative impacts can be found too (Mondain, 2009). Out-migration undermines traditional rural livelihoods as social institutions (Binford, 2003). The male migration gives higher levels of responsibilities and a greater autonomy for their wife left behind and this imbalance in the male/female ratio may have impacts on local politics (Desai and Banerji, 2008; Deshingkar and Grimm, 2004). Furthermore, by allowing the household to pay for school enrollment, remittances decrease incidence of child work, especially for girls in rural areas.

At the same time, the migration-environment nexus is an important issue but a large part of the scientific community focuses only on the impacts of the environment on migration. The attention of researchers, stakeholders and media is focused on the definition, the measures and the geopolitics aspects of the 'environmental refugees' issue (Bilsborrow and Henry, 2012). Studies are looking for how an important arrival of people may disrupt the population-natural resources balance, such as the increasing demand for wood, changes in land use practice, water pollution, and a degradation of natural resources (Black and Sessay, 1997; Hugo, 1996; Lohrmann, 1996; McNally et al., 2002).

The consequences of international migration on socio-ecosystemic issues concerning the left-behinds remains an open question. Some authors argue that migration has potential for transformative impacts on agriculture (Gray, 2009) and constitutes an opportunity for the sustainable development of the home countries (Heilmann, 2006). Others suggest that rural out-migration can lead to land abandonment and reforestation as part of a ''forest transition'' (Rudel et al., 2005). In El Salvador, Hecht et al. (2006) found that remittances allow a decrease of the environmental pressures by the abandonment of uncultivated plots of land, a decrease of the agricultural intensification, and the investment in the other systems of production. An unhoped reforestation is likely to be in progress in this country thanks to changes of household behavior allowed by the remittances. Finally, in Mexico, some changes of landscape have also been attributed to remittances (Hostettler, 2007) but the author does not clearly support the idea of a possible environmental degradation and insists on a future better evaluation of these changes.

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Large-scale examples of this process from the developing countries are scarce (Perz, 2007) and empirical studies which take into account the environmental dimension are called for here. In addition, we point that too little studies take a holistic approach and the main environmental studies too rarely take into account the complexity of socio-ecosystems and nonlinear aspects of population-environment interactions. We know that for the so-called "left-behind", remittances could reduce household vulnerability to economic shocks (Calero et al., 2009) but the benefits of migration to help household to cope with shocks caused by environmental constraints and environmental degradation (at global and local scales) remain misunderstood.

Socio-ecological resilience at the household level

The term "resilience" refers to the idea of a return to normal after a shock or disturbance, this concept originating physics has been taken by a large number of scientific disciplines. Its use in systems analysis and especially ecosystems was initiated by Holling (1973). He has improved the definition of resilience throughout his publications and works. We retain for the work that resilience is "*the capacity of a system to absorb disturbance and still retain its basic function and structures*" (Folke et al., 2002; Holling, 1994; Walker and Salt, 2006).

The characteristics of a resilient system has been established by several authors (Levin, 2007, 1999; Walker and Salt, 2006). We retain four of them.

First, systems need diversity and variability. A resilient system must be composed of a variety of elements and subsystems. For the socio-ecosystems, this means all the dimensions of biodiversity, as well as landscape diversity, as social and economic diversity. This diversity needs to deliver a large number of options in case of problems via redundant functions carried by chains of independent interactions. Variability is also very important. A system is more resilient with dynamic equilibriums that with static equilibriums. As an example, Walker (2006) said that some forests (Mediterranean forest, for example) are much more dangerous and fragile when they are protected against small fires. When they are no longer subject to regular small fires, they gradually lose their fire resistant species and become more vulnerable and susceptible to fires. In addition, they become much slower to recover in case of damage by fire.

Secondly, the system requires modularity. The modularity can be defined by the hierarchy of interactions. If all the elements of a system are connected to all the other elements without hierarchy, an "over-connection" can conduct the shocks to pass quickly through the entire system. In other words, there must be sub-systems that must be sufficiently autonomous to be able to continue to function normally during general system dysfunctions.

Thirdly, there is a need for cross-scale connectivity and asynchronization subsystems. This point qualifies the necessity of modularity. The resilient systems where problems can be rebuilt with a phenomenon of "memory" offered by the top scale in which it is part of. In contrast, a system is reinforced by its subsystems when they have an asynchronization in their adaptive cycle (fig. 2). To summarize, the subsystems should be modular enough to not be disrupted by shocks from higher level system, but must be sufficiently connected to a higher level not to be (definitely) undermined by its own shocks.

Fourthly, the system must contain "tight feedbacks". In reflexive systems, i.e., systems with features that interpret its environment and act in consequence[4], the feedbacks should be tight enough to give a signal that informs a potential problem (or exceeded thresholds).

The sustainability of complex flow systems (flow of materials, energy and information), is defined by the subtle balance between efficiency and resilience (Lietaer et al., 2009). The efficiency is achieved by systems that have antagonistic characteristics of resilient systems, i.e., without redundancy, with a minimum of diversity and maximal inter-connectivity without hierarchy (ie. without subsystems). They are characterized by the extreme specialization of its elements. It is possible to analyze quantitatively according to the same metric axis "efficiency-resilience". It has been observed that too much resilience makes the system decay by lack of efficiency (Zorach and Ulanowicz, 2003). Similarly, too much efficiency weakens systems and conducts at the collapse.

Many studies have investigated mathematically the correct allocation for sustainable systems. The window of viability (fig 1) is ¾ of resilience against ¼ of efficiency (Lietaer et al., 2009). Liétear (2009) and Walker (2006) emphasize that, at present, socio-ecosystems are carried out with objectives and assessment tools focusing too much on efficiency at the expense of resilience.

[4] typically the case of socio-ecosystems.

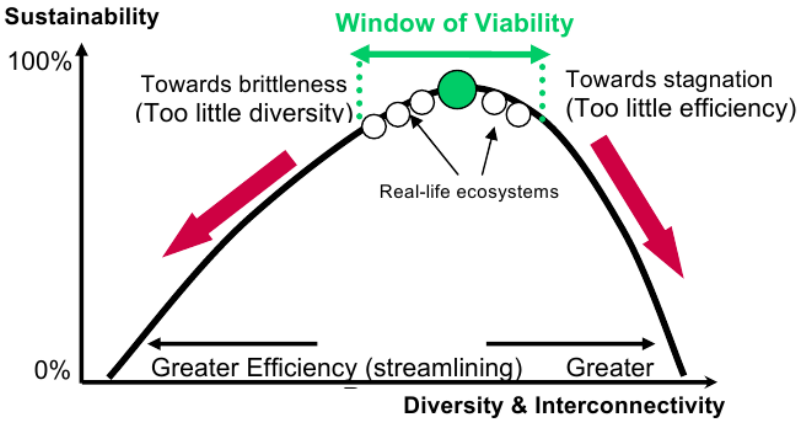

Fig. 1: Sustainability and resilience: the window of viability (Lietaer et al., 2009)

This actual lack of consideration for the systemic resilience is partly explained by the theory of adaptive cycles of complex systems (fig. 2) . This theory explains the natural evolution of the couple "resilience-efficiency" First the resilience is high (r phase) but tends to decrease in favor of efficiency (in k phase) up to one-point where the system becomes too fragile and collapses (omega phase). It goes through a phase of reorganization phase (alpha phase) where it slowly recovers its resilience (r phase) and restarts a cycle.
In the stable phase "k" efficiency appears to be the dominant strategy: elements specialize, diversity falls, redundancies disappear. In ecosystems this results in higher specialist species to the detriment of generalist species (Richmond et al., 2005; Walker and Salt, 2006). The ecosystem becomes more efficient and stores energy, materials and information which ends up weakening and led to its collapse. The same laws are applied to socio-ecosystems (Walker and Salt, 2006), in urban areas, companies etc.
Neoclassical economics, based largely on the theory of comparative advantage as defined by Ricardo (Lamy, 2010) dominates the current economic models. It promotes global trade and grows ever more specialization.
At the household level, this results in the generalization of an occidental-like style of life including in the most remote areas (Hecht, 2010). These lifestyles are characterized by specialization of sources of income and high consumption of goods and products that come from production lines and complex supply chain which are raw materials-intensive and energy-intensive. They are spatially extended and cause a release of feedback (Walker and Salt, 2006). Households are disconnected processes and socio-ecosystems that support them. These lifestyles are freed from local constraints and reduce the vulnerability of households (Adger, 2003) by connecting them to a larger and more complex system (e.g. complex agro-ecological and trading systems) that has greater inertia. This reduction in vulnerability is not due to the increase in their resilience, on the contrary, the resilience is greatly reduced.
Temporality of an adaptive cycle is all the more in long-term than the spatial scale of the system is larger (Gunderson, 2001; Walker and Salt, 2006). It follows an apparent stability when a household "connects" to a larger scale by integrating a broader system in its k phase.
The danger is that this new "globalization" of interactions is too recent to provide a complete adaptive cycle. This "big system of systems" is still in a K phase where specialization and efficiency appear to be the preferable strategies. This system has not yet experienced major shocks or complete collapse and could not learn from its own real weaknesses. A major collapse could come from its great dependence on non-renewable fossil liquids energies (Bridge, 2010; de Almeida and Silva, 2011; de Castro et al., 2009; Fred, 2009; Hirsch, 2008; Hopkins, 2010; Walker and Salt, 2006), but it could also occur from something else: a global supply disruption of phosphorus (Cordell et al., 2009), rupture of rare earth elements, sharp decrease in agricultural production, etc. The only danger is the coupling between its fragility and the theoretical impossibility of having complete and reliable predictions (Berkes, 2007; Dupuy, 1989; Sluijs, 2006) on future shocks threatening the system. It is impossible to ensure pro-activity nor an endless maintenance of the system in K phase which is at the core of scientific thinking.

It is important to note that this world system has begun to show fragilities. One of the most disturbing evidence seems to be the subprime crisis of 2008 and its connection with the beginning of a slowdown in the production of conventional oil (Newman et al., 2009; Tverberg, 2012) that the dominant economic models were unable to predict.
The majority of studies and analysis of economic models and lifestyles of these last thirty years come to conclusions that reinforce options for efficiency and economic growth (Lietaer et al., 2009). Indicators of resilience remains dangerously under-utilized.

Adaptive cycle

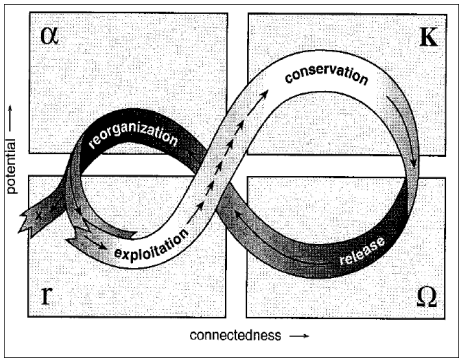

Fig. 2 Adaptive cycle (Gunderson, 2001**)**

Y axis - the potential related to the accumulation (or destruction) of resources within entities or structures
X axis - the degree of connectedness.

R phase. The resources are easily accessible and the system increases sharply. The "generalist/opportunistic" strategies are dominant. They permit to explore and exploit the maximum niches. In this phase, the system is highly resilient.

K phase. Structures freeze. Resources are stored and become inaccessible. The system becomes stable, efficient and rigid. The elements are connected and interdependent. Resilience is becoming weaker.

Release phase *(Ω)*. After a shock, the system can collapse quickly releasing the resources and losing its structures. At most k phase has been long, the more the shock necessary to his "collapse" can be low.

Reorganization phase (α). After the collapse, the system reorganized itself, old relationships and entities can rebuild and new can emerge. The limits are low and the new system may include sets belonging to other systems. At this time, the system is poorly regulated and very unstable, so that it can easily move from one alternative scheme to another. This can lead to the beginning of a new adaptive cycle or, alternatively, a return to the old.

At the household level, there are few studies on the impact of their strategies on their own resilience. The choice (or obligation) of integrating in a particular socio-ecosystem, yet influences the resilience and thus the "sustainability" of the household.
The study of resilience at the household level should help to nuance the existing debate between autarkic life-strategies (or at least promoting the "localization") and specialized life-strategies which are integrated in a globalized system (Adger, 2003; Hopkins, 2010).

In conclusion, the study of the socio-ecological resilience focusing on households' ability to adapt and continue to maintain vital functions despite socio-ecosystemic shocks -predictable and unpredictable- is very important for its contribution to the well-being and sustainability of rural communities.

Objectives of the study

This study is a part of a larger research project that aims to contribute to a better general understanding of the role of the migrant as agent of sustainable development by focusing on the socio-ecological aspects of resilience of the left-behinds. The specific objective of this paper is to analyze the effects of migration on the different factors of resilience at household level.

- **Diversity** of social and environmental interrelations (with functions redundancy).
- Ability to understand/to feel **feedbacks loops** controlling ecosystem services.
- **Modularity** seen as the ability to survive only with local resources and local interactions in case of global systemic shock.
- **Connectivity** as the ability to trade at larger scales to cope with local systemic shocks.

We assume that the whole interactions between the natural environment and the rural households are modified by the departure of one of its member abroad. Hypotheses can be broadly divided into three categories (fig. 3) : those related to the decrease of the workforce generated by the departure of the migrant, those engendered by the remittances and finally, those related to the transfers of the migrants' knowledge, skills and ideas (social remittances).

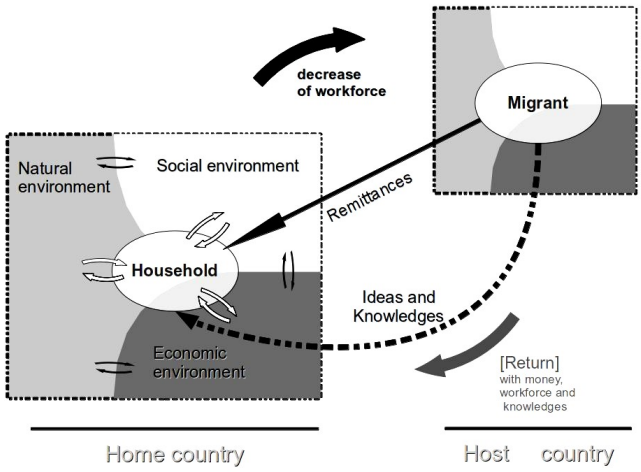

Fig. 3 - Migration–environment nexus at the home country

Hypothesis 1: The departure of one migrant, mostly a young male, decreases the workforce available in a rural household. We expect that this reduction brings a decrease in the consumption of local ecosystems services (wood, water, etc.) and locally, a lower pressure on land. This may leads to greater **diversification** of land use through reforestation of less fertile plots and extensive conversion of remote plots to pasturage (less costly in human capital). This may result in turn in both **diversification** of landscape and agricultural production which can improve *resilience* to local degradations/shocks.

Hypothesis 2: Household income may increase thanks to received remittances that in turn may lower the consumption of local environmental resources by modifying the household' life-style and its agricultural practices. We expect a greater dependence of remote ecological resources as petroleum (direct and indirect uses), rare earth metals, tantalum (element), inorganic phosphorus, etc., which can induce both to improve the **connectivity** of left-behinds and to lose their **modularity** especially when agricultural practices are totally abandoned

Hypothesis 3: Thanks to the knowledge, skills and ideas (social remittances) transmitted by the migrant to his/her household, we expect among the left-behind, different levels of environmental awareness and the acceptance to use environmentally-safer practices (e.g. soil protection management techniques). This may induce a greater capacity to cope with dangerous “positive feedbacks” and others environmental degradation issues especially when left-behinds benefit received remittances.

Context

The two neighborhood Azuay and Cañar provinces in the Ecuadorian Sierra provide a favorable context to test the three research hypotheses. Large study of population-environment have already been conducted in Ecuador, mainly in the Amazonian frontier environments (Oriente). " Facing the relatively few research on the Sierra region (Ecuadorian Andes) we propose to study this region, which represent different cultural, social and environmental household dynamics.

Due to rapid demographic growth and severe land degradation, both the quality and quantity of land available is rapidly decreasing. 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, 1991). These small farms or "minifundios" are further divided into even smaller landholdings. Overgrazing and intensive cultivation of these poor soils have led to severe land degradation, and widespread poverty amongst the rural population.

The provinces of Azuay and Cañar (fig. 4) in the southern Ecuadorian Andes experience high levels of transnational migration. Since the 90s, 600 000 Ecuadorians have left their country to the United States(Jokisch, 2002; Jokisch and Pribilsky, 2002; O'Neil, 2003). By 2000, the second wave of out-migration had reached more than 550 000 Ecuadorians. Europe became to be attractive, mainly Spain. In 2007, the World Bank estimated the amount of remittances sent to Ecuador at 3175 billion US dollars. Three households out of four benefited from this additional income (O'Neil 2003).

The Andean mountains contain unique ecosystems consisting of a wide diversity of natural environments, which range from lowland rainforest to lower mountain rainforest, Andean cloud forest, grassland and shrub vegetation and páramo vegetation at the highest elevations. During the last few decades, the natural ecosystems of the Andean region have increasingly been disturbed by rapid demographic growth and socio-economic development (Hofstede et al., 2002). Despite the fact that these environments are sources of water, energy and biological diversity that are essential to the survival of a large part of the Andean population, they are endangered by human pressure and natural ecological imbalances caused mainly by land use and climate change (Becker and Bugmann, 2001).

Data

Three sources of data were used: the INEC censuses (2001 and 2010), a qualitative survey (2010) and a quantitative survey named as the 3-Paute survey (Vanegas et al., 2011). These two surveys were performed by the authors themselves with the support of a CUD (*Commission universitaire pour le Développement* from Belgium) project in the framework of the technical and academic cooperation between the Faculty of Agricultural Sciences of the University of Cuenca (Ecuador) and the Department of Geography of the University of Namur (Belgium).

The qualitative survey was conducted in three parishes (Azuay provinces) in spring 2010, while the 3-Paute survey was performed during May and June 2011 .

In the case of the qualitative survey (2010), the selection of the study areas have been based on analysis of census data 2001. We selected the parishes with the highest percentage of migrant households. A dendrogram classification (Ward algorithm) was carried out using available socio-economic variables (type of home, employment, bathroom availability, type of combustibles used). Three clusters of parishes were obtained. A parish in each group was selected based on criteria for the accessiblity and the logistical feasibility: Checa, el Cabo and Mariano Moreno.

The main objective of this initial step was to obtain some fundamental ideas and preliminary information for preparing the final questionnaire for the quantitative survey 2011 as well as to manage and fix some logistical and technical aspects on field job. This qualitative survey 2010 also contributed to build a first group of perceived environmental issues by the local population.

For the 3-Paute survey (2011), study areas (fig. 5) were already selected in advance by the mentioned joint research activities (CUD project) between Ecuador and Belgium. In this way, such study areas corresponded to 3 sub-watersheds (Pichacay, Caldera and Llavircay) located respectively in 3 rural parishes (Santa Ana, Javier Loyola and Rivera. The possibility of collaboration for the quantitative survey occurred after the end of the qualitative survey, which explains the difference in study areas.

By using the 2010 population census sector maps (INEC), the surveyed households were selected by simple random sampling. Then, for every study area , a list of houses was obtained and a random rank was assigned to each house.

Daily field job started with a briefing about the different census sectors to be covered for every surveyors team as well as some explanations on INEC census sectors maps. On the evening of each day of investigation, an assessment is made with the investigators and authors. Each dwelling properly investigated was replaced. The erroneous housing (church, abandoned house, etc.) are also replaced. For such replacement, the new houses were selected from the previous randomly ordered list, respecting strictly such order (Vanegas, et al., 2011).

In the case, where the team was unable to meet the head of household, an assessment is made as to whether investigators should insist or if the dwelling should be removed. This technique allows a better control of homes surveyed and prevents that only the most accessible homes and / or the most friendly households are surveyed, per

ease.

Daily field data quality was checked (missing data, mistakes), while the most sensitive and remote households were under direct responsibility of the authors.

The obtained sample includes 239 households surveyed (78 for Pichacay, 90 for Caldera and 71 for Llavircay) and 1,113 individual biographies collected. The questionnaires included (i) environmental topics related to agricultural practices, land use change, land degradation; (ii) socio-demographic topics related to migration (i.e. duration, destination, contacts and remittances), household composition and gender roles; (iii) socio-economic topics related to consumptions, education level, economic activities; and (iv) the perception of the left-behind on the environmental issues (on local to global scale) (Vanegas, et al., 2011).

Fig. 4: Azuay and Cañar, Ecuador

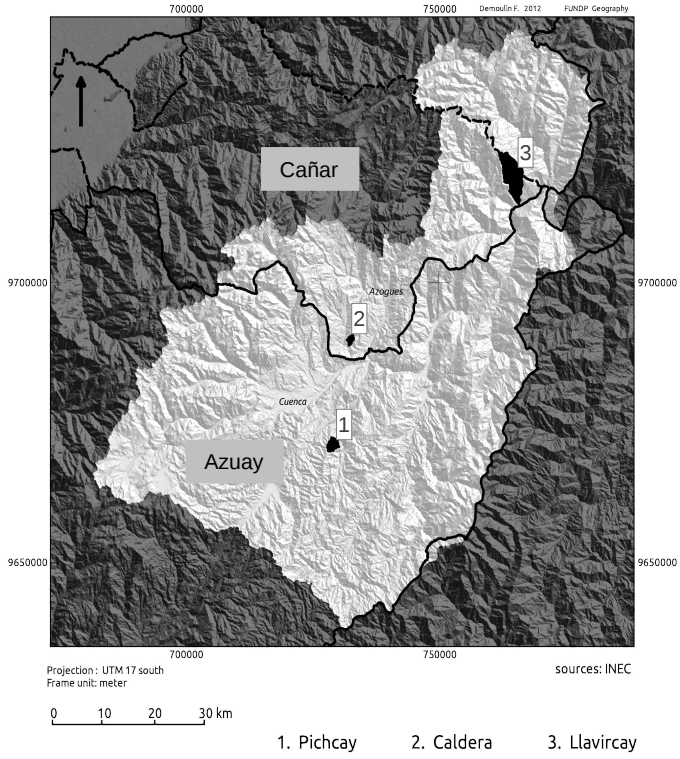

fig. 5: Paute catchment and study areas of 3-Paute survey

Methods

The data sets used for this research are complementary, each addressing specific weaknesses of the other. INEC data is exhaustive but insufficiently detailed on agricultural practices, household livelihoods (consumptions and income sources) and their representation of the relationship to the environment. The 3-Paute data provide more details on household's lifestyle, their assets, their practices and their relations with the environment. However, the fact that the pre-selected study areas are low in international migration does not permit to test all the hypothesis.

INEC 2010

This research focused on households located on three rural parishes[5] of the provinces of Azuay and Cañar. The chief-town parishes and those considered as urban by INEC were excluded.

Hypothesis 1

For hypothesis 1, we tested first the dependency of the source of domestic water as well as the main domestic energy source by using the Chi-square test. If significant chi-square values obtained , we apply Pearsons ' residual to understand the relationship between two variables in each category. The Pearson residuals follow a standard normal distribution. It is therefore possible to control their significance: an alpha value less than "0.05" corresponds to an absolute value greater than 2 (or 1.96). The sense of the relationship is given by the positive or negative sign.

$$Pearson's\,residual = (obs - \exp)/\sqrt{\exp} \qquad 1.1$$

obs: observed value
exp: expected value

We also studied the diversification of household income sources. For this we selected households with more than three members currently working for measuring the diversification of human capital. We applied the index of Heirls and Hirschman (HHI; see formula 1.2) that can extend from 1 / n (minimum) up to 1 (maximum). To analyse the diversification, we used the modified HHI formula (1.3) assuming that each household workers provide an equal share to the total household income. Number of working hours are not available. The Welsh t-test was used to probe the differences between among average values of the diversification index.

[5] Code of the parish must be higher than "50" (see INEC codification)

$$HHI = \sum_{i=1}^{n} S_i^2 \qquad 1.2$$

where S_i represents the portion used by "*i*"

$$Diversification = 1 - IHH \qquad 1.3$$

A Pearson's residual analysis was also performed to determine whether having a female as household head is of the households related to the lack of lower agricultural practices and this, according to the classification "household with" and "household with no migrants".

Hypothesis 2

As for hypothesis 1, we tested the dependency of the sources of domestic water and domestic energy by the Chi-square and Pearsons residuals tests. The tested variable was "having received remittance at least once in the year". It is important ro mention that presence of migrants do not lead systematically to remittance. Similarly, some families receive remittances from persons who are not officially part of the household itself

3-Paute database

Analysis of the preliminary assumptions presented at the beginning of this research by using the 3-Paute data is not possible to accomplish . The migration-related variables such as remittances, lower number of household members, or the transfer of ideas and knowledge can not be studied due to an insufficient number of households with migrants. Only the general variable "has at least one migrant" was used here.

Diversification (diversity and connection to larger systems)

We focused on five aspects that seem to be important in the analysis of linkages between the household and "his" socio-ecological systems: household source of energy, professional skills (extra income or subsistence), social networks, supply of carbohydrates (potatoes, corn, rice, etc..). For each of these aspects, we applied the modified formula IHH (cf 1.3).

The diversification of domestic energy was evaluated considering questions about households' consumption per month: firewood, electricity, gas and fuel (only household use). Such quantities were converted into Joule (J) to be comparable.

The diversification of professional skills was calculated by the different categories of professional occupations for all household members over 18 years (18 years is considered the age of adulthood).

The diversification of social networks was calculated by questions about the household membership to local organizations (community "water boards", cooperatives, farmers associations, community associations and/or "other"). Given our lack of information on investment (money and time spent) we assumed an equal distribution between the different groups. The diversification of supplied carbohydrates was calculated by questions on farming practices (different crop species varieties) and additional purchases (in town, outside town, or supermarkets). Obtained amounts were not precise enough, thus we assumed equivalent distribution among the different cited sources.

Local anchoring (tight feedbacks and modularity)

To assess the local linkage (ie degree of modularity of the household) the "connection to the land" was studied. First, we tested the amount of land dedicated to agricultural activities. A distinction was made between crops and livestock. Their averages were compared by the t-test of Welsh. Next, we evaluated the agricultural techniques used for cropping : mechanization and fertilization. The t-test was also applied.

A list of environmental issues was obtained by interviewing local community leaders (heads of parishes, heads of water boards, and some community priests). Household heads opinions were collected by asking them about every single environmental issue included in the mentioned list. First we asked whether they have heard about such issues. In case of positive answers, they were asked to qualify the importance of such environmental issue as not important, important or very important. Then, two analyzes were performed. First, a score was built by merging all answers "important" and "very important". The scores differences between households with migrant and households with no migrants were evaluated by the t-test of Welsh. A classification of environmental issues was performed according to their "spatial" scale. The analyzes was performed at the three scales: local, regional, and global. Moreover, diversification was also analyzed. The formula IHH modified (cf 1.3) was applied.

Results

INEC data (2010)

Hypothese 1

Table 1: Households' sources of drinking water, INEC 2010 (provinces of Azuay and Caňar)

	Pearson residuals					χ^2
	Car	**Wells**	**Public networks**	**Channels**	**Rainwater**	
Migrant	-0.89	-9.69	0.95	8.86	-12.39	379***
No migrant	0.35	3.82	-0.38	-3.50	4.89	

df = 4, p-value < 2.2e-16

In the table 1, the source of drinking water appears to be dependent in a highly significant way with the existence of at least one migrant at the household. The analysis of residuals suggest that families with migrants use significantly less wells and/or rainwater.

Table 2: Households' sources of energy, INEC 2010 (province of Azuay and Caňar)

	Pearson residuals						χ^2
	Elect.	**Gas**	**Wood**	**No kitchen**	**Gasol. kerex or diesel**	**Waste veget. /animal**	
Migrant	-1.45	4.32	-10.25	-9.24	-0.89	-0.065	245***
No migrant	0.567	-1.698	4.025	3.627	0.35	0.0256	

df = 6, p-value < 2.2e-16

The table 2 show a significant dependence between having at least one migrant and the household source of energy. The residuals results propose that families with migrant use less firewood and electricity. These household significantly account with a kitchen, and they use more gas.

Table 3 Incomes diversification of household, INEC 2010 (province of Azuay and Caňar)

	With migrant	**With no migrant**	**p-value**	Conclusions
Incomes diversification	M=0.55	M=0.55	0.70	**H0 accepeted**

The test of diversification (t-test) of incomes based the presence of at least one migrant is not significant (cf table 3).

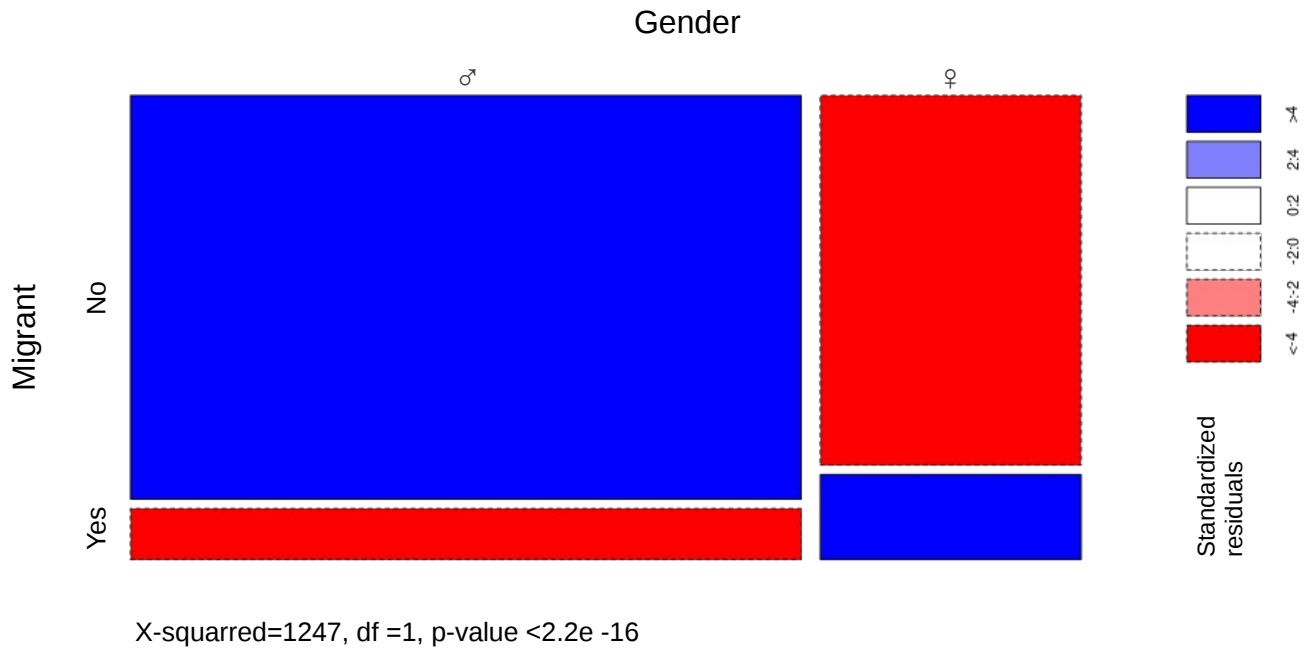

fig. 6: Migrant and gender of household head, INEC 2010

In the "mosaic plot" (fig. 6) female household heads represent less than a quarter of the total number of household heads. Chi-test square shows that gender of the household head is significantly dependent on having at least one migrant in the family. Residual analysis show that female household heads are significantly over-represented in households with migrants.

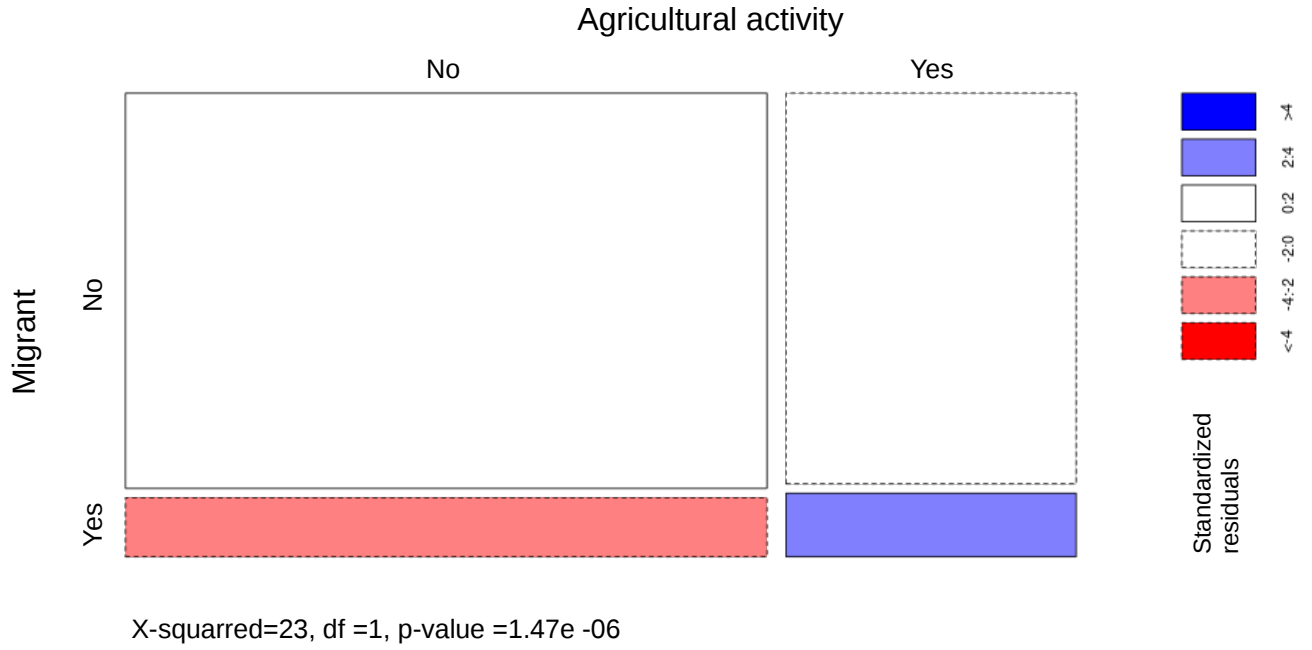

fig. 7: Migrant and agricultural activity, INEC 2010

In the figure 7, we can observe the low proportion of households with at least one "official" farmer in the household. There is a significant dependence between the variables "at least one migrant" and "no any member is a farmer" The residuals indicate that having at least one migrant is negatively related to having at least one farmer at the household. However, the "strength" of this link appears relatively low even if it is significant.

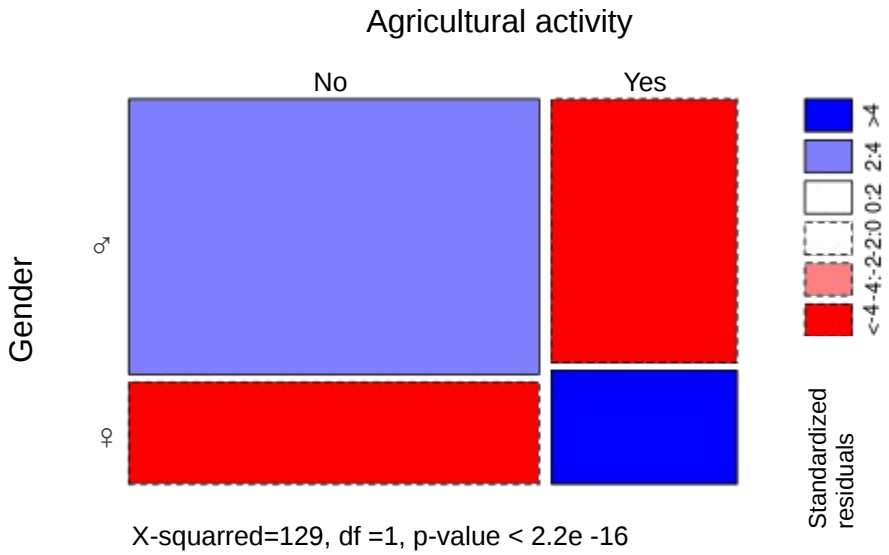

fig. 8: Agricultural activity and gender of the head household, INEC 2010

The mosaic plot shows (fig. 8) that in general households headed by women are more significantly in contact with agricultural activities.

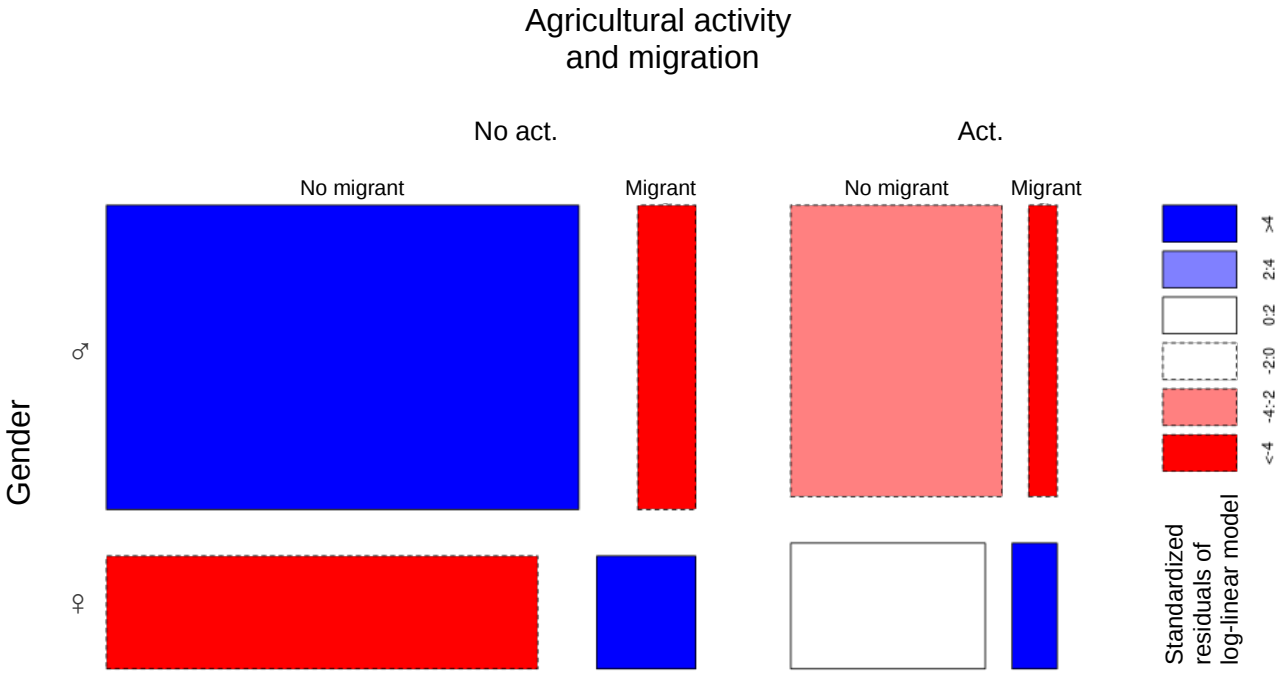

fig. 9: Gender of the head household, migration and agricultural act., INEC 2010

This analysis of residuals was performed using three variables simultaneously: migration, gender of household head and links to agriculture. We observed the following relations. Households with a male head, with no farmers and with no migrants are significantly over-represented, while households with a female head, no engaged in agricultural practices, and no migrants are under-represented. On the other hand, households with a female head , no practicing agriculture, but with a migrant is significantly over-represented as the group of households with a female head, engaged in agriculture and having at least one migrant. This mosaic plot reveals that in general terms households headed by women are significantly more engaged with agricultural activities.

Hypothesis 2

Table 4 Household' sources of energy, INEC 2010 (provinces of Azuay and Cañar) and remittances

	Pearson residuals						χ^2
	Elect.	**Gas**	**Wood**	**No kitchen**	**Gasol. kerex or diesel**	**Waste veget. /animal**	
Remittance	0.40	7.28	-19.98	-8.54	-0.19	-0.49	660***
No remittance	-0.20	-3.67	10.08	4.31	0.1	0.025	

df = 6, p-value < 2.2e-16

The chi-square analysis (fig. 4) on the sources of domestic energy depending on whether the household has received remittances provide a significant dependence. Thus, households receiving remittance use less firewood. In addition they have their own kitchen and a greater tendency to use gas as household energy source.

Table 5 Households' sources of drinking water, INEC 2010 (provinces of Azuay and Cañar) and remittances

	Pearson residuals					χ^2
	Car	**Wells**	**Public networks**	**Channels**	**Rainwater**	
Remittance	-1.99	-15.86	7.21	2.29	-13.01	608***
No remittance	1.0	8.0	-3.7	-1.2	6.6	

df = 4, p-value < 2.2e-16

Households receiving remittances use significantly less wells and rainwater than households not receiving any remittance (table 5). Actually, these no-remittances households use significantly more water from public networks and public channels.

3-Paute survey 2011

Diversification

Table 6 Households' diversifications, 3-Paute

Diversification in	**Withe migrant**	**Withe no migrant**	**P-value (W.t-test**	**Conclusion (α=0,05)**
Domestic energies	M=0.26	M=0.24	0.46	H0=V
Incomes	M=0.43	M=0.37	1.00e-03	H0=X
Origins of starches	M=0.26	M=0.15	4.00e-03	H0=X
Spatial origins of starches	M=0.04	M=0.01	0.01	H0=X

Diversification on sources of household energy is not significantly different between migrants and no-migrants households (table 6). On the other hand, households with migrants have a significantly higher diversification of income sources. These migrant households show also more diversity in the spatial origins of their carbohydrate sources (rice, maize, potato, etc.). The same conclusion was found for the household means applied to obtain it.

Table 7 Use of chemical fertilizers, (3-Paute)

	Pearson residuals		χ^2
	Use chem. ferti.	No chem. ferti.	
Migrant	1.98	-0.39	3.9**
No migrant	-0.68	0.32	
			df = 1, p-value = 0.046

Given that all surveyed households practice at least one agricultural production activity (cropping and/or livestock) the applied test (Pearson residuals) covers all surveyed households. Results in table 7 shows a greater use of chemical fertilizers (secondary products made from oil or gas) for households with migrants.

Table 8 Use of agricultural mechanization , (3-Paute survey)

	Pearson residuals		χ^2
	Use mecanisation	**No mecanisation**	
Migrant	1.75	-0.90	4.0*
No migrant	-0.88	0.45	
			df = 1, p-value = 0.05

Households with migrants have greater use of mechanization for land preparation than no-migrants households (table 8).

Table 9 Land tenure (ha), 3-Paute data, Welsh's t-test (alpha=0.10)

	Migrants	**No migrants**	**p-value**	Conclusion
Culture	M=2.01 ha	M=0.55 ha	0.34	**H0 accepted**
Elevage	M=2.49 ha	M=0.76 ha	0.07	**H0 rejected**
Total	M=2.47 ha	M=0.89 ha	0.057	**H0 rejected**

Results in table 9 propose that households with migrants have significantly more land devoted to farming, while they are no significant for cropping. .

Table 10 Ecological awareness score, 3-Paute survey (alpha=0.10)

	With migrant	**With no migrant**	**p-value**	Conclusions
Ecological awareness score	M=4.0	M=3.6	0.19	**H0 accepeted**

For the scores of the "awareness of environmental issues, the table 10 shows that there is no difference between migrant households and no migrant households.

Table 11 Mondial-scale ecological awareness score, 3-Paute data (alpha=0.10)

	With migrant	**Without migrant**	**p-value**	Conclusions
Ecological awareness score	M=0.6	M=0.49	0.1	**H0 accepeted**

For the scores of the "awareness of the global environmental issues", the table 10 shows that there is no difference between migrant households and no migrant households.

Table 12 Mondial-scale ecological awareness score, 3-Paute data

	p-value	Conclusion
Wilcoxon-test	0.04	**H0 rejected**

Table 12 shows that awareness of environmental issues at the global scale differ significantly between migrant and no-migrant households.

Table 13 Households' diversifications, 3-Paute

	With migrant	With no migrant	P-value (t-test W)
Envi. Perception	M=0,60	M=0,56	0,34
Social network	M=0,48	M=0,35	4,70E-005

We observe in table 13 that diversification of the households' perceptions on environmental issues do not differ between migrant and no-migrant households. On the other hand, households with migrants are integrated in more local community and/or parish social and/or productive networks (water boards, agricultural organizations, etc.).

Discussion and conclusion

Life-style differences

For **hypothesis 1**, we expect that the departure of a migrant, mostly a young male, may decreases the available household workforce. . Thus, a decrease in the consumption of local ecosystems services such as wood and water and a low pressure on local land (e.g. abandonment of less-fertile plots or agricultural practices change) were expected too.

The hypothesis of a less local and less demanding in terms of labor can be maintained for consumption of our results. The use of firewood and wells water actually seems lower in households with migrants. The explanation, however, is not trivial. The main factor may simply be the general higher households living standards of migrant families that can be explained either by the received remittances or by the selection made by the cost of a migration that would be affordable only to households with a minimum of financial means.

With regards to agricultural practices, contradictory outcomes occur between census (INEC, 2010) and 3Paute data (2011). According to census results, migrant households with at least one member "officially" working in the farming activities occur very seldom, since only a quarter of total households practice agriculture, which is in contradiction to the 3-Paute results. This demonstrate that all surveyed households maintain at least a minimum agricultural production. Such difference may be explained by the "official" nature and definition of “working farmers” required by the INEC census (INEC, 2010) that perhaps have been induced an underestimation on its final results.

The 3-Paute survey (Vanegas et al., 2011) shows that households with migrants hold more agricultural land than their counterparts with no migrants. . On the other hand, it is interesting to mention that pastures are over-represented among households with migrants. When household were inquired (in such an informal way) about pasture, some families replied that locating cattle into extensive pasturage maintain and enhance the plots that are no longer cultivated. Moreover, such activity is not labor demanding. This confirms that rural households with migrants tend to simplify their farming practices, which does not include to interrupt such activities. Such results are confirmed by Jokisch (2002). This author proposes that, with the migration, when the wife became the household head, agriculture has been simplified. But, such activity has been also maintained as a household livelihood strategy for facing possible future risks. In a rural town near Cuenca (Azuay), Rebai (2012) has also highlighted the transformation of cultures to pastures thanks to migration.

Hypothesis 1 also imply a greater proportion of male migrants that should lead in turn to a greater proportion of household with female heads. We do find this trend in the census INEC data (2010). In general terms and according to this census data, households headed by woman used to practice agriculture in a highly significant way. Considering residual analysis, and by adding the variable "migration", such analysis propose two conclusions: households with female heads and migrants are found over-represented in families both engaged as well as not engaged in agriculture.. Here the simple fact that the variable "with at least one migrant" is expected to provide to the corresponding subgroups such over-representation, and thus a higher Pearson residual value in turn. It can be then argued that having a migrant in a household is positively related to agricultural activities, mainly in households headed by woman.

For the **hypothesis 2,** we suggest that increasing the household income, thanks to direct and/or indirect benefits of remittances, will induce: i) a lower consumption of local environmental resources, ii) a higher dependence on remote ecological goods (and thus a greater dependence on a more globalized system in turn) by changes on the household life-style and higher diversification.

We found out essentially similar results comparing to results on energy and water consumption among households that have migrants and that have received remittance at least once a year, which is consistent with our hypothesis. However, we can not determine in a more precisely way, the role played only by remittances (c*eteris paribus*) in this type of consumption.

3-Paute data provides the monthly amount of each type of energy consumed at household level. The tests were mostly applied on the diversification of these energy sources. It appears that households with migrants do not significantly diversify their energy sources than their migrants counterparts. The averages on diversification for both groups are about 0.4, which means that there is no a dominant source of household energy used, but several. During informal discussions with local farmers, they admit to use firewood for preparing some specific food (maize and beans mainly, because they are time-consuming cooking food) and sometimes even in a daily basis. This may help to explain the reason why even most households have gas stoves, they continue consuming firewood anyway. Households consuming only firewood must be the minority in the three study areas selected for the 3-Paute survey.

Regarding food consumption, we found that households with migrants show higher diversification of carbohydrates (starch) than the no migrant households. Higher diversification of planted species and higher proportion of purchased

food (from outside producers and supermarkets) have contributed to this result. Similarly, the spatial diversification of production sources of such carbohydrate sources is significantly higher among households with migrants than no migrants families. These two results can be explained by the increase of household purchasing (seeds and/or products from market), which has been possible thanks to the received remittances. The alternative hypothesis states that households with migrants would have a greater risk aversion and a "natural" tendency to search for economic diversification: income from migration, and more food sources through the development of more planted varieties. The last hypothesis does not explain as well as than the "remittance hypothesis" the consumption of foods from other parishes and / or purchased in the supermarket.

Agricultural practices seem to differ between migrant and no migrant households. . In addition to the mentioned observation concerning the higher importance given to livestock, it is important to mention the higher application of modern agricultural techniques: chemical fertilizers and mechanization. Again, the assumption that remittances can increase agricultural investment can be kept. However, these costs may be allowed by the higer economic level of households. The link with the migration that we perceive here can be explained by the ability of these households to pay the migration to one of its members. However, we believe that migration are accessible for numerous social classes. Many loan schemes or wear have been established in andinnes communities.

Result concerning the higher diversification of income sources among households with migrants confirm the findings of some authors (Durand et al., 1996) proposing that remittances induce multiplier effects on the household income resulting in higher economic diversification in turn. Here, some factors such as simplification of agricultural practices (relieving some free time to household in turn), the greatest opportunity to assume training and/or moving costs to urban centers help to explain such dynamics on higher diversification. Another explanation could be given by the difference existing between a households headed by a man comparing to those headed by women. Women should focus more on household security by diversifying the household income sources, as well as given more importance to the formal education of children.

For the **hypothesis 3**, thanks to knowledge, skills and ideas (social remittances) transferred by the migrant to the other households members, we expect among the left-behinds, different levels of environmental awareness as well as different household attitudes regarding the adoption of environmentally-safer practices (e.g. soil protection and management techniques).

Thanks to some data on environmental issues collected before the 3-Paute survey, we tested whenever the heads of migrant households are more sensible to local, regional, and/or global environmental issues. In this regard, results show no differences in the diversification of environmental awareness between migrant and no-migrant households. Conversely, we found a significantly different environmental awareness between these two household heads (migrant vs. no migrant families) for the so-called "global" issues. However, the applied test was the non-parametric Wilcoxon, which is therefore less robust and does not provide the possibility of means comparison. Therefore, we can not state whether households with migrants are more (or less) sensitive than households with no-migrants to “global” environmental issues. The t-test provides a p-value equal to 0.1. If we agree to take 10% of the risk for no accepting the similarity of the average values, we obtain higher scores for households with migrants. We can explain it by a greater openness to the world related to the ideas transmitted by the migrant. An alternative hypothesis would be that the level of interest on “global” environmental issues is eventually higher on households likely to send their members abroad.

The knowledge, ideas and skills can be transmitted trough the local networks. We tested whether households with migrants were no longer part of the different local communitarian and/or parish organizations (farmers, water boards, training, commercialization, etc.). Results show that local networks are more diversified in families with migrants than in those with no migrants. Considering that such networks surely require time, money and commitment, it is expected then that those wealthy migrant households receiving remittances would be more willing and they would have more possibilities to join them. As alternative explanation we consider the most enterprising and dynamic "nature" of migrant households that could be inducing higher household participation on such local and/or parish organizations. An additional explanation is that households enrolled in such local organizations would find some benefits in a relatively easier way (i.e.,financial, networking migration, etc.) that will promote and help to accomplish an out-migration of one of their household members.

Migration and the socio-ecosystemic resilience of household

This research highlight the differences in practices and lifestyles that exist between households with migrant and those with no-migrant. These differences can be evaluated as a gain or loss of household resilience.

The main characteristics of rural households with migrants can be summarized as follow : i) higher use of non-local goods, ii) larger land surface (comparing to average households) allocated to agriculture, iii) larger share of land allocated to livestock, iv) greater use of mechanization and chemical fertilizers, v) higher participation in local organizations and networks, and vi) greater diversification of carbohydrates sources.

For simplifying the analysis, we summarize into two principles the conditions that we believe allow any entity to be resilient, as a consequence of its interaction with the systems in which it fits:

1. 1. To avoid any kind of dependence (system, resource, another entity, a single spatial scale, etc.).
2. 2. To focus on systems and processes visible ones, and which the entity has the ability to act.[6]

The use of non-locals resources (water and energy) can not be considered as unfavorable to household's resilience. Rural households do not appear, in our view, to depend exclusively on these two resources. In instead, rural villages diversify to alternative water and firewood sources.

The maintaining or the development of agriculture coupled with the diversification of household economic activities appear as a great gain of resilience. Carbohydrate products are more diversified. Such households are able to keep the ability to "feel" the changes on this kind of micro-ecosystems and should be able to adapt their farming practices consequently.

The diversification of carbohydrates sources, probably induced by the diversification of household income as well as the contribution of remittances confirms the resilience gain related to migration. In addition, the diversification of local organizations and networks enhance the household diversity and modularity. Spreading information on local issues will be achieved faster. Local knowledge will probably be better shared and the household adaptive capacity will increase. The trap of social networks too dense and closed in on itself - which is detrimental to resilience (Schouten et al, 2012.). This will be avoided if the networks are well differentiated and the households are able to meet groups of different people.

Negative resilience gains are located in the use of fertilizers, the use of mechanization, and the possible future standardization of the agricultural model (pastures as dominant land use). The establishment of an agriculture dependent on a too globalized system can be considered as risky, especially if the other household incomes are also dependent on a more integrated and intensive fossil fuel system.

In case of global shock, backtracking can also be more difficult if the household uses hybrid “F1” varieties. Questions about the use of this type of seeds are missing in the two field surveys. However, the diversification of planted species as well as the use of nitrogen fertilizers could be a sign of the use of such seeds. . The risk of using these seeds would be their widespread among households strengthening their dependence on fossil fuels based products, diminishing the natural genetic diversity, and inducing rural households to become permanently dependent of such seeds as well as their associated products.

Limitations of research

This research is based on a holistic approach in detriment of a more analytical focus . This results in an overall vision through which trends have been outlined but more work could be done to deepen each of the points raised in order to qualify better.

In this work, the evaluation of resilience is performed on the basis of factors from the literature. This allowed us to study any entity not necessarily under real shock or collapse. The no validation of this research in case of real shocks may be limiting our results.

[6] These two statements comply with the characteristics of a resilient system. The modularity is achieved by focusing on near and perceptible systems. In fact, being mostly in interaction with such systems increases their chances to continue to function in the case of global impact. Interact with them first increases the possibility of knowing better and strengthen them. In addition, it has tight feedbacks giving more likely to interpret the emerging problems and act accordingly. Diversity is achieved by avoiding any dependency. This search should help to vary the critical interactions and promotes redundancies. Chasing the dependencies must also apply to "spatial scales" of the systems. An "entity" that dependent on a single area is dangerously linked to local shocks. In other words, we must find a balance between “multi-scale connectivity” and the necessity to stay “modular” and benefit tight feedbacks.

Unfortunately the three study areas of the 3-Paute survey have not been randomly selected. . Results are therefore not statistically representative of a larger area.

Results and outputs obtained from the 3-Paute database could perhaps be related to hidden variables linked in turn to the characteristics of these three areas. . Further deeper statistical analysis is required here.

The conclusions we draw on the benefits of migration do no take into account a possible exodus caused by the international migration. The rural exodus in our approach is considered as a reduction of resilience in favor of both a greater efficiency and a greater integration, in this case migration is considered to be negative for the household resilience.

Conclusions

To conclude, the study of ecological consequences of migration in the home country seems strongly important in the current debate on the international migration (GFMD, 2007). Yet, there is a real lack of empirical researches. Our study aims to contribute to a better understanding on this issue.

With this first part, we argue for real links between migration and left-behinds' life-style. These links appear in favor of a truly differentiation of left-behinds compared to households with no migrants, especially in terms of ecological relationships and more specifically on the ecological resilience: more diversity of sources of consumption, more connectivity (globalizing consumption), loss of modularity and therefore less resilience to shocks to the global scale. However, these encouraging results must be deepened to fully assess the benefits of migration on the ecological households resilience.

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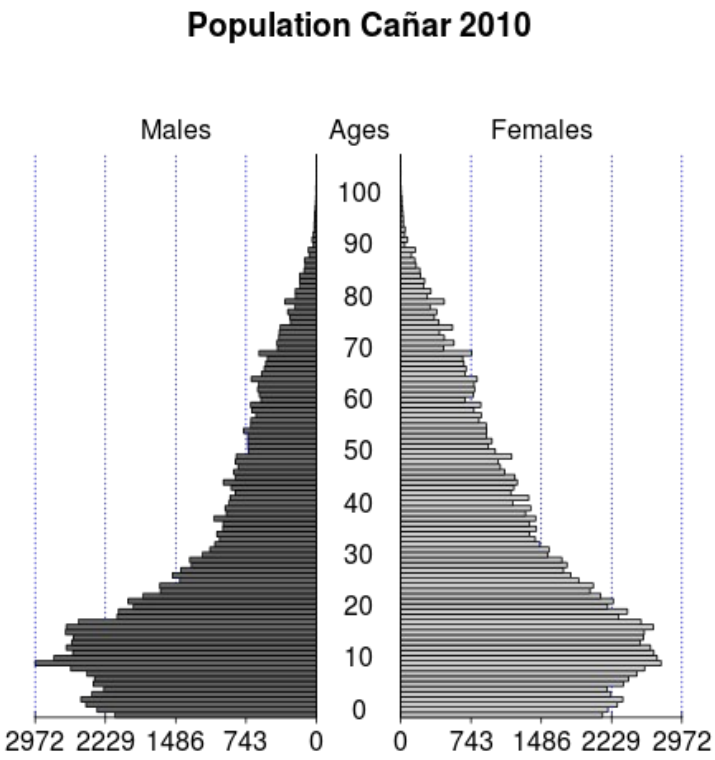
Annexe 1

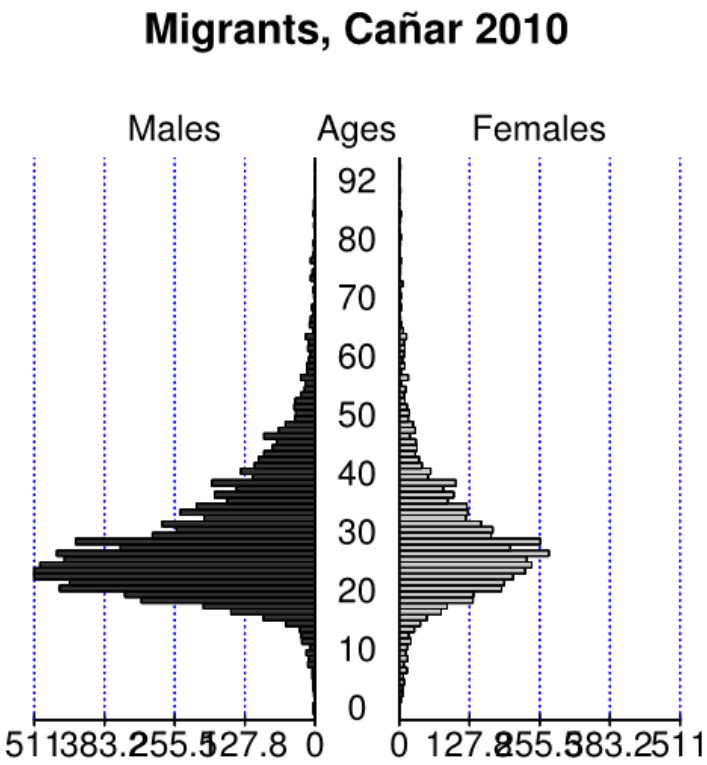
Descriptive Statistics, 3-Paute

		Zone 1	Zone 2	Zone 3	3-paute
Head of household (individual)	♀	14	22	8	44
	♂	59	64	59	182
	Σ	73	86	67	**226**
Population (individual)	♀	202	176	188	552
	♂	188	189	170	561
	Σ	390	365	358	**1113**
Active member (individual)	♀	102	112	93	272
	♂	92	88	92	307
	Σ	194	200	185	**579**
Agricultural activity (household)	Cattle	46	31	55	132
	No cattle	32	59	16	**107**
	Culture	68	86	68	222
	No culture	10	4	3	17
	No agricultural activity	8	4	2	14
School child/member (individual)	♀	36	32	42	110
	♂	48	28	48	124
	Σ	84	60	90	234

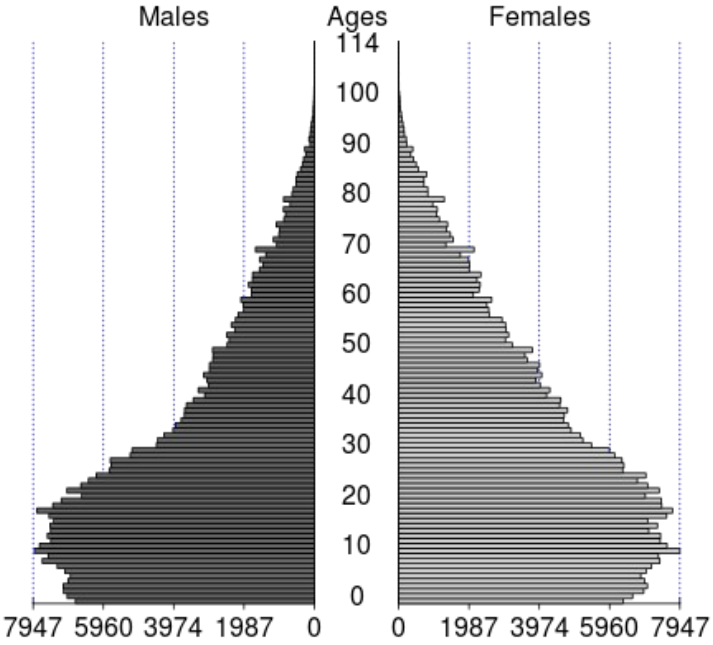
	Pichacay	Caldera	Llavircay	3-Paute
No migrant	57	49	54	**160**
Ecuador only	3	15	2	**20**
Spain only	4	4	1	**9**
Spain and Ecuador	0	1	0	**1**
USA only	14	15	11	**40**
USA and Ecuador	0	2	3	**5**
USA and Spain	0	4	0	**4**
Σ	**78**	**90**	**71**	**239**

Descriptive statistics, INEC (2010)





Population Azuay 2010



Migrants, Azuay 2010