Livelihood strategies of cacao producers in Ecuador: Effects of national policies to support cacao farmers and specialty cacao landraces

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Abstract

This study identifies the livelihood strategies pursued by small cacao farmers in the Guayas coastal region in Ecuador, where two distinct cacao varieties are grown: the fine flavor variety, Cacao Nacional (CN), and a hybrid variety (CCN-51). Enhancing CN production is regarded as an economic development strategy since CN variety beans are characterized by premium prices in international markets. This study aims to assess the trade-offs faced by small cacao producers in the production of specialty (CN) vs. commodity (CCN-51) cacao and how they affect their livelihoods. A detailed household survey sampled 188 households. Based on activity variables, four latent profiles of livelihood strategies were identified, which were related to capital asset endowment and income share variables. The results show that there was not a clear gap between cultivation of CN and CCN-51, as 60% of the sampled households simultaneously grew both varieties. The results indicate that the variable "share of land allocated to CN" does not significantly contribute to discriminating among profiles. Households with a low share of land allocated to CCN-51 showed higher income diversification strategies and vice versa. Our study also shows that the lack of appropriate incentives may threaten the future cultivation of CN since the National policy for CN rehabilitation has had little impact on the more cacao-driven profiles that have a lower asset endowment. The design, structuring and maintenance of a domestic differentiated value chain for the CN variety, together with income diversification measures and prior improvement on the asset endowment of these profiles, seems to be the pathway to improve the livelihoods of small farmers and increase the success of the current policy for fine flavor cacao rehabilitation at the national level.

Keywords: *rural livelihoods, three-step approach, latent profile analysis, specialized value chain, asset endowment*.

1. Introduction

Cacao is the world's third most important agricultural export commodity and the second most important cash crop in the tropics (T. Blare & Useche, 2013; Galarza, 2012). It is estimated that more than 80% of cacao is produced by 7 to 8 million small family-managed cacao farms in over 50 countries worldwide (ECLAC et al., 2015).

The world cacao market distinguishes between two broad categories of cacao beans. Fine flavor cacao beans represent 5% to 10% of the total world market and can be sold for a premium because of their outstanding characteristics (Galarza, 2012; Melo & Hollader, 2013; ICCO, 2006). International demand for fine flavor cacao outweighs supplies, creating a potential attractive niche for its chain development at the national level, if certain additional incentives such as a price premium are appropriately distributed to all actors along the chain (Blare & Useche, 2013; ICCO, 2012).

Ecuador plays a major role in the world cacao market in terms of volume and quality, as it is the largest producer of fine flavor cacao, producing approximately 65% of the global supply (Blare & Useche, 2013; Squicciani & Swinnen, 2016; WFC, 2013). The fine cacao variety in Ecuador, known locally as cacao Nacional (CN), is grown in polyculture systems with other trees that produce timber and fruits and with other crops such as maize or soybeans. The modern hybrid CCN-51 is a full-sun variety that may double the productivity of its CN counterpart at the expense of being more demanding in the use of inputs (fertilizers or herbicides), among other key differences (Astudillo Paredes, 2014; Blare & Useche, 2013; Franzen & Mulder, 2007; MAGAP, 2013; Ton et al., 2008). In the national Ecuadorian market, small farmers are paid the same price for both varieties. Since the small farmers do not perceive price premiums for CN, it is common that they combine both varieties (MAGAP, 2013).

The Ecuadorian cacao small farmers develop their activities in a general context characterized by low productivity, high concentration of assets and vulnerability of markets[1] (SENPLADES, 2017). Sectoral constraints include a lack of adequate grades and standards throughout the marketing chain, difficulties in accessing basic and extension services, inefficient articulation among authorities and support organizations with productive actors, aging trees with low productivity and resistance to disease and pests (Astudillo Paredes, 2014; Blare & Useche, 2013; Kooij, 2013; Lehmann & Springer-Heinze, 2014).

Linking small farmers to higher-value markets has been perceived by governments, donors and NGOs as a way to reduce poverty among these vulnerable populations, either directly through increased incomes or employment or indirectly through spillover effects in local economies (Horton et al., 2016; UNIDO, 2011). Enhancing CN production is viewed as an economic development strategy (CORPEI-BID, 2009) that may contribute to alleviating poverty in rural communities, which reached 38.2% in Ecuador (INEC, 2016). Since 2009, the Ecuadorian government, along with local and international development organizations, has implemented the Project on Restoring CN cultivation (PRCN, hereafter). The assumption underpinning the design of this program is that protecting the quality of the CN variety and strengthening the linkages between producers, buyers and processors in local and international higher-value markets will lead to improvement of the living conditions of cacao producers. PRCN can be viewed as value chain development (VCD) to target poor and vulnerable populations upstream in the value chain and reduce poverty (Horton et al., 2016). However, these strategies have been criticized for the underlying assumption that the small holders to whom these policies are addressed do not face substantial trade-offs when using their resources to participate in these chains (Stoian et al., 2012; Ton et al., 2011).

This study intends to cover a research gap on the trade-offs faced by small cacao farmers in Ecuador in the production of specialty (CN) vs. commodity (CCN-51) cacao and how these

[1] Rural poverty by income is 38.2% whereas the multidimensional poverty rate is 59.9% and the rate of adequate employment is only 27.85% of the population (SENPLADES, 2017).

impact on their livelihoods. This overall aim is focused on two specific objectives. First, to determine the factors associated with the choice of livelihood strategies of small farmers in Ecuador linked to the cultivation of two varieties of cacao, CN and CCN-51, which have significantly different economic, social and environmental impacts. Second, to investigate the influences of the PRCN on the livelihoods of small farmers, including their capital asset endowments, activities, income shares and livelihood strategies. For this purpose, a detailed household survey was applied in nine cacao-producing villages in the Guayas, the largest cacao-producing province in Ecuador.

This study adopts the sustainable rural livelihoods and household livelihood strategy frameworks (Carney, 1999; Scoones, 1998; Jansen et al., 2006, Nielsen et al., 2013). Many studies have adopted these frameworks to determine the livelihood strategies rural farmers engage in to earn a living (outputs) and their relation with external variables such as capitals assets (inputs) or income (outcomes) (e.g., Alemayehu et al., 2018; Alemu, 2012; Browder et al., 2004; Brown et al., 2006; Fang et al., 2014; Hua et al., 2017; Jansen et al., 2006; Pichon, 1997; Walelign et al., 2016 Bebbington, 1999; Bhandari, 2013;).

Most of these studies determine the livelihood strategies of the sampled population (through principal component analysis, latent cluster analysis, or latent Markov cluster analysis). Then, different regression models are adopted (e.g., multinomial logit or ordinary least square models) to determine the relation of these strategies with external variables (Nguyen et al., 2015; Nielsen et al., 2013; Walelign & Jiao, 2017; Walelign et al., 2016). However, to our knowledge, an integrated assessment of strategies and external variables has not been performed.

This study applies a novel variant of latent class analysis (LCA) known as improved three-step that allows for identification of groups or profiles in a population based on a set of observed variables and implicitly acknowledges that these profiles may relate to external variables (Bakk et al., 2013; Vermunt, 2010). LCA uses a probability-based classification, making it advantageous over traditional clustering techniques (Magidson & Vermunt, 2002). The three-step approach of LCA incorporates a correction procedure that avoids the downward-biased estimates of the

strength of the relationships between the profiles and external variables that may arise when these relationships are estimated simultaneously with the model identifying the latent variable (one-step) or separately (three-step method without correction) (Bolck et al., 2004; Vermunt, 2010). This statistical approach also allows for analyzing the relationship between livelihood strategies, capital assets and incomes in a robust manner, more consistently aligned with the household livelihood strategy framework. To our knowledge, this approach has not been applied in the assessment of livelihood strategies.

2. Theoretical framework: sustainable rural livelihoods and household livelihood strategy

Drawing on the work of Walelign & Jiao (2017), this study is theoretically grounded in the conceptual frameworks of sustainable rural livelihoods (SRL) (Ellis, 2000; Scoones, 1998; 2015) and household livelihood strategy (HLS) (Jansen et al., 2006; Nielsen et al., 2013). The SRL describes the basis for livelihood analysis and the HLS elaborates upon the SRL and enables examination of the relationships between the different elements of the SRL framework to determine the different livelihood strategies that households undertake to earn a living.

The SRL framework defines a sustainable livelihood as one that comprises the capabilities, assets (including material and social resources) and activities required for a means of living (R Chambers & Conway, 1992). A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets while not undermining the natural resource base (Chambers & Conway, 1992, p. 5; Scoones, 1998, p. 6).

The SRL framework (Carney, 1999; Scoones, 1998) links livelihood resources (designated here by the term capital assets) and outputs (livelihood strategies) to outcomes (e.g., income generated, wellbeing) (Scoones, 2009). Agricultural intensification (more output per unit area through capital investment or increases in labor inputs), agricultural extensification (more land under cultivation), livelihood diversification (diversifying to a range of off-farm income earning activities) and migration (seeking a livelihood elsewhere, either temporarily or permanently) are some of the broad strategies that rural households pursue to make their living (Scoones, 1998).

These input-output-outcome elements identified by the SRL framework are amenable to quantitative analysis of the livelihood strategies of rural households (I Scoones, 2009). The HLS framework quantifies livelihood strategies based on the portfolio of main activities that rural households undertake depending on the available assets (Babulo et al., 2008; Jansen et al., 2006; Nielsen et al., 2013; Winters et al., 2009). The strategies are directly and indirectly influenced by capital assets and the relevant contextual factors that generate specific outcomes such as income.

Households in both frameworks constitute the basic unit of analysis (Ellis, 2000; Winters et al., 2009; Nielsen et al., 2013; Walelign & Jiao, 2017) in which three closely connected components are assessed: activity variables, capital assets and outcomes. The latter two largely draw on the SRL framework and the definition of activity variables and the modeling approach adopted in this work align with the HLS framework. The variables are described in more detail below and are depicted in Figure 1

2.1 Activity variables

Activities are actions taken by the households to produce outcomes, which involve the use of a single asset or set of assets (Winters et al., 2009). Assessing the proportions of assets allocated by rural households to different income-generating activities is used as a grouping criteria so that households with similar asset allocation choices are grouped together in a livelihood strategy profile (Jansen et al., 2006; Nielsen et al., 2013; Hua et al., 2017; Brown et al., 2006; van den Berg, 2010).

By using activity choices as criteria for livelihood strategy identification, the HLS framework circumvents some drawbacks related to the use of other grouping criteria. Many studies identified livelihood strategy groups based on absolute income or the share of income generated by different livelihood activities (Chilongo, 2014; Tesfaye et al., 2011; Walelign & Jiao, 2017; Zenteno et al., 2103). However, this approach neglects that income per se is stochastic and does not reflect the amount of assets households have invested in different activities (van den Berg, 2010; Walelign & Jiao, 2017). For example, income shares from a particular year reflect a household's short-term coping mechanisms rather than a long-term livelihood strategy (Jansen et al., 2006). Occupation-

grouping criteria has a key downside, since it generally overlooks the fact that rural households, especially in developing countries, engage in a diverse range of activities (Davis et al., 2010; Walelign, 2016). Finally, the asset grouping-criteria may neglect that households combine assets to generate income from a portfolio of activities (Brown et al., 2006; van den Berg, 2010).

The activity choice criteria applied in this study considers the household's use of its main assets, i.e., land and labor (Jansen et al., 2006). We also included remittances to acknowledge one of the main criticisms of activity choice as a grouping criterion, since activities from nonproductive assets often play a key role in livelihood strategy selection in developing countries (Nielsen et al., 2013; Walelign et al., 2016). A more detailed description of the activity variables used in this study is presented in section 3.2.

2.2 Capital assets

Capital assets may be seen as the building blocks for a household to choose its livelihood strategy (Ellis, 2000; Brown et al., 2006; Nguyen et al., 2015) and from which different productive streams are derived. These assets are tangible (resources and stores) or intangible (claims and access) and are commonly considered as composed of five types of capital: natural, human, social, financial, and physical.

Natural capital includes all natural resource stocks and environmental services from which livelihoods are derived, including the central variables of access to farmland and its ownership. Physical capital includes the basic infrastructure and producer goods that are essential to support livelihoods (Bebbington, 1999; Bhandari, 2013; DFID, 1999). Infrastructural assets, such as roads, or production assets, such as vehicles or equipment that foster diversification of rural livelihoods (Amekawa, 2011; Ellis, 2000; Rakodi, 1999) are physical capital. Human capital comprises the amount and quality of labor available, skills, knowledge and health that enable individuals or households to pursue different livelihood strategies (DFID, 1999). Financial capital includes the stock of money available for households in the form of savings, credit, remittances, and pensions (Amekawa, 2011; Carney, 1998). Social capital arises from social relationships and describes the stock of reciprocity and trust embedded in the relations of individuals and

households with other actors and entities such as family, relatives, friends, organizations, and networks (Amekawa, 2011). It plays an important role in mediating people' s access to and utilization of other assets (Bebbington, 1999) and has recently been recognized as a significant component in understanding agricultural value chains (Abbey et al., 2016).

In our study, these assets are mainly used to determine how varying capital assets influence livelihood strategies and evaluate the impact of PRCN policy on structuring the smaller producers` asset endowment and enabling their decisions toward adoption of the CN cacao variety.

2.3 Outcome variables (income shares)

The livelihood strategies pursued by households intend to achieve outcomes such as income, increased well-being, improved food security or social claims (Amekawa, 2011). Among these, income is the most commonly assessed outcome variable, partly because it is relatively straightforward to measure in absolute and relative terms (Jansen et al., 2006). Income is often perceived as a welfare gauge (Barrett et al., 2001), although some authors are reluctant to consider it as an outcome given the multidimensional nature of wellbeing (Alkire & Foster, 2011; Chambers, 1995; Ellis & Freeman, 2005). Household income analysis should include the values per income source (Walelign, 2016) for example, distinguishing between on-farm and off-farm income is crucial since the latter generally eases capital constraints and may contribute to higher farm production and income (Babatunde & Qaim, 2010; Chang & Mishra, 2008).

In this study, the share of different income sources was assessed to determine the income mix of each livelihood strategy. It allowed for analysis of the degree of income source diversification of the livelihood strategies linked to varying cultivation intensities of the two cacao varieties. The relationship between the capital asset endowments that characterize less diversified strategies is also considered to suggest appropriate targets of intervention.

2.4 Relationship between concepts

Livelihood activities link the capital assets to the ex post flow of income (Fig 1) and are subject to the endowment of livelihood capitals because they determine the possibilities for rural households to achieve goals related to revenue, safety, and welfare (Fang et al., 2014; van den Berg, 2010). Depending on their contexts, households harness the assets at their disposal in pursuit of livelihood strategies with a goal of maximizing livelihood outcomes (Amekawa, 2011; Nicol, 2000; Scoones, 1998) (Brown et al., 2006; Fang et al., 2014). Livelihood activities geared toward market or subsistence and a particular asset mix allow for smallholder households to take advantage of new market opportunities and institutional constellations to respond to shocks, adverse trends and seasonality (Scoones, 2009; Sheck et al., 2013).

Identifying what combination of livelihood assets is required for different livelihood strategy combinations is a key step in the analysis process. For example, successful agricultural intensification may combine access to natural capital (e.g., land, water) with economic capital (e.g., technology, credit) whereas, in other situations, social capital (e.g., labor sharing arrangements) may be more significant (Scoones, 1998).

Operationalization of these concepts in the HLS framework is based on identification of groups of livelihood strategies based on activity variables; these strategies are first described based on the capital assets of the households (e.g., Jansen et al., 2006; Nielsen et al., 2013; van den Berg, 2010) and act as predictors of income shares. The three-step approach adopted in this study allows for addressing the relationship of the livelihood strategy profiles with external variables (capital assets and income shares) in a robust manner.

3. Case study description

Ecuador's cacao is produced almost exclusively by small farmers, for whom it represents a key source of income (Astudillo Paredes, 2014; Blare & Useche, 2014).

Fine cacao is the source of high-end chocolate manufacturing. Its production is scarce (5% of the world's cacao production) and it may obtain premiums of 30% (and even 60%) over ordinary

cacao beans in international markets (Blare and Useche, 2013; ICCO, 2012). Ecuador accounts for almost half of the world's production of this variety (ICCO, 2006).

Fine cacao is exclusively harvested from cacao Nacional (CN) trees (Melo & Hollander, 2013). The CN variety is considered part of the Ecuadorian identity (Kooij, 2013). It is typically produced in a shade-cultivation system (Bentley et al., 2004; Melo & Hollander, 2013) together with other tree crops that provide shade and, more importantly, products such as wood (e.g., laurel tree) or fruits such as mango, guayaba, citrus, plantain, or papaya (Coq-Huelva et al., 2018; Ofori-Bah & Asafu-Adjaye, 2011). This complex of trees provides habitat for diverse fauna, contributing to meeting the consumption needs of small rural farmers.

The shade production of cacao has been progressively substituted by the full-sun variety CCN-51 accounted for 48% of plantings during early 2000s (Bentley et al., 2004; Ruf, 2011). CCN-51 is said to be the most productive variety of cacao worldwide, with a production potential of approximately 77 kg/ha. The production approach for CCN-51 is based on monoculture with high plantation densities. Its yields may reach almost four times those of CN (Galarza, 2012) and it is resistant to fungal diseases (Espinosa et al., 2006). However, this usually comes at the expense of increased use of fertilizers and herbicides (Clay, 2004), without which, productivity may decrease to 12-15 kg/ha with respect to the potential production (MAGAP, 2013). The productivity of both varieties can oscillate greatly depending on crop management. The survey conducted by Jano (2007) showed that farmers cultivating CCN-51 spent on average 77% more on pesticide applications and labor than farmers cultivating CN[2]. The CN production potential in the study region may reach 33 kg/ha and, with adequate management productivity, may reach an estimated 40 kg/ha (MAGAP, 2013). Accordingly, management costs per hectare also greatly differ from $660/ha for CN to $820/ha for CCN-51. Even if CCN-51 allows for obtaining more cash income

[2] However, in a more recent study conducted in northern Ecuador, Blare & Useche, 2013, estimated a difference of 19% in cultivation costs between both varieties, similar to the 24% estimate provided by MAGAP (2013)

than CN, in a season with low cacao harvest, households may face difficulty meeting their subsistence needs.

The distinctively lower quality of the hybrid CCN-51 does not qualify its beans for fine cacao production and hence it cannot be sold at premium prices in the international markets like CN, whose unique flavor and aroma make it the base of the finest chocolates worldwide (PROECUADOR, 2013). Therefore, each variety has been commercialized through different value chains in the international markets and have their own regulations and prices.

However, in the Ecuadorian national market, such differentiation is nonexistent and both varieties are sold in the same value chain. As a result, farmers receive the same remuneration for the two varieties, either at the farm gate or the local market. The national cacao value chain in Ecuador is rather long and exporters and intermediaries are the dominant actors that qualify quality, determine prices and establish market rules (Galarza, 2012; Jano, 2007; MAGAP, 2013; Useche & Blare, 2013).

The average price of cacao beans in the Ecuadorian national market, where both varieties are sold at the same price, was $107 in 2016 and $77.02 in 2017 (SINAGAP, 2018). This is one of reason small farmers shifted from CN to CCN-51, since they are not rewarded for their effort to produce quality cacao (B. T. Blare & Useche, 2014; Collinson & León, 2000). The production decisions of small farmers linked to specialty markets such as the CN market significantly depend on incentives (economic and noneconomic) that are transmitted along the value chain (Jano, 2007). Since these benefits are not being transmitted, partly due to the absence of a specialty value chain at the national level, only the farmer associations that have circumvented intermediaries and sold directly to exporters or exported directly have achieved better prices (Astudillo Paredes, 2014; Jano, 2007). However, this constitutes a minority of cases in the sector.

This lack of a price difference also represents an obstacle to avoiding the mixing of varieties that is currently a regular practice (MAGAP, 2013). Until 2004, intermediaries and exporters did not separate National from CCN-51 (Melo & Hollander, 2013). The lack of a monitoring system that enforced the homogenization of cacao quality or the segregation of different qualities (Jano &

Mainville, 2007) allowed for fine quality cacao manipulation. Thereby, some supply chain actors mixed bulk cacao beans with fine ones. The mixture was sold by intermediaries in the international markets as fine cacao to maximize their individual profits (Galarza, 2012). This mixing produced a reduction in quality and led to a downgrading of the Ecuadorian fine flavor cacao rating by the International Cacao Organization (ICCO) from 100% to 75% since 1994. In 2005, possible future grading reductions were announced, motivating the involvement of the Ecuadorian state in the industry (see Melo and Hollander (2013) for a critique and description of the Ecuadorian cacao market). There is obviously a gap between the lack of differentiation in the local market and the efforts the country is making to overcome sanctions and promote fine cacao from Ecuador in international markets (Jano, 2007). Furthermore, the increased cultivation of CCN-51 reduces the opportunities of Ecuador as a big international player in the fine cacao market, since the quality of CCN-51 is not suitable for high-end chocolate manufacturing.

The Ecuadorian government, along with local and international development organizations, initiated a project for CN restoration in 2011, which includes links with other organizations advocating for CN as an economic development strategy to alleviate poverty in rural communities (CORPEI-BID, 2009). The PRCN policy aims to revitalize its production through the improvement of current CN plantations and establishment of new ones. The project actions initially tackled the production and the value chain at large, aiming to develop a specific value chain for CN that would establish the incentive of a premium price at the farm-gate level (Jano, 2007). The project implemented the creation of a germplasm bank, facilitated small farmers, provided technical and training assistance and strengthened farmers' associations. However, the full display of PRCN has been jeopardized by a lack of financing and governmental changes; in recent years, the focus has been on providing technical assistance while value chain development for CN has not been implemented.

Cacao production in Ecuador is primarily concentrated in the coastal-plain region, with 85% of the country's total production. The Guayas account for 26% of the national production and is the largest cacao producing region (INEC, 2015). This study was conducted in nine rural sites in two

districts of the Guayas, Lorenzo de Garaicoa and Yaguachi Viejo, which represent 10% of the Guayas cacao production. Table 1 summarizes the principal statistics of the two districts.

The study area belongs to the dry west woodland ecosystem, characterized by a tropical mega thermal climate with mild temperatures (25ºC – 30ºC) and abundant rainfall (2000 mm). CN and CCN-51 varieties at different cultivation intensities constitute the agricultural basis of these villages, complemented by other crops such as banana, sugar cane, soy, corn, tobacco and rice (GAD-Garaicoa, 2015; GAD-Yaguachi Viejo, 2015; INEC, 2015).

The government has implemented the PRCN program in these nine rural sites since 2012 to stimulate farmers to switch from the CCN-51 variety to the CN variety. The CN variety is now cultivated at different intensities without full withdrawal of the hybrid variety.

4. Material and Methods

4.1 Modeling approach: the improved three-step approach

Latent Class Analysis (LCA) was introduced by Lazarsfeld & Henry (1968) to derive latent attitude variables from responses to dichotomous survey items and was originally designed to be used with dichotomous observed variables or indicators. LCA allows for building typologies based on observed variables. The technique is helpful for researchers who seek to identify subgroups (i.e., latent classes) within large, heterogeneous populations (Tein et al., 2013). A review of the method and its evolution can be found in (Magidson & Vermunt, 2004).

Different from cluster analysis techniques, LCA is a model-based approach. This means that a statistical model is postulated for the population from which the data sample is obtained. An advantage of using a statistical model is that the choice of the cluster criterion is less arbitrary and the approach includes rigorous statistical tests for the selection of a model with optimal (livelihood) classes (Magidson & Vermunt, 2002).

LCA involving continuous variables is also termed a latent profile model (Gibson, 1959; Lazarsfeld & Henry, 1968), which is the focus of this study. Latent profile analysis (LPA) is a person-oriented analytic technique that identifies discrete profiles of individuals who share

similar response patterns across a set of indicator variables using probability-based classification (Collins & Lanza, 2010). Conceptually, it is similar to cluster analysis, but group membership is treated as latent rather than known and measurement error is allowed (Magidson & Vermunt, 2002).

Applications of LCA also investigate how the latent classes are related to external variables (Bakk et al, 2013). This is usually done in three steps: i) building a latent profile (LP) model for a set of response variables; ii) assigning individuals (households, in this study) to latent classes based on their livelihood profile membership probabilities and iii) investigating the association between the profile membership and external variables.

The improved three-step approach (Bakk et al., 2013; Bakk & Oberski, 2014; Bakk et al., 2016; Vermunt, 2010) adopted in this study allows for examining the association between latent profile groups and external variables, acknowledging the uncertainty of group membership (Lanza et al., 2013).

First step: Estimating a Latent Profile (LP) Model

Following Bakk & Oberski (2014), an LP model is estimated employing *K* observed indicator variables. Given a sample of *n* units, the vector of observations *Yi* is modeled as arising from *T* unobserved (latent) profiles *X*,

$$P(Yi) = \sum_{t=1}^{T} P(Xi = t)P(Yi|Xi = t) \quad (1)$$

P(Xi = t) represents the probability of belonging to profile *t* and *P(Yi|Xi = t)* the probability of having a response pattern *y* conditional on belonging to profile *t*.

The conditional probability of the i^{th} response given the latent profile can then be written as a product of conditional item responses, where Rk denotes the categories of responses to variable k,

$$P(Yi|Xi = t) = \prod_{k=1}^{K} P(Yik|Xi = t) = \prod_{k=1}^{K} \prod_{r=1}^{Rk} \pi_{ktr}^{I(Yik=r)} \quad (2)$$

The first-step log-likelihood of the sample data *L1* follows by assuming the independence of observations:

$$L_1(\theta_1) = \sum_{i=1}^{N} logP(Yi) = \sum_{i=1}^{N} log\left[\sum_{t=1}^{T} \rho_t \prod_{k=1}^{K} \prod_{r=1}^{R_k} \pi_{ktr}^{I(Y_{ik}=r)}\right] \quad (3)$$

Second step: calculating the profile membership of each unit

Following Bakk et al. (2016), after estimating the latent profile model in the first step, a new variable W is created, assigning each unit (household, in our study) to an estimated profile. Following Bayes rule, each unit's posterior probability of belonging to profile t is

$$P(Xi = t|Yi) = \frac{P(Xi = t)P(Yi|X = t)}{P(Yi)} \quad (4)$$

The true (*X*) and assigned (*W*) profile membership scores will differ. The classification errors must be calculated and the correction methods[3] for the assignment variable *W* are applied in the third step. The posterior profile membership conditional on the true value can be expressed as:

$$P(W = s|X = \mathrm{t}) = \frac{\frac{1}{N}\sum_{i=1}^{N} P(Xi = t|Yi)P(Wi = s|Yi)}{\mathrm{P(X = t)}} \quad (5)$$

Third Step: Relating Estimated Profile Membership to External Variables (Covariates and Distal Outcomes)

The third step of the approach relates the latent profiles to external variables. These act as predictors of the individual membership to the latent profiles, i.e., covariates. Alternatively, latent profiles can act as predictors of external variables, i.e., distal outcomes.

Following Bakk et al. (2016), the assigned classification *W* is related to a vector of covariates, *Z*, while also correcting for the classification error in *W*. *P(X= t|Zi)* and *P(W= s|Zi)* are related to each other, thus *P(W= s|Zi)* can be written as a weighted sum of the latent profiles given the covariates, with the classification error probabilities as the weights:

[3] For more details of correction methods applied, see Appendix A.

$$P(W = s|Zi) = \sum_{t=1}^{T} \mathrm{P(X = t|Zi)\ P\ (W = s|X = t)} \quad (6)$$

Z_{iq} denotes the value of subject *i* on one of the *Q* covariates and the structural part of the model can be parametrized by means of a multinomial logistic regression model,

$$P(X = t|Zi) = \frac{\exp(\beta_{0t} + \sum_{q=1}^{Q} \beta_{qt} Z_{iq})}{\sum_{s=1}^{T} \exp(\beta_{0t} + \sum_{q=1}^{Q} \beta_{qs} Z_{iq)}} \quad (7)$$

Below, we present the three-step model with external variables that are predictors of latent profile membership (Bakk et al., 2013). The parameters of interest are the logistic regression coefficients β_{qt}, gathered in the vector θ_3. Consistent estimates $\hat{\theta}_3$ can be obtained by maximizing the third-step log-likelihood (Vermunt, 2010),

$$L_3\left(\theta_3 \middle| \theta_2 = \hat{\theta}_2\right) = \sum_{n=1}^{N} \sum_{s=1}^{T} P(W = s|Yi) log \sum_{t=1}^{T} P(X = t|Zi) P(W = s|X = t) \quad (8)$$

4.2 Variables employed and their connection with the improved three-step approach

In this study, we identified three sets of variables: i) activity variables that measure the latent profiles, ii) capital asset variables (covariates) that predict household membership to the latent profiles of livelihood strategies and iii) income share variables (distal outcomes) that are predicted by the latent profiles. Once the entire sample is grouped into livelihood strategy groups based on activity variables, the membership of each of the sampled households to these groups or profiles can be explained based on a set of predetermined capital asset-based variables (Jansen et al. 2006) that encompass the five main types of capital. Finally, the income share of each profile is assessed, considering it as a distal outcome (i.e., predicted by the livelihood profiles).

Activity variables to identify the livelihood strategy profiles

Drawing on the SRL and HLS approaches, identification of livelihood strategies was based on eight activity variables. Five correspond to labor allocation and two variables refer to land allocation, which are the main productive assets that small farmers typically allocate into income-generating activities (Jansen et al., 2006; van den Berg, 2010). The transfer income variable

accounts for income generated from nonproductive assets. The activity variables are shown in Table 2.

In relation to labor, we considered the proportion of family labor allocation to on-farm and off-farm activities (agriculture and non-agriculture related), and the proportion of external workforce hired. Disentangling on-farm and off-farm work is highly relevant, since strategies that combine both tend to earn higher incomes (Jansen et al., 2006).We also identified temporary and permanent modalities of on-farm and off-farm employment.

We identified the share of land allocated to CN and CCN-51 varieties that form the agricultural basis of the farmers in the study to assess the influence of these crops in shaping livelihood strategies and determine whether the PRCN has influenced the livelihood of these households.

Capital asset variables as covariates to predict household membership to the livelihood strategy profiles

After identifying the livelihood profiles, we examine the association between capital asset variables and livelihood profile membership.

The five types of capital assets were measured considering a wide range of variables and some built-in indexes (Table 2). Natural capital was measured considering both access to and ownership of land (Jansen et al., 2006). Two built-in indexes were considered to address the physical capital dimension, in which higher values represent higher access and therefore more physical capital. The production index measured access to machinery, storing installations and transportation and the basic services index measured access to drinking water, health and education. Family size and the educational level of the head of the household were proxies employed to measure the human capital dimension. Financial capital was assessed through the households' savings and debts. Finally, social capital was measured considering membership in rural cooperatives.

The five types of capital variables are entered in the model as predictors (covariates) of household membership to each profile, allowing for determining the asset mixes that characterize the different livelihood strategies. This procedure is equivalent to using a multinomial logistic

regression model, except that the three-step approach estimates classification errors when assigning profile membership and then corrects them by maximum-likelihood adjustment before the regression is applied (Bakk et al., 2013; Bakk et al., 2016; Vermunt, 2010).

Income share variables as distal outcomes of livelihood profiles

A pilot questionnaire served to establish the household's main income sources over the past two years. In the final survey, farmers were requested to indicate the proportion of income from the following sources: on-farm activities, off-farm agricultural activities, off-farm non-agricultural activities and non-agricultural self-employment activities (Table 2).

We examined the association between income shares and livelihood profiles by employing the profiles as predictors of income shares (distal outcomes), acknowledging that income sources are outcomes rather than determinants of livelihood strategies (van den Berg, 2010).

5. Data collection

A detailed household survey was conducted from December 2015 to April 2016. Data collection and handling followed the Poverty Environment Network (PEN) survey guidelines that were designed to measure income and livelihood patterns (Angelsen et al, 2011; PEN, 2015). The PEN prototype questionnaires were translated into Spanish and thoroughly field tested at nine rural sites before operationalization.

Meetings were initially held with presidents of the cooperatives and communities in each area to explain the goals and methodology of the study. A survey schedule was prepared so that heads of the households were randomly selected across the nine villages and summoned on the agreed upon date to complete the questionnaire. Each interview lasted approximately 45 minutes. 188 heads of randomly sampled households were interviewed.

The final questionnaire was divided into three sections. The first recorded household activity variables, the second section collected data about household income shares and the third section compiled information about capital assets.

6. Results

Using the three-step approach adopted in this study, an LPA model was estimated to identify typologies of rural households that exhibited similar patterns of livelihood strategy. Capital asset variables are entered in the model as predictors of household membership to each livelihood strategy profile, describing the capital mix in each of the profiles that enables the choice of that livelihood strategy. Finally, the profiles are employed as predictors of income shares[4].

6.1 Profiles of livelihood strategies

A four-profile model performed the best, according to Bayesian Information Criteria (BIC), Consistent Akaike Information Criterion (CAIC) and conditional bootstrap tests (see Table 3 and for more details of the application of these criterions see Appendix A). Table 4 shows mean values, standard deviations and the overall Wald test for each profile activity variable and the size and name of each profile. All activity variables contributed significantly to discriminating among the profiles ($p<0.05$), except for transfer income and the CN variable, meaning that the land share devoted to CN cultivation does not contribute to discriminating between profiles.

Profile 1 (P1) accounts for 37% of the sample, followed by profile 2 (P2), with 31% of the observations, and profiles 3 (P3) and 4 (P4) comprised approximately 15% of the sample each.

P1 farms allocate approximately half of their land to cacao cultivation with a similar share of land allocated to CCN-51 (M=0.32) and CN (M=0.28), and were the group with the largest share of land devoted to the former. Labor on the farm mostly relies on family members (M=0.67) and off-farm family labor (M=0.04) and on-farm nonfamily labor (M=0.03) were irrelevant. This pattern indicates that, despite the government support given to the CN variety, CCN-51 is still important for certain farmers. Households in P1 can be framed within a strategy of agricultural intensification based on cacao, in which the intensification pattern relies on family workforce resources. We hypothesize that the lower labor requirements to cultivate CCN-51 allow for this

[4] These analyses were estimated with Latent Gold 5.1 software (Vermunt & Magidson, 2015).

profile to manage both varieties exclusively with the family workforce. We named this group *agricultural intensification based on family workforce.*

P2 is the most cacao-oriented profile, with two thirds of the farm land devoted to this crop. Despite having a similar share of land devoted to cacao as P1, the land allocated to CN is double the land share of CCN-51 (M=0.41 versus M=0.24). They make the most intensive use of family labor among the four profiles (M=0.79) and rely on hired workforce (M=0.56) and off-farm family labor (M=0.08) is irrelevant. This pattern is typical in small farms with intensive production of cacao and in which there is a high use of labor and minimal linkage to other agricultural and non-agricultural activities. Households in P2 can easily be identified with a strategy of agricultural intensification based on CN cultivation. We named this group *agricultural intensification based on family and external workforce.*

P3 is the most CN-specialized profile (M=0.44), with marginal participation of CCN-51 (M=0.08) and higher productive diversification than the other groups, dedicating almost 50% of its land to other permanent and temporary crops. This is linked to the standard cultivation procedure for CN, which intermixes other tree crops in polyculture agroforestry. On-farm family labor (M= 0.58) is as important as off-farm family labor (M=0.55), with permanent employment (M= 0.57) as the main modality for the latter case. Households in P3 follow a strategy of diversification in both crop production and family labor. We named this group *diversified crop and family labor.*

P4 also shows specialization in the CN variety (M=0.41) but, in contrast to previous groups, it shows a high proportion of labor in all researched alternatives: family labor on- and off-farm (M=0.65) (as the group with the highest share of the latter), and external workforce (M=0.52). This high percentage of external workforce may indicate more business-oriented activity in this group. Temporary employment is the main modality of labor off-farm (M=0.63) and on-farm (M=0.82). Households in P4 show a distinctive strategy of labor diversification that led us to name it *labor diversification.*

The land allocation to CN and CCN-51 and, more importantly, labor allocation to its different modalities led to identification of four clear patterns of livelihood strategies. The first two are

based on agricultural intensification strategies that rely on family resources or hiring an external workforce to achieve their production objectives. In contrast, profiles 3 and 4 adopt a distinctive diversification strategy; P3 includes bidimensional crop and family labor diversification and P4 is based on labor diversification, with family members working on- and off-farm and reliance on external workers.

Although there is no data available on the labor per hectare needed to manage each cacao variety, our results show that increases in land cultivation of 1% for each variety imply increases in family and total labor of 2% for CN cultivation and 1.75% for CCN-51.

Considering the influence of the PRCN policy in promoting CN cultivation, especially among small farmers, cultivation of CN does not significantly contribute to shaping the membership of households to any of the profiles. Furthermore, among P1 and P2, which comprise two-thirds of the sampled households and who are the more agriculture-oriented households, the CCN-51 variety continues to be highly preferred. These results show that the policy intervention focused on crop management assistance (e.g., pruning, seed selection, technical assistance) is not obtaining the intended results of increasing CN cultivation. This evidences the mismatch between the main theoretical beneficiaries of the PRCN (the small farmers in profiles 1 and 2) and their practices. P3 and P4, which are the profiles favoring CN, show a diversification livelihood strategy. Supporting farmer diversification (either in terms of crops or labor), may be considered by the PRCN as an indirect but effective way of achieving an increase in CN cultivation. However, these results also indicate that CN cultivation may be a residue in a slow process of tree replacement, with a slower pace in P3 and P4, since household strategies in these profiles are oriented toward obtaining non-agricultural income and have lower investments in improving cacao production[5]. In addition, the results highlight the need for creating a value chain for the CN variety in which external incentives such as premium prices are also distributed among small producers.

[5] We are indebted to one of the reviewers of this manuscript for noting this.

6.2 Capital asset variables as predictors of membership to the livelihood strategy profiles

All capital asset mix variables were significant predictors of livelihood strategy profile memberships (overall Wald test with $p<0.05$). At this stage and, similar to other works (Nielsen et al., 2013), a baseline group is defined against which the other strategies are compared to assess the role of capital assets in defining the profiles (see Table 5). First, the profile with the highest share of CC-N51 (P1) was taken as a baseline to pivot P2, P3 and P4. In a second phase, P2 (with more intensive on-farm family labor and cacao land share) was taken as a baseline to compare P3 and P4. See Appendix A for more info.

In the first pivotal comparison, households belonging to farmer associations are more likely to belong to P2 whereas those with larger family size and a primary education are more likely to be in P3. P4 shows significantly different capital assets than P1; medium and large farms are more likely to belong to P4 and being the owner of the land reduces the probability of being in this group. Furthermore, having a positive and relatively high capital production index increases a household's likelihood of being in P4 and a low basic service index decreases the likelihood. Finally, having savings and low debt also increases the probabilities of being in P4.

The second pivotal comparison shows that the probability of belonging to P3 or P4 with respect to P2 increases with land size and decreases with land ownership. In addition, the larger the family size, the more likely the household belongs to the P3 or P4 profiles. Households with primary education are more likely to belong to P3. Finally, having savings and low debt also increases the probability of being in P4.

Examining the role played by different capital assets in defining the profiles, we observe that natural capital, specifically, the area of cultivated land, and human capital (family size) play determinant roles in enabling diversification strategies (either P3 or P4). Households with agricultural intensification strategies (P1 and P2) are small families that own and cultivate small properties whereas the diversification strategies (P3 and P4) are characterized by larger family sizes and hiring strategies to cultivate larger size plots.

Households in P2 appear to be the most vulnerable, with low natural capital and financial indicators (i.e., small land area and financial debts). Social capital through membership in farmers' cooperatives is significant in defining membership to this profile. This may be a strategy to balance and reduce natural and financial vulnerability. In contrast, households in P4 have distinctively high physical capital (i.e., good access to production implements and basic services) and financial capital (savings and low debt).

The low endowment of key assets that characterizes profiles 1 and 2 may explain why these farmers do not prioritize CN in their farms and continue to maintain relatively high levels of CCN-51, contrary to the farmers with better asset endowments in profiles 3 and 4. As some studies show, both endowment and the wise use of such assets permit responding to the shocks, adverse trends and seasonality that characterize rural activities and better addressing risk decisions, especially for small farmers (Scoones, 2009; Sheck et al., 2013). With a low endowment of assets and without major incentives, the higher productivity of CCN-51 continues to be an important factor in the production decisions of these farmers.

The national policy to stimulate the production of CN has a two-fold objective to improve the competitiveness of Ecuadorian cacao in global markets and to reduce the poverty of small farmers through premium prices obtained for CN beans (MAGAP, 2013). However, the former objective has not been achieved since premium prices for farmers are not in place in the national markets, as the PRCN policy focused on improving cultivation procedures. Although we do not have ex ante data to measure the impacts of PRCN policy on the asset endowment of profiles 3 and 4, it is relevant to signal that the small farmers in the study area on whom many PRCN policies are focused, profiles 1 and 2, are currently the least endowed with assets. This adds to evidence of the mismatch between the main theoretical beneficiaries of the PRCN policy (small farmers in profiles 1 and 2) and their current situation in terms of asset endowment.

6.3 Income share predictions by livelihood strategy profiles

We computed the profile-specific means for income share variables related to four labor types (see Table 6). The overall Wald test was significant for three of them: on-farm agricultural

activities, off-farm non-agricultural activities and off-farm agricultural activities (see Appendix A for additional information on the statistical tests).

The income share results align with the findings of the livelihood strategy identification in which P1 and P2 clearly differentiate from P3 and P4. The income share from on-farm agricultural activities represents the largest proportion for all groups. However, it differs among them; P1 and P2's own-farm income source represents more than 70% of their total income whereas its importance is somewhat less (approximately 50%) for P3 and P4, showing a more diversified income structure. Differences were also observed between these two groups regarding the second-most important source of income. For farmers in P3, it is off-farm agricultural activities (21%) whereas for farmers in P4, it is off-farm non-agricultural activities (23%).

These differences between the two groups of profiles reflect the vulnerable condition of the cacao producers in profiles 1 and 2 whose household income is highly dependent on the behavior of the cacao market.

These profiles appear to be in a setup in which the intensive labor dedication to cacao cultivation and a low endowment of assets may jeopardize their access to less vulnerable livelihood strategies. Increasing their asset endowment and share of CN cultivation (and hence dependency), as intended by the PRCN policy, may not necessarily result in improvement of their income status, especially while lacking a differentiated value chain for CN at the national level that rewards farmers with higher prices. This result adds to previous evidence signaling the existing gap between the objectives of the PRCN policy to improve the situation of small farmers and the actual results.

7. Discussion

Small farmers face some opposing goals and trade-offs when cultivating cacao. CN may accrue premium prices in international specialty markets, and full-sun, high-yield CCN-51 benefits from less labor but relies more on external inputs and obtains lower prices (Franzen & Mulder, 2007). Most studies assessing the role of these two varieties and their distinctive implications in terms

of ecosystem service provision, cultivation or market access suggest that farmers would opt for one or the other variety (Andres et al., 2016; Jano & Mainville, 2007; Ton et al., 2008; Vaast & Somarriba, 2014). In contrast, our survey shows that more than two thirds of the sampled households (P1 and P2), specifically those showing livelihood strategies focused on agricultural intensification, solve this "dilemma" by allocating a substantial share of their land to concurrent cultivation of CN and CCN-51. Furthermore, the variable "share of land allocated to CN" does not significantly contribute to the adoption of a particular household livelihood strategy.

Our results show how the asset endowment of small farmers affects their livelihood strategies; two broad patterns can be disentangled. Profiles P1 and P2 are highly dependent on their agricultural production whereas P3 and P4 show a more diversified farm economy. Diversification toward off-farm activities is a key strategy in rural livelihoods (Hua & Zhang, 2017; Nielsen et al., 2013; Walelign, 2016) since it may reduce vulnerabilities to prevailing agricultural risk (Davis, 2006; Kandulu et al., 2012) and is generally a viable strategy for improving living standards in rural areas (Nielsen et al., 2013; Walelign et al., 2016). Profiles that were less diversified toward off-farm activities also had the highest share of land devoted to CCN-51 production and vice versa. However, high welfare strategies tend to be associated with high levels of capital (van den Berg, 2010), as our study also supports.

Labor is a building block in acquiring livelihood objectives and sustaining livelihood outcomes (Bhandari, 2013) and its analysis shows how P2 farmers rely on external workers to support their farm activities. The P2 group allocated more land to cacao production and a substantial share to CN. CN cultivation requires more labor whereas households that produce CCN-51 substitute labor with other inputs, especially herbicides (Bentley et al., 2004; Franzen & Mulder, 2007; Blare & Useche, 2013). Therefore, for less diversified livelihood strategies, cultivation of CCN-51 may be viewed as a way to obtain benefits in the short-term and reduce the need to hire an external workforce.

Similar to other studies, cultivated land resource endowment was a key factor influencing the differentiation of livelihood strategies (Hua et al., 2017; Jansen et al., 2006; Winters et al., 2009).

A high allocation of land resource endowments to CN production (approximately 40%) and marginal land allocated to CCN-51 indicates a pathway of off-farm income diversification. Large farmers tend to have better access to economic/financial capital and can afford to purchase modern farm inputs that allow for them to strengthen their livelihood (Bhandari, 2013). Households in P4 can easily be identified with this pattern, showing positive and significant values for medium and large property sizes, a positive and significant production implements index compared to P1 and a diversified economy with off-farm income based on non-agricultural activities. In addition, our results show that access to the land, not land ownership, is the key factor contributing to engaging in higher income opportunities (Jansen et al., 2006; van den Berg, 2010).

Human assets enable households to pursue different livelihood strategies to achieve their livelihood objectives (Bhandari, 2013). Family size plays a crucial role in this respect since larger families are able to pursue non-agricultural livelihood strategies due to their higher labor capacity (Hua et al., 2017). P3 and P4 show distinctively larger family sizes than P2, translating into increased labor capacity and greater ability to diversify income sources. Some studies also suggest that family size positively impacts the adoption of innovations in crop management and restoring CN cultivation (Tiwari et al., 2008).

The importance of cacao as a major global commodity makes the establishment of effective cacao policy a high priority (Franzen & Mulder, 2007); our findings may contribute to shaping current implementation of PRCN policy as well as future policies in Ecuador. Through PRCN policy, the Ecuadorian government has focused on developing measures related to agronomic issues in CN production and disregarded other factors that shape cacao production and commercialization (Astudillo Paredes, 2014). The lack of a differentiated value chain for CN at the national level impedes farmers from receiving differentiated prices for CN beans. Some farmer associations in Ecuador have achieved better prices for CN by circumventing the intermediaries and selling directly to exporters or exporting directly (Astudillo Paredes, 2014; Jano & Mainville, 2007). Thus, strengthening the role and capacity of farm cooperatives may be a successful approach to

reinforcing the ability of CN farmers to obtain premium prices in international markets. However, strategies that intend to link small farmers to markets tend to implicitly assume that these farmers have sufficient assets to participate in high-value markets and can assume higher risks for their investments, overlooking the trade-offs they incur (Donovan et al., 2015; Horton et al., 2016).

Without such asset endowments, cacao farmers are constrained by entry barriers (Amekawa, 2011) and income diversification measures may be detrimental for these families if their household asset stocks and feasible activity options are neglected (Amekawa, 2011; Barrett et al., 2001). Development interventions that would allow for them to effectively participate in value chains would support poor households in building a minimum stock of productive assets, without which the poorest may experience asset depletion and increased vulnerability (Donovan & Poole, 2013; Sheck, et al., 2013).

Since asset thresholds are key to improving poverty transitions (Mutenje et al., 2010; Scoones, 2015; Walelign, 2016), national policies oriented toward reducing the poverty of cacao small holders should consider increasing cacao productivity and investments in infrastructure and social safety nets to develop sustainable livelihoods (Bhandari, 2013; Davis & Lopez-Carr, 2014; Mahdi et al., 2016; Mbaiwa, 2011; Park et al., 2012; Reenberg et al., 2013; Timmer, 2012)

However, the measures implemented through PRCN have not provided the small farmers who are focus of this policy with key asset endowments to support them in the case of allocating more land to the less productive CN variety, which results in the same prices as CCN-51 in the national markets they have access to.

For CN cultivation, to create a real impact on the small farmers, it is necessary to establish a differentiated value chain for the CN variety at the national level in which external incentives such as premium prices are distributed among small producers. The lack of this value chain may limit the future viability of CN cultivation in Ecuador.

Since our study analyzed household livelihood strategies at a given moment in time, several hypotheses can be considered to understand the dynamic allocation of land to the two cacao

varieties. Farmers who are more dependent on on-farm income are the largest producers of CCN-51; probably because shifting completely to CN may be seen as a risk when they receive the same price for both varieties. The short-term benefits of cultivating CCN-51 allowed for its spread (Franzen & Mulder, 2007; MAGAP, 2013; Melo & Hollander, 2013), but it appears that many farmers acknowledge the benefits of combining CN cultivation with other tree crops that are key for family subsistence and the lower maintenance costs of this variety. In addition, cultivation of both varieties by agricultural intensification profiles may be a resilience strategy in case of plant diseases, pests or plagues. Finally, the higher share of CN observed in the more diversified profiles may indicate a higher capacity to adopt innovations in CN cultivation or CN may be a residue in the process of replacing trees, which occurs a slower pace in these profiles due to their prioritization of non-agricultural incomes. Further adoption of CN or halting its substitution process could be enhanced by creation of a value chain and improvement of the asset endowment of small farmers.

The nonsignificant role played by the CN land cultivation in differentiating livelihood strategies and the lower asset endowment income diversification of the theoretical target beneficiaries of the PRCN highlight the gap between the postulates of this policy and the actual results.

This work builds on previous studies assessing Ecuadorian cacao production (e.g., Galarza, 2012; Melo & Hollander, 2013; Useche & Blare, 2013) and adopts a robust statistical approach aligned with the theoretical frameworks adopted to investigate livelihood strategy profiles. Different from traditional cluster analysis (Babulo et al., 2008; Nielsen et al., 2013; Walelign, 2016), the improved three-step approach allows for more statistically robust and less arbitrary final grouping and profile assignment (Collins & Lanza, 2010; Magidson & Vermunt, 2002; Bolck et al., 2004).

8. Conclusions

Establishment of effective policies to improve cacao cultivation is viewed as a way to enhance the livelihood of small producers. Ecuador, as the largest global producer of fine flavor cacao (CN), has developed a national policy (PRCN) to rehabilitate and stimulate production of the CN

variety over its hybrid counterpart (CCN-51) to preserve the former and adopt its cultivation as a rural development strategy for cacao small farmers.

The production decisions of small farmers occur in a context of diversified livelihood strategies in which they make decisions related to their linkage to markets for specialized or bulk cacao varieties. This study shows that fine flavor cacao does not insure the living conditions of small farmers that would enable them to opt for a specific livelihood strategy. In contrast, the capital assets significantly determine the livelihood strategies of small farmers. Low capital asset endowments hinder transitioning toward more rewarding livelihood strategies. Accordingly, policy interventions should be oriented to enhancing access to quality asset endowments and providing asset protection for small farmers.

In the context of diversified livelihood strategies, policy interventions should also focus on measures to facilitate income diversification and improved opportunities for off-farm employment, as they may encourage adoption of CN by small producers

The mismatch identified by this study between the PRCN policy and its theoretical beneficiaries, small cacao farmers, also calls for policies that design, structure and maintain a differentiated national value chain for the fine flavor variety. Ensuring that small farmers receive the incentives that accompany this variety, such as the premium prices obtained in international markets, would contribute to securing the mid-term viability of CN and the potential of this crop to enable access of small farmers to more rewarding livelihood strategies.

This study advocates for a multidimensional policy strategy to promote fine flavor cacao cultivation, in which improved asset endowment, income diversification measures and development of a specific national value chain should accompany the improved CN breeding and management.

Finally, in the framework of policy interventions, longitudinal data collection and analysis could improve assessment of the pathways that the livelihood strategies of small cacao farmers follow over time under the application of specific sectorial policies.

Conflict of interest

The authors declare that they have no conflicts of interest.

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REFERENCES

Abbey, P., Tomlinson, P. R., & Branston, J. R. (2016). Perceptions of governance and social capital in Ghana's cocoa industry. *Journal of Rural Studies*, *44*, 153–163.

Alemayehu, M., Beuving, J., & Ruben, R. (2018). Risk Preferences and Farmers' Livelihood Strategies: A Case Study from Eastern Ethiopia. *Journal of International Development*.

Alemu, Z. G. (2012). Livelihood Strategies in Rural South Africa : Implications for Poverty Reduction Livelihood Strategies in Rural South Africa : Implications for Poverty Reduction. *Paper at International Association of Agricultural Economists Triennial Conference, Foz Do Iguacu, Brazil*, 1–24.

Alkire, S., & Foster, J. (2011). Understandings and misunderstandings of multidimensional poverty measurement. *Journal of Economic Inequality*, *9*(2), 289–314.

Amekawa, Y. (2011). Agroecology and sustainable livelihoods: Towards an integrated approach to rural development. *Journal of Sustainable Agriculture*, *35*(2), 118–162.

Andres, C., Comoé, H., Beerli, A., Schneider, M., Rist, S., & Jacobi, J. (2016). Cocoa in Monoculture and Dynamic Agroforestry. In E. Lichtfouse (Ed.), *Sustainable Agriculture Reviews (Vol. 19, pp. 121–153)* (Vol. 19, pp. 121–153). Springer International Publishing.

Angelsen, A., Larsen, H. O., Lund, J. F., Smith-Hall, C., & Wunder, S. (2011). *Conclusions and key notes from every chapter*. *Measuring livelihoods and environmental dependence: Methods for research and fieldwork*.

Astudillo Paredes, J. G. (2014). *Soft Systems Methodology: Prososal to improve the cocoa value chain in Ecuador (Master's thesis)*. Australia/Royal Melbourne Institute of Technology University. Retrieved from http://repositorio.educacionsuperior.gob.ec/handle/28000/1778

Babatunde, R. O., & Qaim, M. (2010). Impact of off-farm income on food security and nutrition in Nigeria. *Food Policy*, *35*(4), 303–311.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., & Mathijs, E. (2008). Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. *Agricultural Systems*.

Bakk, Z., & Oberski, D. L. (2014). Relating Latent Class Assignments to External Variables : Standard Errors for Correct Inference. *Political Analysis*, *22*, 520–540.

Bakk, Z., Oberski, D. L., & Vermunt, J. K. (2016). Relating Latent Class Membership to Continuous Distal Outcomes: Improving the LTB Approach and a Modified Three-Step Implementation. *Structural Equation Modeling: A Multidisciplinary Journal*, *23*(2), 278–289.

Bakk, Z., Tekle, F. B., & Vermunt, J. K. (2013). Estimating the Association between Latent Class Membership and External Variables Using Bias-adjusted Three-step Approaches. *Sociological Methodology*, *43*(1), 272–311.

Barrett, C. ., Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy*, *26*(4), 315–331.

Bebbington, A. (1999). *Capitals and capabilities: A framework for analysing peasant viability, rural livelihoods and poverty in the Andes*. (Simon Croxton, Ed.). London: International Institute for Environment and Development, IIED.

Bentley, J. W., Boa, E., & Stonehouse, J. (2004). Neighbor trees: Shade, intercropping, and cacao in Ecuador. *Human Ecology*, *32*(2), 241–270.

Bhandari, P. B. (2013). Rural livelihood change? Household capital, community resources and livelihood transition. *Journal of Rural Studies*, *32*, 126–136.

Blare, B. T., & Useche, P. (2014). What Does it Mean to be Socially Responsible ? Case Study on the Impact of the Producer-Plus-Program on Communities , Women , and the Environment in Ecuador, (July), 1–15.

Blare, T., & Useche, P. (2013). Competing objectives of smallholder producers in developing countries: examining cacao production in Northern Ecuador. *Environmental Economics*, *4*(1), 71–79.

Bolck, A., Croon, M., & Hagenaars, J. (2004). Estimating latent structure models with categorical variables: One-step versus three-step estimators. *Political Analysis*, *12*(1), 3–27.

Browder, J. O., Pedlowski, M. A., & Summers, P. M. (2004). Land use patterns in the Brazilian Amazon: Comparative farm-level evidence from Rondônia. *Human Ecology*, *32*(2), 197–224.

Brown, D., Stephens, E., Ouma, J., Murithi, F., & Barrett, C. B. (2006). Livelihood strategies in the rural Kenyan highlands. *African Journal of Agricultural and Resource Economics*, *1*(1), 21–36.

Carney, D. (1998). Implementing the sustainable rural livelihoods approach. Paper presented at the DFID Natural Resource Advisors' conference: London, UK: Department for International Development.

Carney, D. (1999). *Approaches to sustainable livelihoods for the rural poor*. London: Overseas Development Institute: Overseas Development Institute. Retrieved from http://dlc.dlib.indiana.edu/dlc/handle/10535/3863

Chambers, R. (1995). Poverty and livelihoods : whose reality counts? *Environment and Urbanization*, *7*(1), 173–204.

Chambers, R., & Conway, G. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century* (Discussion Paper No. 296). Retrieved from http://opendocs.ids.ac.uk/opendocs/handle/123456789/775

Chang, H. H., & Mishra, A. (2008). Impact of off-farm labor supply on food expenditures of the farm household. *Food Policy*, *33*(6), 657–664.

Chilongo, T. (2014). Livelihood strategies and forest reliance in Malawi. *Forests Trees and Livelihoods*, *23*(3), 188–210.

Clay, J. (2004). *World Agriculture and Environment: A Commodity-by-Commodity Guide to Impacts and Practices*. *Island Press*. Washington.

Collins, L. M., & Lanza, S. T. (2010). *Latent class and latent transition analysis: with applications in the social, behavioral, and health sciences*.

Collinson, C., & León, M. (2000). Economic viability of ethical cocoa trading in Ecuador. In *Report 2519, Natural Resources and Ethical Trade Programme*. United Kingdom. Final Draft: Natural Resources Institute.

Coq-Huelva, D., Torres-Navarrete, B., & Bueno-Suárez, C. (2018). Indigenous worldviews and Western conventions: Sumak Kawsay and cocoa production in Ecuadorian Amazonia. *Agriculture and Human Values*, *35*(1), 163–179.

CORPEI-BID. (2009). *Programa de establecimiento de una estrategia de competitividad de la cadena del cacao fino de aroma del Ecuador*. Corporación Ecuatoriana de Promoción de Exportaciones e Inversiones (CORPEI). Banco Interamericano de Desarrollo (BID). Quito.

Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quiñones, E. J., Zezza, A., … DiGiuseppe, S. (2010). A Cross-Country Comparison of Rural Income Generating Activities. *World Development*, *38*(1), 48–63.

Davis, J. (2006). Rural non-farm livelihoods in transition economies: emerging issues and policies. *Agricultural and Development Economics*, *3*(2), 180–224.

Davis, J., & Lopez-Carr, D. (2014). Migration, remittances and smallholder decision-making: Implications for land use and livelihood change in Central America. *Land Use Policy*, *36*, 319–329.

DFID. (1999). Sustainable Livelihoods Guidance Sheets, section 2.1. Department for International Development.

Donovan, J., Franzel, S., Cunha, M., Gyau, A., & Mithöfer, D. (2015). Guides for value chain development: a comparative review. *Journal of Agribusiness in Developing and Emerging Economies*, *5*(1), 2–23.

Donovan, J., & Poole, N. (2013). Asset building in response to value chain development: lessons from taro producers in Nicaragua. *International Journal of Agricultural Sustainability*, *11*(1), 23–37.

ECLAC, FAO, & IICA. (2015). *The outlook for agriculture and rural development in the Americas: A perspective on Latin America and the Caribbean 2015-2016. Economic Commission for Latin America and the Caribbean*.

Ellis, F. (2000). The Determinants of Rural Livelihood Diversification i n Developing Countries. *Journal of Agricultural Economics*, *51*(2), 289–302.

Ellis, F., & Freeman, A. (2005). *Rural Livelihoods and Poverty Reduction Policies*. *Routledge*. London.

Espinosa, J., Mite, F., Cedeño, S., Barriga, S., & Andino, J. (2006). GIS-Based Site-Specific Management of Cocoa. *Better Crops*.

Fang, Y. P., Fan, J., Shen, M. Y., & Song, M. Q. (2014). Sensitivity of livelihood strategy to livelihood capital in mountain areas: Empirical analysis based on different settlements in the upper reaches of the Minjiang River, China. *Ecological Indicators*, *38*, 225–235.

Franzen, M., & Mulder, M. B. (2007). Ecological, economic and social perspectives on cocoa production worldwide. *Biodiversity and Conservation*.

GAD-Garaicoa. (2015). Complementación y actualización del Plan de Desarrollo y Ordenamiento Territorial de la Parroquia Crnel Lorenzo de Garaicoa. Gobierno Autónomo Descentralizado (GAD). Simón Bolivar. Retrieved from http://app.sni.gob.ec/sni-link/sni/PORTAL_SNI/data_sigad_plus/sigadplusdiagnostico/0968538900001_DIAGNOSTICO GAD PARROQUIAL LORENZO DE GARAICOA 18 DE MAYO DEL 2015_18-05-2015_16-02-15.pdf

GAD-Yaguachi Viejo. (2015). Plan de Desarrollo y Ordenamiento Territorial de la Parroquia Rural de Yaguachi Viejo "Cone" 2015-2025. Retrieved December 16, 2016, from http://app.sni.gob.ec/sni-link/sni/PORTAL_SNI/data_sigad_plus/sigadplusdocumentofinal/0968551680001_3_30-10-2015_21-33-10.pdf

Galarza, J. (2012). *Smallholders and "fine" cocoa´s supply chain: designing an experiment on social dilemmas in cocoa "quality manipulation" (Master Thesis)*. Universiteit Gent.

Gibson, W. A. (1959). Three multivariate models: Factor analysis, latent structure analysis, and latent profile analysis. *Psychometrika*, *24*(3), 229–252.

Horton, D., Donovan, J., Devaux, A., & Torero, M. (2016). Innovation for inclusive value-chain development: Highlights. In A. Devaux, M. Torero, J. Donovan, & D. Horton (Eds.), *Innovation for inclusive value-chain development: successess and challenges* (pp. 3–34). Intl Food Policy Res Inst.

Hua, X., Yan, J., & Zhang, Y. (2017). Evaluating the role of livelihood assets in suitable livelihood strategies: Protocol for anti-poverty policy in the Eastern Tibetan Plateau, China. *Ecological Indicators*, *78*, 62–74.

ICCO. (2006). Annual Report 2004/2005. Retrieved from: www.icco.org/pdf/An_report/ARENGLISHV4.pdf. (Accessed 14 October 2017).

ICCO. (2012). The World Cocoa Economy: Past and Present. In Executive Committee (Ed.), *One hundred and forty-sixth meeting* (pp. 1–43). International Cocoa Organization.

INEC. (2015). Encuesta de Superficie y Producción Agropecuaria Continua, ESPAC. Instituto Nacional de Estadísticas y Censos (INEC). Retrieved from: http://www.ecuadorencifras.gob.ec/estadisticas-agropecuarias-2/. (Accessed 24 January 2017).

INEC. (2016). Reporte de Pobreza-2016. Retrieved from: http://www.ecuadorencifras.gob.ec/documentos/web-inec/POBREZA/2016/Diciembre_2016/Reporte pobreza y desigualdad-dic16.pdf. (Accessed 20 February 2017).

Internacional Cocoa Organization. (2007). Assesment of the Movements of Global Supply and Demand. Retrieved from: http://www.icco.org/documents/documents.aspx. (Accessed 1 November 2017).

Jano, P. (2007). *Quality Incentives and the Development of High-value Agrifood Markets: Ecuador's Cacao Marketing Chain*. *Agricultural and Applied Economics*. Virginia Polytechnic Institute. Retrieved from: http://scholar.lib.vt.edu/theses/available/etd-06082007-131653/unrestricted/2007_07_17_PJanoMasterThesis.pdf.

Jano, P., & Mainville, D. (2007). The Cacao Marketing Chain in Ecuador: Analysis of Chain Constraints to the Development of Markets for High-Quality Cacao. *International Food and Agribusiness Management Association*. Blacksburg, VA: Agricultural & Applied Economics.

Jansen, H. G. P., Pender, J., Damon, A., & Schipper, R. (2006). Rural Development Policies and Sustainable Land Use in the Hillside Areas of Honduras: A Quantitative Livelihoods Approach. *Agricultural Economics*, *34*, 141–153.

Kandulu, J. M., Bryan, B. A., King, D., & Connor, J. D. (2012). Mitigating economic risk from climate variability in rain-fed agriculture through enterprise mix diversification. *Ecological Economics*, *79*, 105–112.

Kooij, S. van der. (2013). Market study of fine flavour cocoa in 11 selected countries – revised

version Pre – read of revised version Overview of the main revisions. *Royal Tropical Institute*, (October), 1–109.

Lanza, S. T., Tan, X., & Bray, B. C. (2013). Latent Class Analysis With Distal Outcomes: A Flexible Model-Based Approach. *Structural Equation Modeling: A Multidisciplinary Journal*, *20*(1), 1–26.

Lazarsfeld, P. F., & Henry, N. W. (1968). Latent structure analysis. Boston: Houghton Mifflin.

Lehmann, S., & Springer-Heinze, A. (2014). Global value chains and world trade: Prospects and challenges for Latin America. In R. Hernández, J. Martínez-Piva, & N. Mulder (Eds.). Santiago de Chile: United Nations, ECLAC, Deutsche Zusammenarbeit. Retrieved from: http://repositorio.cepal.org/handle/11362/37041

MAGAP. (2013). *Proyecto de Reactivación del café y cacao fino de aroma*. Ministerio de Agricultura, Ganadería, Acuicultura y Pesca (MAGAP). Quito.

Magidson, J., & Vermunt, J. (2004). Latent Class Models. *Latent Variable Models and Factor Analysis*, (617), 157–189.

Magidson, J., & Vermunt, J. K. (2002). Latent class models for clustering: A comparison with K-means. *Canadian Journal of Marketing Research*, *20*(1), 37–44.

Mahdi, Shivakoti, G. P., & Schmidt-Vogt, D. (2016). Livelihood Change and Livelihood Sustainability in the Uplands of Lembang Subwatershed, West Sumatra Province of Indonesia, in a Changing Natural Resources Management Context. In *Redefining Diversity and Dynamics of Natural Resources Management in Asia: The Reciprocal Relationship between Governance of Natural Resources and Socio-Ecological Systems Dynamics in West Sumatra Indonesia* (Vol. 4, pp. 19–43).

Mbaiwa, J. E. (2011). Changes on traditional livelihood activities and lifestyles caused by tourism development in the Okavango Delta, Botswana. *Tourism Management*, *32*(5), 1050–1060.

Melo, C. J., & Hollander, G. M. (2013). Unsustainable development: Alternative food networks and the Ecuadorian Federation of Cocoa Producers, 1995-2010. *Journal of Rural Studies*,

32, 251–263.

Mutenje, M. J., Ortmann, G. F., Ferrer, S. R. D., & Darroch, M. A. G. (2010). Rural livelihood diversity to manage economic shocks: Evidence from south-east Zimbabwe. *Agrekon*, *49*(3), 338–357.

Nguyen, T. T., Do, T. L., Bühler, D., Hartje, R., & Grote, U. (2015). Rural livelihoods and environmental resource dependence in Cambodia. *Ecological Economics*, *120*, 282–295.

Nicol, A. (2000). Adopting a Sustainable Livelihoods Approach to Water Projects : Implications for Policy and Practice. *ODI Working Paper 133*, 35.

Nielsen, Ø. J., Rayamajhi, S., Uberhuaga, P., Meilby, H., & Smith-Hall, C. (2013). Quantifying rural livelihood strategies in developing countries using an activity choice approach. *Agricultural Economics (United Kingdom)*, *44*(1), 57–71.

Ofori-Bah, A., & Asafu-Adjaye, J. (2011). Scope economies and technical efficiency of cocoa agroforesty systems in Ghana. *Ecological Economics*, *70*(8), 1508–1518.

Park, S., Howden, M., & Crimp, S. (2012). Informing regional level policy development and actions for increased adaptive capacity in rural livelihoods. *Environmental Science and Policy*, *15*(1), 23–37.

PEN. (2015). Technical Guidelines Version 4. Poverty Environment Net- work. Retrieved July 1, 2015, from http://www.cifor.cgiar.org/pen.

Pichon, F. J. (1997). Colonist Land-Allocation Decisions, Land Use, and Deforestation in the Ecuadorian Amazon Frontier. *Economic Development and Cultural Change*, *45*(4), 707–744.

PROECUADOR. (2013). *Análisis del Sector Cacao y elaborados*. Quito.

Rakodi, C. (1999). A Capital Assets Framework for Analysing Household Livelihood Strategies: Implications for Policy. *Development Policy Review*, *17*(3), 315–342.

Reenberg, A., Maman, I., & Oksen, P. (2013). Twenty years of land use and livelihood changes

in SE-Niger: Obsolete and short-sighted adaptation to climatic and demographic pressures? *Journal of Arid Environments*, *94*, 47–58.

Ruf, F. O. (2011). The Myth of Complex Cocoa Agroforests: The Case of Ghana. *Human Ecology*, *39*(3), 373–388.

Scoones, I. (1998). *Sustainable rural livelihoods: a framework for analysis* (Working Paper No. 72). Brighton, UK.

Scoones, I. (2009). Livelihoods perspectives and rural development. *The Journal of Peasant Studies*, *36*(1), 171–196.

Scoones, I. (2015). Suatainable Livelihoods And Rural Development. In *Practical Action Publishing* (pp. 793–832).

SENPLADES. (2017). Plan nacional de desarrollo 2017-2021 "Toda una Vida." *Senplades*.

Sheck, R., Donovan, J., & Stoian, D. (2013). *Assessing Impacts of Value Chain Development on Poverty A Case-Study Companion to the 5Capitals Tool*. (R. Sheck, J. Donovan, & D. Stoian, Eds.) (1era.). Turrialba, Costa Rica: CATIE; ICRAF; Bioversity International.

Sheck, R., Donovan, J., Stoian, D., & (eds.). (2013). *Evaluación de impactos del desarrollo de cadenas de valor sobre la pobreza*. (CAITIE; ICRAF, Ed.) (1 era ed.). Costa Rica: Serie Técnica. Boletin Técnico Catie No. 69.

SINAGAP. (2018). Sistema de Información Nacional de Agricultura, Ganaderia, Acuacultura y Pesca. Retrieved from: http://sipa.agricultura.gob.ec/index.php/productos/precios-productos. (Accessed 25 March 2018).

Squicciani, M. P., & Swinnen, J. (2016). *The Economics of Chocolate*. *The Economics of Chocolate*. Oxford: Oxford University Press.

Stoian, D., Donovan, J., Fisk, J., & Muldoon, M. F. (2012). Value chain development for rural poverty reduction: A reality check and a warning. *Enterprise Development and Microfinance*, *23*(1), 54–60.

Tein, J.-Y., Coxe, S., & Cham, H. (2013). Statistical Power to Detect the Correct Number of Classes in Latent Profile Analysis. *Structural Equation Modeling : A Multidisciplinary Journal*, *20*(4), 640–657.

Tesfaye, Y., Roos, A., Campbell, B. M., & Bohlin, F. (2011). Livelihood strategies and the role of forest income in participatory-managed forests of Dodola area in the bale highlands, southern Ethiopia. *Forest Policy and Economics*, *13*(4), 258–265.

Timmer, C. P. (2012). Structural Transformation, Small Farmers, and Food Security in Asia. In *Institutions and Comparative Economic Development* (pp. 281–297). London: Palgrave Macmillan UK.

Tiwari, K. R., Sitaula, B. K., Nyborg, I. L. P., & Paudel, G. S. (2008). Determinants of farmers' adoption of improved soil conservation technology in a Middle Mountain Watershed of Central Nepal. *Environmental Management*, *42*(2), 210–222.

Ton, G., Hagelaars, G., Laven, A., & Vellema, S. (2008). *Chain Governance, Sector Policies and Economic Sustainability in Cocoa: A Comparative Analysis of Ghana, Côte D'Ivoire, and Ecuador*. *Markets, chains and Sustainable development*.

Ton, G., Vellema, S., & de Ruyter de Wildt LEI, M. (2011). Development impacts of value chain interventions: how to collect credible evidence and draw valid conclusions in impact evaluations? *Journal on Chain and Network Science*.

UNIDO. (2011). *Pro-Poor Value Chain Development: 25 guiding questions for designing and implementing agroindustry projects*. Vienna, Austria: United Nations International Development Organization. Retrieved from: http://www.unido.org/fileadmin/user_media/Services/Agro-Industries/Pro-poor_value_chain_development_2011.pdf

Useche, P., & Blare, T. (2013). Traditional vs. modern production systems: Price and nonmarket considerations of cacao producers in Northern Ecuador. *Ecological Economics*, *93*, 1–10.

Vaast, P., & Somarriba, E. (2014). Trade-offs between crop intensification and ecosystem

services: the role of agroforestry in cocoa cultivation. *Agroforestry Systems*, *88*(6), 947–956.

van den Berg, M. (2010). Household income strategies and natural disasters: Dynamic livelihoods in rural Nicaragua. *Ecological Economics*, *69*(3), 592–602.

Vermunt, J. K. (2010). Latent class modeling with covariates: Two improved three-step approaches. *Political Analysis*, *18*(4), 450–469.

Walelign, S. Z. (2016). Livelihood strategies, environmental dependency and rural poverty: the case of two villages in rural Mozambique. *Environment, Development and Sustainability*, *18*(2), 593–613.

Walelign, S. Z., & Jiao, X. (2017). Dynamics of rural livelihoods and environmental reliance: Empirical evidence from Nepal. *Forest Policy and Economics*, (May 2016), 0–1.

Walelign, S. Z., Pouliot, M., Larsen, H. O., & Smith-Hall, C. (2016). Combining Household Income and Asset Data to Identify Livelihood Strategies and Their Dynamics. *The Journal of Development Studies*, *0388*(July 2016), 1–19.

WFC. (2013). *Ecuador: WCF, LINDT & SPRÜNGLI, and USDA-ARS support fine-flavor cocoa research. World Cocoa Foundation.* (WCF Newsletter March and April 2013). Retrieved from: http://worldcocoafoundation.org/wcf-newsletter-march-april-2013

Winters, P., Davis, B., Carletto, G., Covarrubias, K., Quiñones, E. J., Zezza, A., … Stamoulis, K. (2009). Assets, Activities and Rural Income Generation: Evidence from a Multicountry Analysis. *World Development*, *37*(9), 1435–1452.

Zenteno, M., Zuidema, P. A., de Jong, W., & Boot, R. G. (2103). Livelihood strategies and forest dependence: New insights from Bolivian forest communitieso Title. *Forest Policy and Economics*, *26*, 12–21.

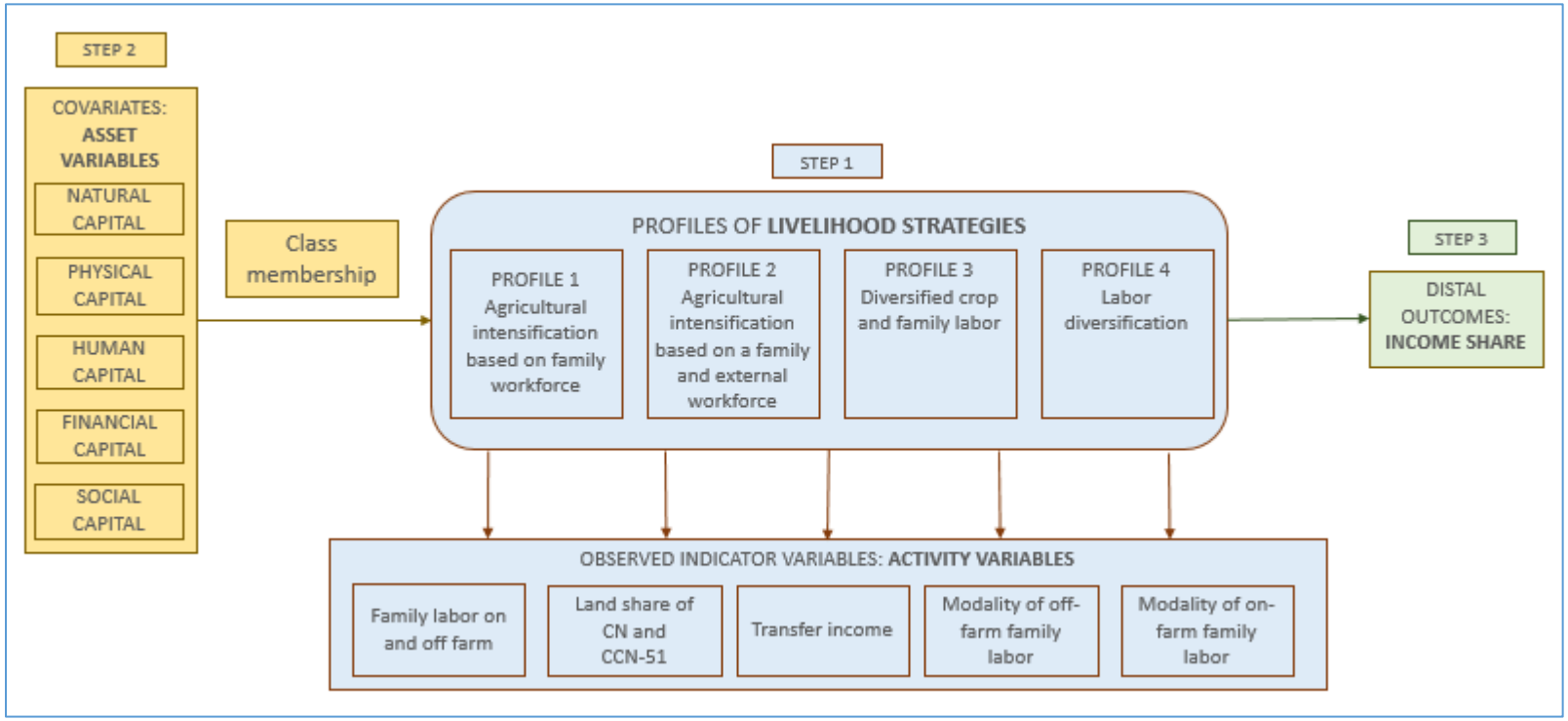

Figure 1. The three-step approach methodology adapted to the household livelihood strategy framework. Source: authors' elaboration on Magidson Vermunt (2015) and Nielsen et al. (2013). First step: Activity variables (land and labor) measure the livelihood strategies. Second step: Capital asset variable covariates predict the profile membership of the households to the latent profiles. Third step: The latent profiles act as predictors of the income share variables.

Table 1. Summary statistics of surveyed respondents

VARIABLE	Lorenzo de Garaicoa		Yaguachi Viejo		Full sample			
	M	SD	M	SD	M	SD	Min.	Max.
Age (years)	48.47	13.94	54.19	15.36	50.23	14.59	18	86
Gender (% female)	22.00	-	20.70		21.80	-	-	-
Education (years)	8.03	4.52	8.38	3.89	5.33	4.01	0	15
Household size	2.50	1.23	3.31	1.74	2.75	1.46	1	7
Land area (ha)	4.99	6.46	4.49	3.48	4.96	5.79	0.38	47.5
Married or living together (%)	70.0	-	74.10	-	71.30	-	-	-
Nacional Cacao variety (ha)	1.23	2.45	2.56	2.26	1.64	2.46	0.20	12.00
CCN-51 Cacao variety (ha)	1.23	2.30	0.17	0.74	0,9	2.02	0.45	13.50
Permanent crops (ha)	0.71	1.66	0.76	2.06	0.73	1.79	0	13.50
Other crops (ha)	1.81	4.98	0.84	1.61	1.51	4.25	0	44.50

Table 2. Activity, income and asset variables

Variable	*Description*
Activity variables	
On-farm family labor	Household adults working on-farm/Total household adults
Off-farm family labor	Household adults working off-farm/Total household adults
On-farm non-family labor	External workers/Total on-farm workers
Cacao Nacional CN	Ha of CN/Total ha
Hybrid cacao CCN-51	Ha of CCN-51/Total ha
Transfer income[a]	The transfer income percentage of the total income. Transfer income/Total income
Modality of off-farm family employment[b]	1= permanent employment, 2= temporary employment, 3= other forms of employment, 4= does not apply
Modality of on-farm non-family employment[c]	1= permanent employment, 2= temporary employment, 3= other forms of employment, 4= does not correspond
Income share variables	
On-farm agricultural activities	Income share of on-farm agricultural activities over total income
Off-farm agricultural activities	Income share of off-farm agricultural activities over total income
Off-farm non-agricultural activities	Income share of off-farm non-agricultural activities over total income
Non-agricultural self-employment activities	Income share of non-agricultural self-employment activities over total income
Natural capital	
Land	**1**= < 3 ha, **2** = 3-6 ha, **3** = > 6 ha
Own land	The total amount of arable land owned by the household.
Physical Capital	
Production implement index[d]	Measures the household possession of production implements. The larger the index, the greater the asset holding
Basic services index[e]	Measures the access of households to basic services. The larger the index, the greater the access
Human Capital	
Family size	Adult income household members
Education	1=No education, 2=Primary education, 3=Secondary education and higher.
Financial Capital	
Savings	Dummy variable indicating possession or absence of savings
Debt	Dummy variable indicating possession or absence of debt
Social Capital	
Farmer association	Dummy variable indicating membership in rural cooperatives

[a] Includes retirement pensions, remittances from family members residing abroad and *Bono de Desarrollo Humano* (a government cash transfer program)

[b] Other forms of employment include jobs as payment for lending and mixtures of permanent and temporary work. Option 4 is selected when the household does not have adult members who labor outside of the farm

[c,d] Access to productive assets: plow, storing installation and transport.

[e] Access to basic services: drinking water, health and education.

Table 3. Fit statistics for models comprising 1 to 5 latent profiles

VARIABLE	PROFILE MODEL				
	1	**2**	**3**	**4**	**5**
Log-likelihood	-2184.49	-2092.56	-2057.25	-2009.68	-1991.5
Global measures-fit (1)					
BIC	4992.12	4855.38	4831.90	4783.89	4794.66
AIC	4606.98	4441.11	4388.51	4311.37	4293.01
CAIC	5111.12	4983.38	4968.90	4929.89	4949.66
Local measures-fit					
max (BVR)	97.794	82.856	42.927	41.893	41.431
Entropy-R2	1	0.9907	0.9541	0.9798	0.9348
Class.Err. (CE)	0	0.0013	0.0166	0.0059	0.0395

BIC: Bayesian Information Criterion
AIC: Akaike's Information Criterion
CAIC: Consistent Akaike's Information Criterion.
BVR: Bivariate Residual.

Table 4. Profiles of livelihood strategies

	PROFILE 1		PROFILE 2		PROFILE 3		PROFILE 4		p-value[a]	R2
	Agricultural intensification based on family workforce		*Agricultural intensification based on family and external workforce*		*Diversified crop and family labor*		*Labor diversification*			
Profile Size (%)	37%		31%		17%		15%			
	M	SD	M	SD	M	SD	M	SD		
On-farm family labor	0.67[2]	0.03	0.79[1,3,4]	0.00	0.58[2]	0.00	0.65[2]	0.04	0.015	0.060
Off-farm family labor	0.04[3,4]	0.00	0.02[3,4]	0.00	0.55[1,2]	0.00	0.65[1,2]	0.00	0.000	0.630
On-farm nonfamily labor	0.03[2,4]	0.00	0.56[1,3]	0.00	0.03[2,4]	0.00	0.52[1,3]	0.00	0.000	0.717
CN	0.28	0.16	0.41	0.16	0.44	0.42	0.41	0.55	0.580	0.026
CCN-51	0.32[3]	0.01	0.24[3]	0.02	0.08[1,2]	0.01	0.16	0.16	0.058	0.059
Transfer income	0.12	0.38	0.08	0.38	0.12	0.41	0.08	0.39	0.690	0.008
Modality of off-farm family employment	3.04[3,4]	0.03	1.43[3,4]	0.04	1.43[1,2]	0.09	1.66[1,2]	0.10	0.000	0.810
1. Permanent employment	0.00	0.00	0.00	0.00	0.57	0.09	0.36	0.09		
2. Temporary employment	0.01	0.01	0.01	0.02	0.42	0.08	0.63	0.09		
3. Other forms of employment	0.05	0.03	0.03	0.02	0.00	0.00	0.00	0.00		
4. Does not apply	0.94	0.03	0.96	0.02	0.00	0.02	0.02	0.02		
Modality of on-farm nonfamily employment	3.05[2,4]	0.03	1.85[1,3]	0.05	3.03[2,4]	0.04	1.83[1,3]	0.07	0.000	0.795
1. Permanent employment	0.00	0.00	0.16	0.05	0.00	0.00	0.18	0.07		
2. Temporary employment	0.00	0.07	0.84	0.05	0.01	0.01	0.82	0.07		
3. Other forms of employment	0.06	0.03	0.00	0.00	0.96	0.03	0.00	0.00		
4. Does not correspond	0.94	0.03	0.00	0.01	0.03	0.03	0.00	0.01		

[a] From overall Wald test. Superscripts correspond to profiles for which the data are significantly different at the 5% level.

Table 5. Capital asset variable prediction of household profile membership

	a) P1 vs P2, P3 and P4 profiles						b) P2 vs P3 and P4 profiles					
	P2 ***Agricultural intensification based on family and external workforce***		**P3** ***Diversified crop and family labor***		**P4** ***Labor diversification***		**P3** ***Diversified crop and family labor***		**P4** ***Labor diversification***		**Wald**	**p-value**
Capital Asset variable	**β**	**z-value**	**β**	**z-value**	**β**	**z-value**	**β**	**z-value**	**β**	**z-value**		
Land											13.71	0.030
Less than 3 ha.	0.00	.	0.00	.	0.00	.	0.00	.	0.00	.		
Between 3 and 6 ha.	-0.09	-0.17	-0.29	-0.48	1.65	2.24	-0.21	-0.32	1.74	2.21		
More than 6 ha	-0.31	-0.34	1.57	1.66	3.38	2.64	1.88	2.31	3.69	2.95		
Land ownership	0.11	1.25	-0.08	-0.83	-0.38	-2.33	-0.19	-2.73	-0.49	-3.13	13.50	0.000
Production implement index	0.46	1.67	-0.02	-0.06	0.85	2.37	-0.48	-1.62	0.39	1.07	8.18	0.040
Basic services index	-0.36	-1.77	-0.24	-0.99	-0.60	-2.77	0.11	0.41	-0.25	-0.99	8.69	0.030
Family size	-0.29	-1.47	0.36	2.36	0.29	1.54	0.65	2.97	0.57	2.12	10.35	0.020
Education											27054.68	0.000
No education	0.00	.	0.00	.	0.00	.	0.00	.	0.00	.		
Primary education	1.47	1.58	54.80	95.32	0.87	0.65	56.73	96.16	-0.60	-0.48		
Secondary education	0.39	0.43	53.48	0.00	-0.32	-0.24	56.49	0.00	-0.72	-0.56		
Savings											9.79	0.020
No	0.00	.	0.00	.	0.00	.	0.00	.	0.00	.		
Yes	0.15	0.25	-0.21	-0.32	1.91	2.90	-0.36	-0.49	1.76	2.16		
Debt											10.05	0.020
No	0.00	.	0.00	.	0.00	.	0	.	0	.		
Yes	0.80	1.75	0.48	0.81	-1.42	-2.02	-0.32	-0.54	-2.22	-2.94		
Farmer association											12.23	0.007
No	0	.	0	.	0	.	0	.	0	.		
Yes	1.57	2.98	-0.22	-0.43	1.12	1.52	-1.78	-2.98	-0.46	-0.57		

Table 6. Income share prediction by livelihood strategy profile

Income share	PROFILE								Wald	p-value
	P1 ***Agricultural intensification based on family workforce***		**P2** ***Agricultural intensification based on family and external workforce***		**P3** ***Diversified crop and family labor***		**P4** ***Labor diversification***			
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**		
On-farm agricultural activities	0.72[3,4]	0.04	0.79[3,4]	0.03	0.50[1,2]	0.06	0.55[1,2]	0.05	24.771	0.000
Off-farm agricultural activities	0.10[3]	0.02	0.06[3]	0.02	0.21[1,2,4]	0.05	0.09[3]	0.02	8.745	0.033
Off-farm non-agricultural activities	0.04[4]	0.02	0.03[3,4]	0.01	0.14[2]	0.04	0.23[1,2]	0.05	12.429	0.006
Non-agricultural self-employment activities	0.01[4]	0.01	0.04	0.01	0.03	0.02	0.06[1]	0.03	3.073	0.380

[1,2,3,4] Indicates the profiles are significantly different at the 5% level.

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Appendix A

Latent profile analysis solution

LPA was applied in an iterative process by progressively increasing the number of profiles as long as each profile had a sufficient number of households (minimum of 5% of the sample) to reduce ulterior errors in the estimates of the profiles with the external variables. The eight activity variables were used as the indicator variables of the LPA model.

Bayesian Information Criteria (BIC) and Consistent Akaike Information Criterion (CAIC) information criterions suggested the 4-profile model fitted the data best, while Akaike Information Criterion (AIC) values dropped while increasing the number of profiles. Entropy values were always above 0.90 and showed the best results for 2-profile and 4-profile models, indicating adequate classification. These two profiles also showed the lower classification errors. A conditional bootstrap test was performed to assess the significance of the difference in the statistics associated with the 2 and 4-profiles models and indicated that the 4-profile model over performed to the 2-profile model. The 4-profile solution was chosen as the best-fit model since it provided the neatest difference among profiles and the most substantively interpretable results with a good balance between parsimony, fit and interpretability. The local independence also was tested. Its results and implications are show in Tables A.1, A.2 and A.3.

Correction methods

Several correction methods have been proposed in the literature. In this article we applied two of them. For Latent Profile Analysis (LPA) with covariates we used a maximum likelihood (ML) approach that involves estimating the profile-specific means and variances by maximum likelihood (Bakk et al., 2013; Vermunt, 2010). For LPA with distal outcomes we used an approach based on the work of Bolck et al. (2004), and Vermunt (2010) known as improved BCH (Bolck, Croon, and Hagenaars), that involves performing a weighted ANOVA, with weights that are inversely related to the classification error probabilities (Bakk et al., 2013; Vermunt, 2010).

Table A.1. Bivariate Residuals (BVR) of Activity variables for four-profile solution model

	a) BVR without direct effects						
	Activity variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	On-farm family labor	.						
2	Off-farm family labor	2.078	.					
3	On-farm nonfamily labor	1.757	0.002	.				
4	CN	0.185	0.038	0.027	.			
5	CCN-51	0.258	0.084	0.020	**41.893**	.		
6	Transfer income	0.948	0.338	0.019	0.054	2.489	.	
7	Modality of off-farm family employment	0.000	0.489	0.005	0.310	0.529	0.020	.
8	Modality of on-farm nonfamily employment	0.263	0.010	**5.148**	0.006	0.028	0.002	0.0367
	b) BVR with direct effects							
	Activity variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	On-farm family labor	.						
2	Off-farm family labor	2.092	.					
3	On-farm nonfamily labor	1.759	0.002	.				
4	CN	0.181	0.027	0.026	.			
5	CCN-51	0.257	0.079	0.020	0.000	.		
6	Transfer income	0.950	0.332	0.019	0.054	2.503	.	
7	Modality of off-farm family employment	0.000	0.523	0.006	0.288	0.534	0.018	.
8	Modality of on-farm nonfamily employment	0.263	0.010	**5.150**	0.007	0.027	0.002	0.037

Note: in the 4-profile solution model, we also assessed if whether the indicators were mutually independent in each livelihood strategy (local independence) and we decided to which local dependencies should be freed relaxed by introducing direct effects among the indicators via the bivariate residuals (Vermunt, 2010). Only two pairwise variables showed BVRs above 3.84 (section a) We decided to free relax the local dependence between variables numbered 4 and 5, in contrast, we kept it between variables numbered 3 and 8 (section b) despite the fact that their BVR was statistically significant due to the BVR between these variables is reduced from 97.79 in the 1-class model to 5.15 in the 4-class model, meaning that the 4-class model explains almost completely (95%) their association.

Table A.2. Pairwise comparison of Income share

Profiles comparison	*Income share variables*							
	On-farm agricultural activities		Off-farm agricultural activities		Off-farm non-agricultural activities		Non-agricultural self-employment activities	
	Wald	p-value	Wald	p-value	Wald	p-value	Wald	p-value
1 vs 2	1.8104	0.180	1.181	0.280	0.635	0.430	1.570	0.210
1 vs 3	10.174	0.001	4.518	0.034	3.161	0.075	1.256	0.260
1 vs 4	6.6452	0.010	0.239	0.630	5.526	0.019	2.876	0.090
2 vs 3	19.053	0.000	5.837	0.016	7.230	0.007	0.010	0.920
2 vs 4	13.790	0.000	0.441	0.510	11.161	0.000	0.825	0.360
3 vs 4	0.471	0.490	5.680	0.017	1.918	0.170	0.676	0.410

Table A.4. Pairwise comparison of *Capital assets*

Profiles comparison	Land		Own_Land		Production implement index		Basic_services_index		Family_size		Education		Savings		Debt		Farmers_association	
	Wald	p-value	Wald	p-value	Wald	p-value	Wald	p-value	Wald	p-value	Wald	p-value	Wald	p-value	Wald	p-value	Wald	p-value
1 vs 2	0.116	0.940	1.556	0.210	2.790	0.095	3.134	0.077	2.148	0.140	6.463	0.039	0.063	0.800	3.052	0.081	8.873	0.003
1 vs 3	4.626	0.099	0.689	0.410	0.004	0.950	0.980	0.320	5.573	0.018	3951.652	0.000	0.102	0.750	0.656	0.420	0.181	0.670
1 vs 4	7.385	0.025	5.451	0.020	5.617	0.018	7.698	0.005	2.359	0.120	0.045	0,980	8.410	0,004	4.087	0.043	2.306	0.130
2 vs 3	7.430	0.024	7.476	0.006	2.640	0.100	0.167	0.680	8.821	0.003	4057.776	0.000	0.241	0.620	0.287	0.590	8.858	0.003
2 vs 4	8.780	0.012	9.787	0.002	1.141	0.290	0.982	0.320	4.481	0.034	0.289	0,870	4.646	0,031	8.611	0.003	0.323	0.570
3 vs 4	5.569	0.062	3.977	0.046	5.573	0.018	1.673	0.200	0.140	0.710	2909.527	0.000	7.257	0,007	6.898	0.009	2.569	0.110