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Quantifying rural livelihood strategies in developing countries using an activity choice approach

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Abstract

This article uses a quantitative activity choice approach, based on identification of activity variables and application of latent class cluster analysis, to identify five major rural livelihood strategies pursued by households ($n = 576$) in Bolivia, Nepal, and Mozambique. Income sources and welfare outcomes are compared across strategies and household differences in asset holdings are analyzed using multinomial logit regression. Findings reveal that income diversification is the norm, that a higher degree of specialization does not characterize more remunerative livelihood strategies, that nonfarm income significantly contributes to higher income earnings, that environmental reliance does not vary across strategies, and that small-scale farmers are the largest and poorest livelihood group. Some livelihood strategies are superior to all other strategies in terms of income earned; access to more remunerative livelihood strategies is determined by land ownership, education, and ethnic affiliation. Finally, the article also highlights that additional work is required to determine the most suitable methods for livelihood strategy identification.

JEL classifications: I31, O30, Q12, Q50, R20

Keywords: Latent class cluster analysis; Cross-country comparison; Environmental income; Household asset endowments

1. Introduction

Rural livelihood analyses are central to development research that aims to identify appropriate poverty-reducing interventions—what do people do to gain a living, what income options provide the most promising means to escape poverty, and what are the entry barriers? Overall, empirical studies show that rural households engage in a diverse set of income-generating activities (e.g., Davis et al., 2010) so as to smooth income, accumulate wealth, and reduce risk exposure.

Most studies on the role of income diversification strategies in rural livelihoods use total income to assess how income sources vary across income groups (e.g., Cavendish, 2000; Reardon, 1997). This approach is, however, exposed to the stochastic nature of income, which potentially could introduce considerable variation in apparent income dependencies from year to year (Barrett et al., 2001). For example, crop income may show considerable yearly fluctuations due to climatic variation; but low income in low return years does not necessarily imply less importance of this income source to rural households. Even if income was not stochastic, households in the same income groups may differ on a number of asset characteristics and, hence, on how they invest in different income-generating activities. Thus, certain income strategies risk being averaged out if households are grouped according to total income.

Few income studies use multiple criteria to account for different income strategies. Ellis (2000), for example, uses the relative contribution of several income sources to group households into income strategy typologies. This study, however, proposes a different approach to account for the multiple activities households engage in and the stochastic nature of their outcomes. Rather than using relative shares of income components, the article defines income strategies according to household asset allocations into different income-generating activities; these strategies are termed livelihood

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Data Appendix Available Online

A data appendix to replicate main results is available in the online version of this article.

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strategies—defined as a portfolio of activities and choices that people make to achieve their livelihood goals (Jansen et al., 2006). The determinants for diversification choices in livelihood strategies are similar to those put forward in the income diversification literature, among which are; risk reduction, response to diminishing returns (from, e.g., labor supply in the presence of land constraints), seasonality of different income opportunities, specialized skills held by different household members that make it rational to optimally allocate labor into different activities, shocks, and meso/macro-level conditions, such as credit and insurance market failures (Barrett et al., 2001; Ellis, 1998, 2000). Households that are similar in their asset allocation choices are grouped together in same livelihood strategies. By using activity choices, livelihood strategy identification is first and foremost detached from the stochastic influence of productivity outcomes, which introduces opportunities for assessing strategy welfare outcome and reasons for choice of strategy. Total income earned still provides the best measure of welfare—but contrary to normal income groupings we can here assume that mean total income of an observed strategy is a proxy for its expected earnings. Thus, the approach offers possibilities to identify which strategies are poverty reducing and which are not. Second, assuming that households strive to achieve the best possible standard of living, a livelihood strategy choice that provides lower expected income may reflect important asset differences between livelihood strategies and thus point to barriers to entry to more remunerative livelihood options. Finally, livelihood strategy identification also quantifies proportions of the population engaged in each strategy, allowing for development of targeted interventions. Studies that focus on specific income groups risk overlooking certain development options (Brown et al., 2006). It should be noted that these opportunities are not limited to an activity choice approach only; livelihood strategy identification based on the share of different income sources can also be used in studying welfare outcomes—bearing in mind the stochastic influence of income.

Livelihood strategies cannot be identified by a single activity variable only, as the diverse mix of assets available to individual households typically produce a wide range of different asset allocation choices (Barrett et al., 2001). For example, two households endowed with equal areas of land might choose to use that land differently depending on other factors such as human and financial capital at their disposition. Hence, livelihood strategy identification requires clustering a vector of activity variables. A common approach is to use the *k*-means clustering technique (e.g., Brown et al., 2006; Jansen et al., 2006; van den Berg, 2009), which requires starting with pre-determining a more-or-less arbitrary number of cluster centers. Although a range of values for the final number of groups can be tried using the *k*-means clustering technique, the final choice remains rather arbitrary. This is also the case if hierarchical agglomerative clustering is used to determine the number of clusters, as different algorithms may produce different results on the same data set. Therefore, this study uses the latent class clustering technique in livelihood strategy identification, which involves a less arbitrary cluster selection technique based on parameter estimation and model testing.

The overall objective of this article is to contribute to the understanding of empirical regularities of important sources of income among rural livelihood strategies in developing countries and the factors associated with choice of strategy. More specifically, the article seeks to answer (i) if identical activity variables across three case studies in Bolivia, Nepal, and Mozambique identify similar livelihood strategies, (ii) if the livelihood strategies have similar welfare outcomes, and (iii) what the potential barriers are to enter different livelihood strategies. Income-generating activities are used to label livelihood strategies to improve understanding of commonalities and differences between cases and strategies. Total income and income components are used to identify more remunerative strategies and their sources of income. Identification of assets that constrain access to more remunerative livelihood strategies is used to suggest appropriate targets of intervention.

2. Methods

2.1. Conceptual framework

Fig. 1 presents the livelihood strategy framework with the main concepts used, that is, assets, activities, and outcomes. The center piece of the livelihood framework is the activities and choices that households make to achieve their livelihood goals—these choices are shaped by their assets (e.g., land, crops, seed, labor, knowledge, cattle, money, and social relationships) and relevant contextual factors (e.g., problems of access, political, economic and sociocultural contexts, risks, and shocks), all of which influence how people choose to make use of material and social resources (Barrett et al., 2001; Bryceson 1999; Ellis, 1998, 2000; Scoones, 1998). In this article, a livelihood strategy refers to the combination of income-generating activities that a household pursues in order to sustain or improve their livelihood (Ellis, 2000). The framework acknowledges direct links between assets and outcomes, e.g., income gained from remittances made available through relatives working away from the household. The context likewise has a strong influence on strategy choice and outcomes; for example, laws/cultures may dictate what households can invest in and crop income is highly correlated with weather variability.

2.2. Choice of activity variables

Activity variables should link the stock concept of assets to the *ex post* flow of income. Since households employ different assets to generate a living, several variables should be included to capture livelihood strategies (Barrett et al., 2001). First, a combination of variables that measure the allocation of labor and input costs into different income-generating

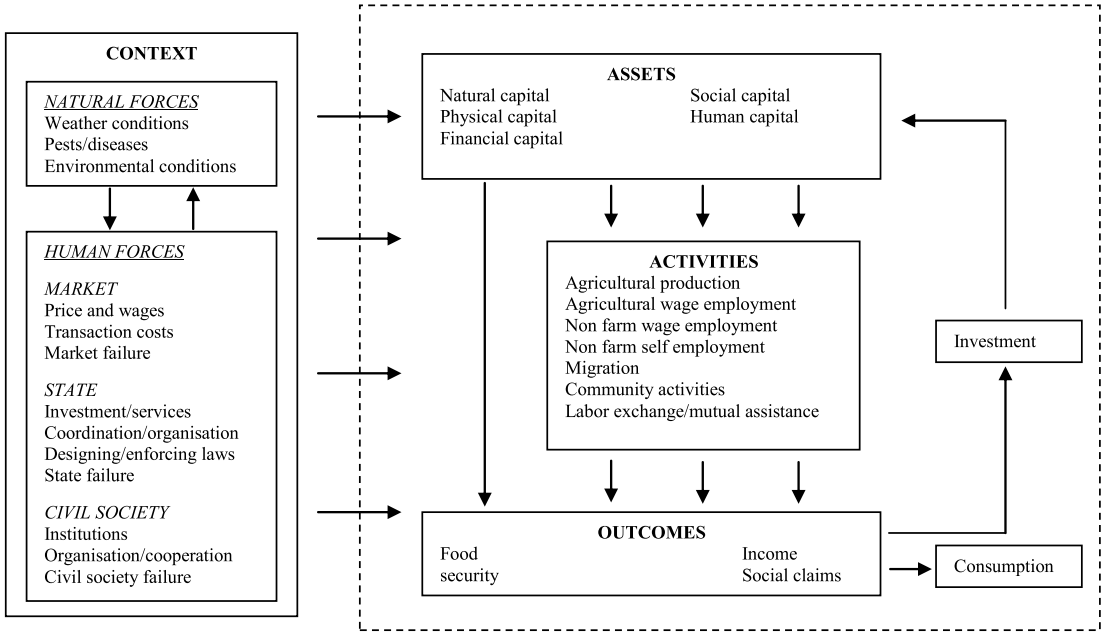

Fig. 1. Household livelihood strategy framework (adapted from Winters et al., 2001).

activities have to be included to encompass all important aspects of livelihood strategy choice; labor allocation as it is the most direct measure of strategy choice and input costs because it measures the level of investment (on top of labor) for each activity. Also transfers, e.g., pensions and remittances, need to be considered to account for income generated from nonproductive assets. The three case studies measured labor allocation in employed activities (i.e., wage labor), but did not measure it for self-employed activities—mainly because self-employed labor allocation is difficult and time-consuming to capture. In this article, we are limited to using input costs in productive activities as an approximate measure for how households choose to invest in self-employed activities. Finally, transfer payments are included to take into account the aspect of generating income from nonproductive assets. In total, seven activity variables are included: (i) purchased inputs in activities related to collection of environmental products, (ii) purchased inputs in agricultural- and (iii) livestock-related activities, (iv) purchased inputs (i.e., operational expenses) in business activities, (v) days allocated to on-farm and (vi) off-farm wage work, and finally (vii) transfer income. Wage work classification follows sectorial distinctions; on-farm wage work include all agricultural-related wage work activities (regardless of location), whereas off-farm wage work include all other wage work types (such as wage work in the forest product processing industry and in the transport, construction, mining, and service industries). The final set of activity variables (adjusted to adult equivalent units to make them comparable across households) was derived through principal component analyses of a larger set of variables to identify key activities that characterize strategy choice. Activity and key asset variables were also tested for correlation to exclude those with significant correlations at 5% level of 0.6 or above. Significant correlations were almost eliminated in the final set of activity and asset variables; livestock inputs were correlated with Tropical Livestock Units (TLU) in Nepal (Pearson corr. $= 0.7482$, $P \leq 0.0001$) and agricultural inputs in Mozambique (Pearson corr. $= 0.6605$, $P \leq 0.0001$). Livestock input was, however, kept in the final set as no appropriate substitute was available in the data set.

Previous studies have also used a mix of indicators in livelihood strategy identification. Jansen et al. (2006) and van den Berg (2009) both uses the proportion of labor and land allocated into different activities. Labor allocation is a central component in livelihood strategy identification, but none of the studies consider other forms of self-employment, e.g., business-related activities, and income from nonproductive assets. Brown et al. (2006) partly base their livelihood identification on asset variables, e.g., head counts of different livestock types, which is problematic if these are closely related to asset variables used to explain strategy choice.

2.3. Clustering method

Latent class cluster analysis of the seven selected activity variables (all continuous) was used to group households into livelihood strategies. The advantage of this method, compared to standard clustering techniques that, e.g., minimizes within cluster variation, is that it assigns probabilities to each solution and offers significance tests that support choices of variables and number of clusters, thereby making the final clustering and cluster assignment less arbitrary (Magidson and Vermunt, 2002). The basic latent class cluster model with no covariates and no local dependencies between variables is given by

(Vermunt and Magidson, 2003b):

$$\pi(x_1 x_2 \ldots x_n) = \sum_z \pi(z) \prod_{i=1}^{n} \pi(x_i \mid z), \quad (1)$$

where n is the number of indicator variables, x_i, z is a single latent class variable which is assumed to have a certain number of levels corresponding to the number of classes/clusters/subpopulations in the data set, $\pi(x_1 x_2 \ldots x_n)$ is the probability of observing a particular combination of indicator values, $\pi(z)$ is the probability of a certain value of the latent class variable, and $\pi(x_i \mid z)$ is the conditional probability of x_i for a given latent class z. For the seven continuous (activity) variables, the conditional probabilities $\pi(x_i \mid z)$ are determined according to a normal distribution function.

In the above model, the indicators are assumed to be locally independent. However, as this is not true for all variables, it is necessary to compare the basic model with models where the local independence assumption is relaxed for selected pairs of indicators. In practice, we compared the performance of models with 1–12 clusters and 0–2 dependent pairs. Although inputs to agriculture and livestock were to some extent related it turned out that operating with dependent pairs of variables did not consistently improve the performance of the model. Hence, models reported in this article are based on the assumption of local independence of indicator variables.

Finally, models were compared using the Bayesian Information Criterion (*BIC*) for the logarithm of the likelihood function ($\log \ell$), which includes a penalty for the numbers of parameters j and observations N: $BIC_{\log \ell} = -2 \log \ell + j \log N$. The lower the value of $BIC_{\log \ell}$ the better the fit of the model. The analysis was carried out using Latent Gold 3.0 (Vermunt and Magidson, 2003a,b).

2.4. Econometric model specification

To identify determinants of households' choice of livelihood strategy, the identified livelihood groups were subjected to discrete choice modeling, using multinomial logit (MNL) regression.

The MNL model provides a set of equations that each show the effect of explanatory variables on the log-odds ratios $\ln[\frac{P_{ij}}{P_{ik}}] = x_i' \beta_j$: for each unit change of x_i, the coefficients β_j reflect the change in the log-ratio between the probability of choosing livelihood strategy j and the probability of choosing livelihood strategy k (Greene, 2003). The baseline group k against which other strategies are compared is in this article the largest and poorest livelihood group, as we assume that this strategy is open to all or most households.

Eight asset variables were selected as being important to livelihood choice. These were number of adult (i) male and (ii) female members in the household to reflect labor availability and if gender characterize strategy choice, (iii) household head education in years to reflect skills, (iv) savings, (v) productive implements and (vi) livestock holding (TLU) to capture liquidity to, e.g., undertake more risky and more remunerative income activities, (vii) size of landholding to reflect natural capital available to the households, and (viii) ethnic relation as this is normally correlated with wealth, e.g., in Nepal.

2.5. Study areas

Data were collected from three sites in highland Asia (Nepal), dryland Africa (Mozambique) and lowland South America (Bolivia) that each represents different socioeconomic settings—an overview of site and country-specific information is provided in Table 1. The study sites form part of the Poverty Environment Network (Angelsen et al., 2011), aiming to undertake the first global analysis of environmental reliance among rural households in developing countries. The primary site selection criteria for all sites were that households had to live in proximity to forest resources—hence the results presented in this article are mainly representative for rural settings adjacent to forest resources sharing similar socioeconomic attributes. The six (three in-migrant and three indigenous) communities selected in relatively well-off Bolivia are located in an area dominated by tropical lowland rainforest. Access to market with public transportation via river and road is reasonable. Main subsistence crops are rice, maize and, cassava; main commercial crops are coca leaves (legal to produce on small plots) and fruits (citrus, plantain, and cocoa). The surveyed households in Bolivia enjoy the benefits of a relatively stronger commercial agricultural sector compared to Nepal and Mozambique. The six selected villages in Mozambique are located in dry miombo woodland approximately 60 km from the provincial capital Chimoio. Households rely on rainfed agriculture (rainfall is about 1,080 mm); maize is the most important staple crop whereas cash crops include cotton, sugar cane, banana, and sunflower. Parasitic diseases prevent production of cattle and other large livestock. Households in Mozambique generate a larger share of their income from commercial forest products and from a growing informal gold extraction sector. The five selected villages in upland Nepal are situated in a conservation area with grasslands on rugged steep mountain slopes, forests on mid-slopes and plateaus, and cultivated river valleys. The climate is temperate to alpine, with precipitation around 1,250 mm per year. Market and road access is poor: all settlements are at least half a day's walk to the district headquarter and one day's walk to the nearest all weather road linking to major markets. The Nepalese site is influenced by tourism that creates favorable business opportunities with trickle down effects on wage employment opportunities. Transfers are also a common source of income—many households have family members working in cities or abroad. Environmental resource use is restricted by conservation area rules.

2.6. Data collection

The data were collected using the Poverty Environment Network survey protocol designed to measure income and

Table 1
Overview of the Bolivia, Mozambique, and Nepal case studies, 2006–2007 (based on data from the household survey and secondary information)

	Bolivia	Nepal	Mozambique
Lat. / long.	16°59′08″ S / 65°25′44″ E	28°37′00″ N / 83°38′00″ E	19°00′52″ S / 33°55′36″ E
Altitude (m.a.s.l)	340	> 1900	400
Ecological zone	Moist tropical forest	Temperate to alpine forest	Dry tropical forest
No. of villages	6	5	6
No. of households	322	337	1104
No. of sampled households	118	186	272
Av. household size	5.5	5.2	5.9
Av. distance to market (km)	70	38	60
Accessibility	Medium	Poor	Medium/Good
Main income activities	Agriculture, fishing, timber harvesting, hunting	Agriculture, livestock, trade, business, forestry	Agriculture, forestry, gold exploitation
Daily income per capita (USD PPP)	8.5	5.3	0.9
Country indicators:			
Adult literacy (%)	86.7	61.4	56.2
Life expectancy (yrs)	64.7	60.9	42.4
Population with access to safe water (%)	86	89	42
Human development index	0.723	0.530	0.366

Note: Daily income is converted into purchasing power parity (PPP) adjusted U.S. Dollars (USD)

livelihood patterns (Angelsen et al., 2011; PEN, 2007). Use of standardized data collection methods resulted in high-quality data (e.g., Uberhuaga and Olsen, 2008); and findings reflect study area realities that are not caused by differences in data collection methods. The primary unit of analysis is the household, randomly selected from household lists: 186 in Nepal, 272 in Mozambique, and 118 in Bolivia. The data collection period spanned a complete year covering the production cycle in each location: December 2005–December 2006 in Nepal, February 2006–January 2007 in Bolivia, and June 2006–May 2007 in Mozambique. Four quarterly surveys collected data on assets, income, and production costs from seven major income categories: (i) forest and environment, (ii) agriculture, (iii) livestock, (iv) wage employment, (v) business, (vi) transfers, and (vii) others. Market prices or households' own reported values for products with thin or no market values were used to calculate income. Net income is inclusive of households' own labor input because household labor allocation into different activities is difficult to disaggregate—only for wage employment is labor allocation estimated (Babulo et al., 2008; Cavendish, 2002; Kamanga et al., 2009).

3. Results

3.1. Livelihood strategy classifications

As mentioned earlier, the latent class cluster model with lowest BIC value provides the best fit. There was, however, no clear indication of an optimal cluster solution for any of the three case studies. For Bolivia, only very small improvements in BIC values were observed beyond three clusters, for Nepal this was the case for four clusters and more, whereas for Mozambique cluster solutions of five or more also produced similar BIC values. The final number of clusters was therefore based on the highest coefficient of determination (Pseudo-R^2) from MNL regressions of different cluster solutions—using cluster classification as the dependent variable and the asset variables in Section 2.4 as the independent variables. For all case studies, the five-cluster solution generated the highest coefficient of determination and, as indicated earlier, this was not in conflict with the BIC values observed for the cluster models.

Each household was assigned to one strategy only. Table 2 summarizes the statistics for activity variables for each of the five clusters and their livelihood strategy names. Statistical comparison is based on Bonferroni pairwise tests of the activity variables (see Appendix A for significant results). None of the three case studies have exact similar livelihood strategies—there are important between-country differences—and therefore cluster names vary between countries. For all case studies, however, cluster 1 is labeled small-scale farmers because of low mean values of all activity variables. The remaining clusters are named in accordance with their significant differences to small-scale farmers (cluster 1). For Bolivia, cluster 2 uses significantly more inputs in agriculture and livestock (relative to cluster 1) and is labeled large-scale farmers. Cluster 3 is labeled off-farm workers, cluster 4 is livestock producers and off-farm workers, and, finally for Bolivia, cluster 5 is labeled off-farm workers and business operators due to their engagement in off-farm wage work and business-related activities. In Nepal, cluster 2 is labeled livestock producers and business operators as these two activities signify the differences between the two clusters (significant differences also exist for environmentally related activities). Clusters 3 and 4 are labeled farm and off-farm workers, respectively, due to their engagement in these two activities. Finally, agriculture, livestock, and business remain the core activities of cluster 5, this cluster is hence labeled large-scale farmers and businesses operators. For Mozambique,

Table 2
Mean activity values for each of the five livelihood clusters. Livelihood strategy names are based on Bonferroni pairwise tests of activity variables (see Appendix A)

Livelihood strategy	1	2	3	4	5
Bolivia	Small-scale farmers	Large-scale farmers	Off-farm workers	Livestock producers and off-farm workers	Off-farm workers and business operators
Input costs (USD PPP), environmental products	5.9	2.1	2.6	890.3	1.1
Input costs (USD PPP), agriculture	200.6	2,596.8	625.4	746.0	1,071.0
Input costs (USD PPP), livestock	252.1	1,838.4	371.9	1,334.0	260.4
Input costs (USD PPP), business	28.8	185.4	20.8	75.3	1,381.2
Agricultural wage work (days)	18.5	7.2	3.5	20.1	21.9
Off-farm wage work (days)	0.7	1.1	46.4	27.5	50.7
Transfer income (USD PPP)	6.1	1.6	299.1	4.9	119.6
No. of households	45	32	17	14	10
Nepal	Small-scale farmers	Livestock producers and business operators	Farm workers	Off-farm workers	Large-scale farmers and business operators
Input costs (USD PPP), environmental products	25.4	405.4	11.3	532.0	934.2
Input costs (USD PPP), agriculture	222.7	684.7	229.6	379.9	4,291.7
Input costs (USD PPP), livestock	132.1	2,645.5	40.5	81.9	9,299.8
Input costs (USD PPP), business	131.6	1,559.1	4.4	173.4	4,163.4
Agricultural wage work (days)	0.1	0.1	14.0	1.6	1.5
Off-farm wage work (days)	7.8	0.1	5.5	27.0	2.8
Transfer income (USD PPP)	51.0	12.8	353.2	1,261.6	113.1
No. of households	71	47	41	16	11
Mozambique	Small-scale farmers	Livestock producers	Wage workers	Business operators	Large-scale farmers and off-farm workers
Input costs (USD PPP), environmental products	0.9	0.4	0.9	36.7	29.7
Input costs (USD PPP), agriculture	8.9	65.0	34.2	96.6	453.8
Input costs (USD PPP), livestock	0.2	15.4	3.7	0.5	74.5
Input costs (USD PPP), business	1.9	35.0	5.4	282.2	52.8
Agricultural wage work (days)	3.4	0.6	18.6	1.6	0.5
Off-farm wage work (days)	0.3	0.1	24.6	0.0	10.3
Transfer income (USD PPP)	2.4	12.7	13.0	0.7	98.1
No. of households	120	72	36	28	16

Note: All variables are adult equivalent adjusted and converted into purchasing power parity (PPP) adjusted U.S. Dollars (USD).

livestock-related activities are what distinguishes cluster 2 from 1, and it is therefore labeled livestock producers. Cluster 3 is characterized by being farm and off-farm workers and is labeled wage workers. Households in cluster 4 are business operators, and cluster 5 are large-scale farmers and off-farm wage workers due to a relatively large use of inputs into agriculture and days spent in wage work.

In Table 2, the clusters are arranged according to their size. Small-scale farmers are by far the largest group in all countries—their relative shares range from 38% (Bolivia and Nepal) to 44% (Mozambique) of the total sample sizes. In Bolivia, large-scale farmers is a medium-sized group (27%), whereas the remaining livelihood strategy groups are small—their shares range from 8% (off-farm workers and business operators) to 12% (livestock producers and off-farm workers) and 14% (off-farm workers). Off-farm work is, however, common to these individual livelihood strategies and is therefore an important income component for many households in Bolivia. In Nepal, livestock producers and business operators (cluster 2) and farm workers (cluster 3) are of medium size (relative shares are 25% and 22%, respectively), whereas off-farm workers (cluster 4) and large-scale farmers and business operators (cluster 5) are smaller groups (6% and 9%, respectively). In Mozambique, livestock producers (cluster 2) is also a fairly large group (26%), whereas the remaining cluster shares range from 6% (cluster 5) to 10% (cluster 4) and 13% (cluster 3). Findings thus indicate that the major livelihood strategy groups (the large and medium-sized groups) account for 65% (Nepal), 71% (Mozambique), and 85% (Nepal) of the observations; how they perform in terms of generating income is thus central for poverty analyses.

3.2. Comparing livelihood strategy incomes

In the following sections, we assess which livelihood strategies have (i) better outcomes in terms of mean total income earned (assuming that mean total household income reflects the expected outcome of a chosen strategy) and (ii) greater probabilities of earning higher incomes compared to other strategies (assuming that the sample distributions approximate the underlying distribution for each strategy). Households that choose a

Table 3
Absolute contribution of income components to total income (numbers in brackets show standard deviations)

Livelihood strategy	*n*	Environmental income	Crop income	Livestock income	Wage income	Business income	Transfer income	Other income	Total income
Bolivia									
1	45	356.2 [686.3]	1, 089.1 [1, 403.6]	75.3 [150.6]	277.8 [369.7]	78.7 [152.0]	13.0 [39.8]	67.9 [208.1]	1,958 [1,998]
2	32	779.1 [2, 871.5]	2, 316.8 [3, 487.6]	199.1 [604.3]	121.2 [158.3]	217.8 [443.3]	3.4 [12.1]	210.1 [795.9]	3,847 [4,566]
3	17	573.1 [1, 162.3]	1, 464.9 [1, 684.6]	9.8 [35.3]	876.7 [1, 069.9]	61.4 [173.4]	312.3 [710.7]	219.3 [627.3]	3,517 [3,593]
4	14	946.5 [812.0]	937.6 [795.6]	18.6 [112.8]	917.9 [925.9]	118.5 [240.6]	10.7 [24.0]	23.0 [60.1]	2,973 [1,299]
5	10	1, 223.5 [3, 143.0]	1, 479.9 [1, 482.2]	44.3 [78.7]	740.4 [840.2]	1, 761.7 [1, 657.3]	133.4 [181.0]	68.2 [110.3]	5,451 [4,143]
Overall	118	645.7 [1, 859.3]	1, 491.3 [2, 208.3]	90.1 [335.3]	436.8 [681.8]	261.3 [704.7]	63.4 [289.8]	123.0 [495.3]	3,111 [3,384]
Nepal									
1	71	120.5 [117.8]	221.6 [254.9]	421.0 [704.5]	241.0 [356.0]	105.3 [197.8]	63.6 [120.3]	112.4 [537.0]	1,285 [966]
2	47	88.3 [89.5]	203.8 [286.3]	594.1 [627.6]	184.4 [403.2]	1, 002.5 [1, 170.6]	52.1 [146.8]	118.2 [200.7]	2,243 [1,431]
3	41	71.4 [51.6]	94.2 [114.0]	230.6 [197.0]	215.3 [265.7]	13.0 [25.7]	359.3 [530.6]	12.7 [52.4]	996 [655]
4	16	230.1 [159.5]	303.0 [349.5]	380.9 [354.8]	351.8 [494.8]	150.1 [278.6]	1, 271.1 [1, 669.3]	101.3 [232.3]	2,788 [1,855]
5	11	152.2 [196.0]	491.5 [526.6]	2, 629.7 [5, 307.2]	154.5 [351.2]	2, 160.6 [2, 360.7]	204.3 [397.7]	1, 132.1 [1, 150.7]	6,925 [6,062]
Overall	186	112.8 [117.5]	212.0 [284.9]	550.0 [1, 454.6]	225.4 [363.8]	437.1 [1, 005.1]	238.1 [649.8]	151.2 [508.1]	1,927 [2,268]
Mozambique									
1	120	51.0 [50.5]	83.0 [47.8]	12.1 [15.2]	17.8 [23.4]	15.5 [34.8]	2.9 [4.8]	26.5 [56.0]	209 [99]
2	72	73.6 [110.6]	154.3 [125.1]	31.7 [33.3]	8.0 [17.3]	36.7 [53.3]	13.5 [22.3]	45.8 [95.9]	364 [221]
3	36	88.4 [89.8]	71.9 [48.8]	21.6 [25.0]	106.4 [116.8]	17.7 [42.2]	13.3 [23.3]	35.7 [49.2]	355 [170]
4	28	118.1 [160.7]	146.4 [147.7]	36.0 [57.7]	13.8 [25.0]	141.5 [164.6]	1.9 [6.4]	111.2 [377.5]	569 [502]
5	16	101.9 [88.2]	254.8 [431.9]	54.5 [57.8]	46.2 [124.9]	32.2 [40.1]	103.5 [190.2]	25.3 [71.1]	618 [459]
Overall	272	71.8 [94.2]	117.0 [142.4]	23.5 [33.7]	28.2 [63.4]	35.4 [75.3]	12.9 [52.5]	41.5 [138.6]	330 [274]

Note: All variables are adult equivalent adjusted and converted into purchasing power parity (PPP) adjusted U.S. Dollars (USD).

livelihood strategy with less expected income or less likelihood of getting higher income could indicate constraints that limit livelihood strategy choice.

Table 3 shows mean income from different sources and total income earned for each livelihood strategy. In order to rank the livelihood strategy outcomes in terms of total income earned—and examine what income components contribute to income differences—Bonferroni pairwise tests of income components and total income were performed between the five livelihood strategies for each country. Appendix B reports the significant pairwise test results. Surprisingly, total income does not differ significantly between livelihood strategies in Bolivia. The exception is off-farm workers and business operators (cluster 5) who generate significantly more income than small-scale farmers (primarily due to their income from business-related activities). By removing five outliers in clusters 1, 2, and 3, however, mean total income of off-farm workers and business operators become significantly higher than the other strategies (what characterizes the five outliers is discussed in the next section). Another interesting finding is that livelihood strategies do not differ in income earned from crops and livestock, despite that, e.g., large-scale farmers (cluster 2) spend significantly more on inputs in these activities. Again, crop income becomes significantly different for large-scale farmers versus small-scale farmers when the five outliers are removed. What generates income differences are activities related to wage work, business, and transfer, which shows that off-farm income opportunities in Bolivia are important for improving local livelihoods. In Nepal, small-scale farmers (cluster 1) and farm workers (cluster 3) are significantly poorer than other livelihood strategies in terms of total income earned. Livestock producers and business operators (cluster 2) and off-farm workers (cluster 4) are medium-income groups; they have significantly higher total incomes compared to clusters 1 and 3, which is mainly due to their earnings from business (cluster 2) and transfer income (cluster 4). Off-farm workers also generate significantly more income from environmental resources, although the contribution is small compared to other income sources. The richest livelihood strategy group in Nepal is large-scale farmers and business operators (cluster 5); income components that contribute to higher earnings are livestock, business, and other income. Crop income is, like in Bolivia, less important in contributing to income differences between livelihood strategies; large-scale farmers and business operators do earn significantly more from crop production compared to other strategies—the difference is however small relative to other income components. In Mozambique, the small-scale farmer group (cluster 1) is also the least remunerative livelihood strategy. Livestock producers (cluster 2) and wage workers (cluster 3) are medium-income groups, whereas business operators (cluster 4) and large-scale farmers and off-farm workers (cluster 5) are the richest livelihood groups. Compared to small-scale farmers (cluster 1), livestock producers (cluster 2) earn significantly more from crop income and wage workers (cluster 3) earn more from wage income. For the most remunerative strategies, business operators (cluster 4) earn more from business whereas large-scale farmers and off-farm workers (cluster 5) earn more from crop production and transfers. Crop income seems to play a more prominent role in explaining income differences for livelihood strategies in Mozambique along with off-farm activities (such as wage work and business). As was the case for Bolivia and Nepal, environmental income has a limited contribution to income differences between livelihood strategies.

We also ranked livelihood strategy outcomes based on first-order stochastic dominant analyses. When plotting the cumulative densities of total income per capita for each livelihood

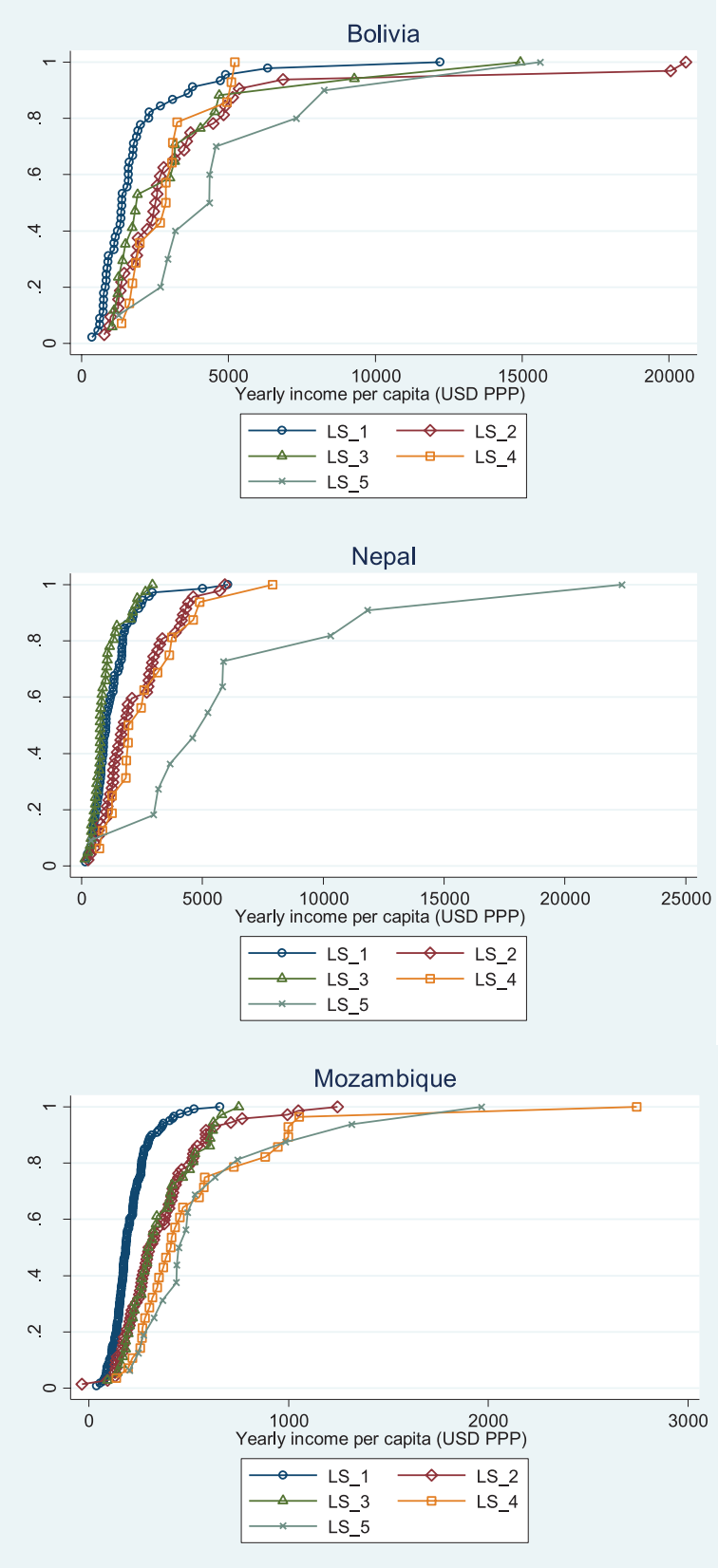

Fig. 2. Cumulative density distributions for each livelihood strategy (LS) in Bolivia, Nepal, and Mozambique.

strategy in the three case study areas (see Fig. 2), stochastically dominant strategies are those that—for all income levels—are characterized by a lower cumulative density compared to other strategies. These strategies produce better outcomes as the likelihood of drawing higher incomes are greater for every possible income draw (Brown et al., 2006). Here, we relax this criterion by accepting that few observations (one or two) may overlap other cumulative density curves. For Bolivia, however, the cumulative density distributions reveal one outlier for small-scale farmers (cluster 1) and two outliers for larger scale farmers (cluster 2) and off-farm workers (cluster 3), respectively. Closer examination of their attributes reveals that the total income observed is likely not stochastic as all outliers have significantly more land compared to other households in their respective livelihood strategy groups. Thus, the outliers are excluded from the interpretation of the cumulative distribution curves for livelihood strategies in Bolivia. The results indicate that small-scale farmers is first-order stochastically dominated by all the other strategies. Small-scale farmers thus appears to be the most inferior strategy—although according to the Bonferroni pairwise tests mean total income was only significantly smaller compared to off-farm workers and business operators (cluster 5, Appendix B). Disregarding the outliers, off-farm workers and business operators (cluster 5) also first-order stochastically dominate the other strategies—making it the best strategy in terms of income. Finally, comparing large-scale farmers (cluster 2), off-farm workers (cluster 3) and livestock producers and off-farm workers (cluster 4) do not indicate that one livelihood strategy is better than others. In Nepal, the cumulative density curves confirm the Bonferroni pairwise tests; large-scale farmers and business operators (cluster 5) stochastically dominate other strategies, whereas off-farm workers (cluster 4) and livestock producers and business operators (cluster 2) have greater likelihood of drawing higher incomes compared to small-scale farmers (cluster 1) and farm workers (cluster 3). Also for Mozambique, the cumulative density curves confirm the Bonferroni test results; small-scale farmers are first-order stochastically inferior to other strategies, whereas large-scale farmers and off-farm workers (cluster 5) and business operators (cluster 4) first-order stochastically dominate wage workers (cluster 3) and livestock producers (cluster 2).

In conclusion, the mean income differences and the cumulative density distributions show that some strategies are to be preferred over others assuming that households strive to maximize income. Many households, however, pursue livelihood strategies with a low expected return—the next section will explore what factors are associated with choice of strategy.

3.3. Determinants of livelihood strategy choice

Results from the MNL regression are presented in Table 4; the coefficients reflect the effect of assets on the likelihood of strategy choice relative to the choice of being small-scale farmers (cluster 1 for all case studies). Appendix C presents the mean values of household asset characteristics that underlie the regression results.

In Bolivia, off-farm workers and business operators (cluster 5) are characterized by households with higher education relative to the small-scale farmers. Households are also characterized by having fewer adult males, probably due to their engagement in off-farm employment away from the household. It is also clear that off-farm workers and business operators do not engage in and build up livestock—but rather divert savings into productive implements related to, e.g., business activities. Surprisingly, they have fewer savings compared to small-scale farmers; it is likely that the total savings that these households have access to be larger, as savings held by household members working away from the household was not considered. Large-scale farmers (cluster 2) do hold more capital in the form of implements and livestock compared to small-scale farmers. They too are less likely to hold liquid capital in the form of savings compared to small-scale farmers—most of their financial capital is stored in livestock. This could indicate that they are better off compared to small-scale farmers; richer households tend to hold more risky capital, whereas poorer households, due to their larger risk aversion, prefer to hold savings in cash (Zeller et al., 1997). Off-farm workers (cluster 3) in Bolivia are characterized as being migrant households holding less livestock. The households are female-dominated, likely because male members are away for off-farm work. Finally, livestock producers and off-farm workers (cluster 4) are not much different from small-scale farmers in terms of assets—they are more likely to hold more productive implements for, e.g., livestock production.

In Nepal, ethnic affiliation has a strong bearing on choice of strategy. Here, we distinguish between the occupational caste group—including traditional occupations such as blacksmith and tailor—and the privileged caste group who enjoy access to job positions in the public and private sectors. The most remunerative livelihood strategy, large-scale farmers and business operators (cluster 5) is, compared to small-scale farmers, dominated by the privileged caste group and households with larger land holdings (which is closely associated with ethnic affiliation). Large-scale farmers and business operators are also more likely to hold more livestock and productive implements. On the other hand, off-farm workers (cluster 4), a more remunerative livelihood strategy compared to small-scale farmers, is characterized by households belonging to the occupational caste group. Hence, ethnic affiliation is not necessarily an entry barrier to higher income earnings—opportunities are available on the wage labor market for the occupational caste group as well. Households are also less likely to have male laborers compared to small-scale farmers—indicating that it is the male members who travel away for off-farm employment opportunities. Livestock producers and business operators (cluster 2), a similarly remunerative strategy as off-farm workers, is dominated by households from the privileged caste group. They only differ from

Table 4
Multinomial logistic regression showing differences in asset characteristics between livelihood groups

Livelihood strategy	2		3		4		5	
Bolivia	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$
Males (>11 years)	−0.181	0.389	−0.524	0.251	−0.421	0.416	−8.784	0.001
Females (>11 years)	0.240	0.332	0.706	0.054	0.077	0.850	1.332	0.191
Education, hh head (years)	0.066	0.432	0.095	0.434	−0.032	0.761	0.653	0.002
Savings (USD PPP)	−0.002	0.031	0.002	0.150	−0.002	0.169	−0.005	0.004
Productive implements (USD PPP)	0.002	0.002	−0.001	0.320	0.002	0.023	0.004	0.000
Total land (hectares)	0.038	0.197	0.059	0.103	−0.079	0.198	0.096	0.135
TLU	0.976	0.011	−3.971	0.047	−1.583	0.299	−20.367	0.007
Ethnic group[a]	−0.698	0.233	−1.596	0.042	0.191	0.802	−0.572	0.741
Constant	−1.397	0.092	−1.306	0.251	−0.232	0.803	−1.106	0.687
Number of obs = 118, Pseudo $R^2 = 0.2841$								
Nepal	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$
Males (>11 years)	−0.050	0.813	−0.391	0.072	−0.602	0.014	0.585	0.272
Females (>11 years)	0.376	0.143	0.591	0.023	−0.378	0.293	−0.234	0.583
Education, hh head (years)	0.051	0.440	0.068	0.401	−0.125	0.107	−0.010	0.930
Savings (USD PPP)	0.000	0.605	−0.001	0.005	0.000	0.859	0.000	0.471
Productive implements (USD PPP)	0.002	0.001	−0.006	0.030	0.003	0.002	0.003	0.000
Total land (hectares)	0.116	0.923	−2.700	0.066	−0.623	0.659	3.706	0.055
TLU	0.325	0.135	−1.097	0.015	−0.266	0.289	0.498	0.033
Ethnic group[a]	1.339	0.021	−1.426	0.064	−1.705	0.082	15.359	0.000
Constant	−3.170	0.000	1.190	0.118	0.461	0.576	−21.183	0.000
Number of obs = 186, Pseudo $R^2 = 0.3614$								
Mozambique	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$	Coef.	$P > z$
Males (>11 years)	0.262	0.055	−0.590	0.016	−0.208	0.474	0.042	0.875
Females (>11 years)	0.010	0.943	−0.070	0.740	−0.183	0.448	0.281	0.282
Education, hh head (years)	0.111	0.197	0.062	0.562	0.465	0.000	0.432	0.010
Savings (USD PPP)	0.053	0.005	0.068	0.000	0.061	0.001	0.066	0.001
Productive implements (USD PPP)	0.027	0.002	−0.026	0.079	0.030	0.001	0.016	0.361
Total land (hectares)	0.259	0.174	−0.112	0.650	0.405	0.071	0.569	0.009
TLU	10.214	0.002	4.814	0.167	7.796	0.063	16.240	0.000
Ethnic group[a]	−0.783	0.022	0.819	0.091	−0.296	0.597	−1.223	0.001
Constant	−2.513	0.000	−1.341	0.073	−4.087	0.000	−6.471	0.000
Number of obs = 272, Pseudo $R^2 = 0.2367$								

[a]Ethnic group: Bolivia: 0 = Migrant, 1 = Indigenous; Nepal: 0 = Occupational caste group, 1 = Privileged caste group; Mozambique: 0 = Minor ethnic group, 1 = Dominant ethnic group.

small-scale farmers in terms of productive implements (e.g., business-related activities). Finally, farm workers (cluster 3), dominated by the occupational caste group, are the most asset-poor households. They are characterized by female-dominated households with less savings, productive implements, land holdings, and livestock compared to small-scale farmers. Their income earned is however not significantly different from that of small-scale farmers as some of their income is money transfers—indicating that male members living away support the household through sending money; out of the 359 U.S. Dollars (USD) that households on average receive in transfer income, 340 USD are remittances (not shown in Table 3).

In Mozambique, education is significantly higher for households in the most remunerative livelihood groups; business operators (cluster 4) and large-scale farmers and business operators (cluster 5). They also have more savings, productive implements (cluster 4), land (cluster 5), and livestock. Livestock producers (cluster 2), a medium remunerative strategy, is characterized by having more labor, savings, productive implements, and livestock compared to small-scale farmers. And finally, wage workers (cluster 3), have less male adults, more savings, and less productive implements.

4. Discussion

When interpreting findings, it should be kept in mind that (i) the village selection criteria included access to forest, and (ii) that the unified data collection method (Angelsen et al., 2011; PEN, 2007) enables comparison of results across study areas.

The case studies documented that multiple income sources are important to all households regardless of strategy. This supports existing quantitative livelihood strategy findings (Brown et al., 2006; Ellis and Freeman, 2005; Jansen et al., 2006; van den Berg, 2009) as well as more qualitative findings (e.g., Homewood, 2005). Diversification is the norm (Davis et al., 2010)—no household relies on one or two income sources alone. The level of diversification among livelihood strategies is, however, more or less similar. As a measure for income diversification, we calculated the Simpson Diversity Index across livelihood strategies for each case study and tested for significant differences using the Bonferroni method (not reported in the Results section). In Bolivia, income diversification is significantly larger for large-scale farmers (cluster 2) compared to small-scale farmers (cluster 1), off-farm workers (cluster 3), and livestock producers and off-farm workers (cluster 4). In Nepal and Mozambique, no significant differences in terms of income diversification were found between the strategies. Although it is beyond the scope of this article to assess the reasons for the observed income diversification—risk management could be one motive (particular among the poorer livelihood strategies)—one should bear in mind that, in a developing country context, the seasonal nature of employment opportunities as well as the differences in skills among household members naturally encourage the household to optimally allocate labor into different activities (e.g., skilled household members who can earn higher return to their labor in wage work compared to working on their own agricultural plot). Therefore, results indicate that income diversification plays a prominent role in optimizing income and that specialization into specific income-generating activities, as we would expect to observe among the more remunerative livelihood strategies, is generally not a viable strategy for any of the livelihood groups. The importance of different income sources in maintaining and improving livelihoods, however, varies across study sites as a consequence of locally available income opportunities. In Nepal, nonfarm income such as business and transfer income provide higher income earning opportunities—livestock production also contributes to significantly higher incomes for one of the livelihood strategies. In Mozambique, both farm and nonfarm incomes are important for higher income earnings—crop, business, wage, and transfer income are the most important income types among more remunerative livelihood strategies. In Bolivia, it is mainly nonfarm income that characterizes more remunerative livelihood strategies—i.e., wage and business income. Thus, in agreement with previous studies (e.g., Carter and Barrett, 2006; Reardon, 1997), we found that nonfarm income is important to local livelihoods.

In Bolivia, assets that in particular play a role in access to more remunerative livelihood strategies are education and access to off-farm labor markets. In-migrated households are more engaged in off-farm employment, partly because of formal education. Indigenous households are more engaged in livestock production while migrant farmers invest in implements (although this relationship is not significant), which suggests differences in skills among migrants and indigenous households. Livelihood improving interventions, through generation of additional income, should thus focus on education, improved access to markets, and productive skills. In Nepal, caste membership has a strong influence on livelihood choice: generally the privileged caste group has access to more remunerative livelihood strategies and they also appear more asset rich in terms of land and livestock. Ethnic affiliation is thus an important factor for economic status and mobility. Off-farm wage labor markets do provide opportunities for occupational caste group households to access more remunerative strategies, but an uneven distribution of assets suggests that these households are restricted in improving their livelihoods. In Mozambique, a local wage labor market is accessible for asset poor households. Education and land determine access to more remunerative livelihood strategies; these, however, also yield low per capita daily income and may thus not necessarily provide pathways out of poverty—especially not in situations where macro-level economic poverty traps, e.g., caused by lack of infrastructure, are present.

The most dominant and poorest livelihood strategy is small-scale farmers. In Bolivia and Nepal, 38% of households are small-scale farmers whereas the share in Mozambique is 44%. It is a livelihood strategy that earns less on any income source, in absolute terms, compared to other strategies. Other studies emphasize that there are certain sources of income that are relatively more important to rural poor households than others, e.g., income from crop production and environmental resources (Homewood, 2005; Vedeld et al., 2007). Babulo et al. (2009), for example, identify a large group of poor households (58%) that critically rely on agricultural and environmental income, although a different method to categorize households into livelihood strategy groups is applied. In their study, crop and environmental income accounted for 42.6% and 27.0%, respectively. The present study also found high shares of income from environmental resources and crop production. In Bolivia, the shares of small-scale farmers' earnings from crop and environmental income are 55.6% and 18.2%, respectively. Small-scale farmers in Mozambique get 39.7% from crop production and 24.4% from environmental resources. In Nepal, the contributions of crop and environmental income are relatively low, 17.2% and 9.4%, respectively; this is in part due to a year characterized by poor agricultural production, thin markets for environmental products, and restrictive use regulations in the conservation area where the households live. Despite the high shares of income from environmental resources and crop production among small-scale farmers (the findings from Nepal being an important exception), this article only found few cases where the reliance on environmental resources and crop production were significantly different between livelihood strategies. Excluding the outliers (see Section 3.2), livestock producers and off-farm workers (cluster 4) in Bolivia are significantly more reliant on environmental resources compared to other strategies (based on Bonferroni pairwise test not presented in this article)—likely because they have

access to timber resources (Uberhuaga et al., 2012)—while large scale-farmers (cluster 2) rely more on crop production relatively to other strategies. In Nepal, small-scale farmers are more environmental and agricultural-dependent than livestock producers and business operators (cluster 2). In Mozambique, all strategies are equally dependent on income from environmental resources, and only compared to wage workers are small-scale farmers more dependent on crop income. Thus, although it is common to observe that poorer households rely more on agriculture and environmental resources in terms of income (e.g., Babulo et al., 2008; Kamanga et al., 2009)—our findings suggest that crop and environmental reliance do not change among livelihood strategies and hence these resources are consistently important to all households. It should be noted that the study did not measure labor allocation into self-employed activities which could imply that important aspects of the role of crop and environmental income are not fully accounted for in rural livelihood strategies (e.g., that subsets of small-scale farmers are particularly dependent on crop production and environmental resources).

For policy makers, the findings present a challenge. The factors determining livelihood choices vary across strategies; and outside the group of small-scale farmers, they are determined by ethnic relationship, education, and land holding. The multiple activities and household diversification across the cases suggest that rural development policies should be closely tailored to rural realities in each country. One important finding is that higher degrees of specialization does not characterize more remunerative livelihood strategies—rather prosperity rests on providing a range of income earning opportunities to rural households. As also noted by Krishna (2007), income diversification is the most frequently mentioned reason for rural households escaping poverty. Thus, policies need to simultaneously include agricultural and environmental resources initiatives that will directly have a large welfare effect on all households, such as crop production enhancing initiatives, and address issues related to rural nonfarm activities as these make up the core income sources in richer households. Indeed, while all households remain particularly dependent on crop income, it is noteworthy that more well-off households are propelled out of poverty because of engagement in nonfarm activities (Mozambique being the important exception).

A few previous studies have used the iterative partitioning method called *k*-means clustering to identify rural livelihood strategies (Brown et al., 2006; Jansen et al., 2006; van den Berg, 2009). However, this method does not provide a statistical measure clearly indicating which cluster solutions should be preferred over others. We aimed to solve this problem by using latent class cluster analysis which is a parametric approach that allows model testing. We were not, however, able to produce a cluster solution with a clear model BIC minimum. Thus, although the article has applied a less arbitrary clustering technique and put considerable emphasis on using broad and economically sound activity variables, studies are needed that explore which variables are best suited for quantitative livelihood strategy identification. Measuring allocation of labor and other assets into different self-employed and employed activities is central to livelihood identification. To approximate engagement in self-employed productive activities, we used costs of inputs in these activities. This approach, however, does not fully account for the ways that low input cost households allocate their labor to self-employed activities. Households using no or very limited inputs are identified as small-scale farmers—but we are unable to observe if these households in fact have similar labor allocation choices or if potentially important subsets of small-scale farmers exist. Better data on allocation of self-employed labor into, e.g., environmental product harvesting, crop and livestock production, and business activities, would improve livelihood strategy identification. In addition, this article divides employed labor allocation into on-farm and off-farm wage work. Although we consider this distinction sufficient for assessing the importance of the agricultural sector relative to off-farm sector employment opportunities, one could examine how the inclusion of more sectors (e.g., the primary, secondary, and tertiary sectors) influence livelihood strategy identification. Finally, one should not overlook the link between outcome and nonproductive assets, such as access to remittances and other social support mechanisms, as they may add important dimensions to factors associated with livelihood strategy choice.

5. Conclusions

The livelihoods framework allows a structured focus on rural household assets, activities, and outcomes. In the past decade, quantitative work on characterizing livelihood strategies has been done mainly by grouping households according to income shares in sectors of employment; however, this approach is problematic due to the stochastic nature of income which risk over- or undervaluing certain income sources. Recently, there have been attempts to address this by quantitatively analyzing household livelihood strategies through investigation of household activity choices using cluster analysis techniques, and identifying factors differentiating households across strategies using multinomial regression models. This article has improved this approach by using latent class cluster analysis that allows the use of the normal statistical framework of parameter estimation and model testing rather than *ad hoc* procedures when determining the number of clusters. However, findings do indicate that additional work is required to determine which variables are best suited for quantitative livelihood strategy identification, in particular the importance of including labor allocation into self-employed activities.

The article found commonalities in livelihood strategies across regions: all households across all sites could be classified into five livelihood strategies; diversification is the norm and multiple income sources are important to all households regardless of strategy; small-scale farmers form the largest and poorest livelihood group; and environmental income is

consistently important for maintaining and improving livelihoods. Factors that constrain access to more remunerative livelihood strategies are education, land, and ethnic affiliation. The study identified livelihood strategies that on average generate significantly more income than other strategies—in particular nonfarm income contributed to differences in income levels.

Finally, it should be noted that the above commonalities do not lend themselves to formation of blueprint rural development policies. Large variations in contextual factors and the activities households base their livelihood on suggest that rural development policies should be closely tailored to realities in each country.

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Appendix A

Table A1
Pairwise comparison of activity variables using the Bonferroni method

Livelihood strategy comparison	Input costs (USD PPP), environmental products	Input costs (USD PPP), agriculture	Input costs (USD PPP), livestock	Input costs (USD PPP), business	Agricultural wage work (days)	Off-farm wage work (days)	Transfer payments (USD PPP)
Bolivia							
1 vs 2		−2396.2(0.000)	−1586.3(0.000)				
1 vs 3					15.0(0.062)	−45.6(0.000)	−292.9(0.003)
1 vs 4	−884.4(0.000)		−1081.9(0.012)			−26.7(0.034)	
1 vs 5				−1352.4(0.000)		−50.0(0.000)	
2 vs 3		1971.3(0.002)	1466.5(0.000)			−45.3(0.000)	−297.5(0.005)
2 vs 4	−888.1(0.000)	1850.8(0.009)				−26.4(0.000)	
2 vs 5			1578.0(0.001)	−1195.8(0.000)		−49.6(0.000)	
3 vs 4	−887.7(0.000)						294.2(0.036)
3 vs 5				−1360.4(0.000)			
4 vs 5	889.2(0.000)			−1305.9(0.000)			
Nepal							
1 vs 2	−380.0(0.001)		−2513.5(0.003)	−1427.6(0.000)			
1 vs 3					−13.9(0.000)		−302.1(0.056)
1 vs 4	−506.6(0.003)					−19.2(0.000)	−1210.5(0.000)
1 vs 5	−908.7(0.000)	−4069.0(0.000)	−9167.7(0.000)	−4031.8(0.000)			
2 vs 3	394.1(0.003)		2605.0(0.008)	1554.8(0.000)	−13.9(0.000)		−340.3(0.042)
2 vs 4				1385.7(0.047)		−26.9(0.000)	−1248.8(0.000)
2 vs 5	−528.8(0.019)	−3607.1(0.000)	−6654.2(0.000)	−2604.3(0.000)			
3 vs 4	−520.8(0.005)				12.5(0.000)	−21.5(0.000)	−908.4(0.000)
3 vs 5	−922.9(0.000)	−4062.1(0.000)	−9259.2(0.000)	−4159.0(0.000)	12.5(0.000)		
4 vs 5		−3911.8(0.000)	−9217.8(0.000)	−3990.0(0.000)		24.1(0.003)	1148.4(0.000)
Mozambique							
1 vs 2			−15.2(0.001)				
1 vs 3					−15.3(0.000)	−24.4(0.000)	
1 vs 4	−35.8(0.000)	−87.7(0.084)		−280.3(0.000)			
1 vs 5	−28.8(0.007)	−444.9(0.000)	−74.3(0.000)			−10.0(0.012)	−95.7(0.000)
2 vs 3					−18.0(0.000)	−24.6(0.000)	
2 vs 4	−36.3(0.000)		14.9(0.085)	−247.2(0.000)			
2 vs 5	−29.3(0.008)	−388.8(0.000)	−59.0(0.000)			−10.2(0.014)	−85.4(0.000)
3 vs 4	−35.8(0.000)			−276.8(0.000)	17.0(0.000)	24.6(0.000)	
3 vs 5	−28.8(0.000)	−419.5(0.000)	−70.8(0.000)		18.1(0.000)	14.4(0.000)	−85.1(0.000)
4 vs 5		−357.2(0.000)	−74.0(0.000)	229.5(0.000)		−10.2(0.047)	−97.4(0.000)

Note: Results reported are mean differences and p-values below 10% (in brackets). All variables are adult equivalent adjusted and converted into purchasing power parity (PPP) adjusted U.S. Dollars (USD).

Appendix B

Table B1
Pairwise comparison of income components using the Bonferroni method

Livelihood strategy comparison	Environmental income	Crop income	Livestock income	Wage income	Business income	Transfer income	Other income	Total income
Bolivia								
1 vs 2								
1 vs 3				−598.8 (0.009)		−299.3 (0.002)		
1 vs 4				−640.1 (0.009)				
1 vs 5					−1, 683.0 (0.000)			−3, 493.4 (0.028)
2 vs 3				−755.5 (0.001)		−308.9 (0.003)		
2 vs 4				−796.8 (0.001)				
2 vs 5				−619.2 (0.063)	−1, 543.9 (0.000)			
3 vs 4						−301.7 (0.028)		
3 vs 5					−1, 700.4 (0.000)			
4 vs 5					−1, 643.2 (0.000)			
Nepal								
1 vs 2					−897.2 (0.000)			−957.9 (0.055)
1 vs 3						−295.6 (0.077)		
1 vs 4	−109.6 (0.004)					−1, 207.4 (0.000)		−1, 502.8 (0.031)
1 vs 5		−269.9 (0.026)	−2, 208.7 (0.000)		−2, 055.3 (0.000)		−1, 019.7 (0.000)	−5639.5 (0.000)
2 vs 3					989.5 (0.000)			1, 246.9 (0.015)
2 vs 4	−141.8 (0.000)				852.3 (0.000)	−1, 218.93 (0.000)		
2 vs 5		−287.8 (0.019)	−2, 035.6 (0.000)		−1, 158.2 (0.000)		−1, 013.9 (0.000)	−4, 681.6 (0.000)
3 vs 4	−158.7 (0.000)					−911.8 (0.000)		−1, 791.8 (0.010)
3 vs 5		−397.3 (0.000)	−2, 399.1 (0.000)		−2, 147.6 (0.000)		−1, 119.4 (0.000)	−5, 928.5 (0.000)
4 vs 5			−2, 248.8 (0.000)		−2, 010.5 (0.000)	1, 066.7 (0.000)	−1, 030.9 (0.000)	−4, 136.7 (0.000)
Mozambique								
1 vs 2		−71.2 (0.005)	−19.6 (0.000)					−155.0 (0.000)
1 vs 3				−88.6 (0.000)				−146.3 (0.016)
1 vs 4	−67.1 (0.006)		−23.9 (0.004)		−126.0 (0.000)		−84.7 (0.036)	−360.1 (0.000)
1 vs 5		−171.7 (0.000)	−42.4 (0.000)			−100.6 (0.000)		−409.6 (0.000)
2 vs 3		82.4 (0.030)		−98.4 (0.000)				
2 vs 4					−104.8 (0.000)			−205.2 (0.002)
2 vs 5		−100.5 (0.075)	−22.7 (0.100)			−90.0 (0.000)		−213.8 (0.002)
3 vs 4				92.6 (0.000)	−123.8 (0.000)			−254.6 (0.005)
3 vs 5		−182.9 (0.000)	−32.9 (0.006)	60.3 (0.003)		−90.2 (0.000)		−263.3 (0.003)
4 vs 5					109.3 (0.000)	−101.6 (0.000)		

Note: Results reported are mean differences and *P*-values below 10% (in brackets). All variables are adult equivalent adjusted and converted into purchasing power parity (PPP) adjusted U.S. Dollars (USD).

Appendix C

Table C1
Mean asset values for each of the five livelihood clusters (number in brackets show standard deviations)

Livelihood strategies	1	2	3	4	5
Bolivia					
Males (> 11 years)	1.7 [1.1]	1.7 [1.3]	1.5 [0.7]	1.6 [1.2]	0.7 [0.5]
Females (> 11 years)	1.8 [1.1]	1.8 [1.1]	2.0 [1.5]	1.7 [1.1]	1.4 [1.1]
Education of household head (years)	4.3 [2.6]	4.4 [3.2]	5.2 [4.2]	4.2 [3.0]	7.0 [4.9]
Savings (USD PPP)	107.0 [276.3]	108.4 [410.2]	181.7 [360.8]	65.3 [111.4]	37.6 [67.2]
Productive implements (USD PPP)	234.1 [350.0]	639.9 [959.9]	183.7 [178.6]	416.8 [406.4]	1492.7 [2.203.0]
Total land (hectares)	9.4 [11.6]	14.0 [11.2]	15.7 [15.4]	6.1 [5.3]	26.0 [25.1]
TLU	0.2 [0.5]	0.5 [0.9]	0.1 [0.1]	0.1 [0.1]	0.1 [0.1]
Ethnic group	0.8 [0.4]	0.7 [0.5]	0.6 [0.5]	0.7 [0.5]	0.8 [0.4]

(*Continued*)

Table C1
Continued

Livelihood strategies	1	2	3	4	5
Nepal					
Males (> 11 years)	2.0 [1.4]	1.7 [1.1]	1.8 [1.1]	1.1 [0.8]	1.3 [1.2]
Females (> 11 years)	1.5 [1.0]	1.9 [1.2]	1.9 [1.0]	1.2 [0.8]	1.3 [0.8]
Education of household head (years)	2.6 [3.5]	4.6 [4.6]	2.0 [3.0]	1.5 [2.3]	4.3 [4.9]
Savings (USD PPP)	2498.7 [6.103.1]	3428.5 [4.352.6]	357.0 [440.4]	3619.1 [3.815.6]	9339.4 [11.007.6]
Productive implements (USD PPP)	155.3 [236.4]	913.4 [1.178.4]	38.8 [55.9]	473.4 [648.7]	1702.4 [1.204.5]
Total land (hectares)	0.3 [0.3]	0.3 [0.3]	0.1 [0.1]	0.3 [0.3]	0.7 [0.4]
TLU	0.7 [1.2]	1.5 [2.6]	0.3 [0.3]	0.4 [0.7]	3.5 [5.7]
Ethnic group	0.5 [0.5]	0.8 [0.4]	0.1 [0.3]	0.3 [0.5]	1.0 [0.0]
Mozambique					
Males (> 11 years)	1.8 [1.2]	1.9 [1.3]	1.2 [0.8]	1.3 [0.7]	1.3 [0.9]
Females (> 11 years)	1.8 [1.1]	1.8 [1.3]	1.5 [0.9]	1.4 [0.8]	1.6 [1.7]
Education of household head (years)	1.7 [1.9]	2.1 [2.1]	2.0 [2.2]	3.7 [2.4]	2.6 [2.2]
Savings (USD PPP)	4.3 [8.0]	13.9 [18.7]	20.0 [48.2]	27.2 [42.5]	28.8 [36.5]
Productive implements (USD PPP)	8.2 [11.3]	30.4 [117.4]	8.5 [9.9]	90.9 [291.6]	23.7 [18.1]
Total land (hectares)	1.1 [1.2]	1.5 [1.3]	1.3 [1.4]	2.0 [1.7]	2.6 [3.7]
TLU	0.0 [0.1]	0.1 [0.1]	0.1 [0.1]	0.1 [0.1]	0.3 [0.3]
Ethnic group	0.6 [0.5]	0.5 [0.5]	0.8 [0.4]	0.6 [0.5]	0.1 [2.5]

Note: All variables are adult equivalent adjusted and converted into purchasing power parity (PPP) adjusted U.S. Dollars (USD).

References

Angelsen, A., Larsen, H.O., Lund, J.F., Smith-Hall, C., Wunder, S. (Eds.), 2011. Measuring Livelihoods and Environmental Dependence. Earthscan, London.

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. Agric. Syst. 98, 147–155.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., Mathijs, E., 2009. The economic contribution of forest resource use to rural livelihoods in Tigray, Northern Ethiopia. Forest Policy Econ. 11, 109–117.

Barrett, C.B., 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.

Brown, D., Stephens, E.C., Ouma, J.O., Murithi, F.M., Barrett, C.B., 2006. Livelihood strategies in the rural Kenyan highlands. Afr. J. Agric. Resour. Econ. 1(1), 21–35.

Bryceson, D.F., 1999. African rural labour, income diversification and livelihood approaches: A long-term development perspective. Rev. Afr. Polit. Econ. 80, 171–189.

Carter, M.R., Barrett, C.B., 2006. The economics of poverty traps and persistent poverty: An asset-based approach. J. Devel. Stud. 42(2), 178–199.

Cavendish, W., 2000. Empirical regularities in the poverty-environment relationship of rural households: Evidence from Zimbabwe. World Devel. 28(11), 1979–2003.

Cavendish, W., 2002. Quantitative methods for estimating the economic value of resource use to rural households. In: Campbell, B.M., Luckert, M.K. (Eds.), Uncovering the Hidden Harvest: Valuation Methods for Woodland and Forest Resources. Earthscan, London, pp. 17–66.

Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quiñones, E.J., Zezza, A., Stamoulis, K., Azzarri, C., Digiuseppe, S., 2010. A cross-country comparison of rural income generating activities. World Devel. 38(1), 48–63.

Ellis, F., 1998. Household strategies and rural livelihood diversification. J. Devel. Stud. 35(1), 1–38.

Ellis, F., 2000. Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, New York.

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

Greene, W.H., 2003. Econometric Analysis, 5th ed. Pearson Education, Inc., New Jersey.

Homewood, K. (Ed.), 2005. Rural Resources and Local Livelihoods in Africa. James Currey, Oxford.

Jansen, H.G.P., Pender, J., Damon, A., Wielemaker, W., Schipper, R., 2006. Policies for sustainable development in the hillside areas of Honduras: A quantitative livelihoods approach. Agric. Econ. 34(2), 141–153.

Kamanga, P., Vedeld, P., Sjaastad, E., 2009. Forest incomes and rural livelihoods in Chiradzulu District, Malawi. Ecol. Econ. 68, 613–624.

Krishna, A., 2007. For reducing poverty faster: Target reasons before people. World Devel. 35(11), 1947–1960.

Magidson, J., Vermunt, J.K., 2002. Latent class models for clustering: A comparison with K-means. Can. J. Market. Res. 20, 36–43.

PEN, 2007. PEN Technical Guidelines Version 4. Poverty Environment Network. Available from http://www.cifor.cgiar.org/pen (accessed January 5, 2011).

Reardon, T., 1997. Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. World Devel. 25(5), 735–747.

Scoones, I., 1998. Sustainable rural livelihoods: A framework for analysis. IDS Working Paper No. 72, Institute of Development Studies, University of Sussex, Brighton.

Uberhuaga, P., Olsen, C.S., 2008. Can we trust the data? Methodological experiences with forest product valuation in lowland Bolivia. Scand. Forest Econ. 42, 508–524.

Uberhuaga, P., Smith-Hall, C., Helles, F., 2012. Forest income and dependency in lowland Bolivia. Environ. Devel. Sustain. 14(1), 3–23.

van den Berg, M., 2009. Household income strategies and natural disasters: Dynamic livelihoods in rural Nicaragua. Ecol. Econ. 69(3), 592–602.

Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., Berg, G.K., 2007. Forest environmental incomes and the rural poor. Forest Policy Econ. 9, 869–879.

Vermunt, J.K., Magidson, J., 2003a. Latent Gold: User's Guide. Statistical Innovations, Belmont, MA.

Vermunt, J.K., Magidson, J., 2003b. Technical Appendix for Latent Gold 3.0. Statistical Innovations, Belmont, MA.

Winters, P., Corral, L., Gordillo, G., 2001. Rural livelihood strategies and social capital in Latin America: Implications for rural development projects. Working Paper Series No. 2001-6, School of Economics, University of New England, Armidale.

Zeller, M., Schrieder, G., von Braun, J., Heidhues, F., 1997. Rural finance for food security for the poor. Food Policy Review 4, International Food Policy Research Institute, Washington, DC.