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A novel approach to dynamic livelihood clustering: Empirical evidence from Nepal

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Abstract

Rural households are heterogeneous: different socio-economic characteristics and asset endowments dictate their engagement with different livelihood activities resulting in different livelihood outcomes. Poverty reduction policies should consider this. Using a unique environmentally augmented three-wave panel dataset from 427 households in three locations of Nepal, we proposed an approach that combines households' income and assets to identify different livelihood strategy clusters. Based on a Latent Markov Model we identify seven distinct livelihood strategies and analyse households' movements between strategies through time. Most sampled households changed their livelihood strategy at least once between 2006 and 2012, and very few households transited directly from the least to the most remunerative strategy. A common pathway out of poverty appears to have involved an intermediate step during which households accumulated assets and capital through farming, petty trading and migratory work. The applied approach of combining income and assets better distinguishes the identified livelihood strategies compared to both the income and the asset approach and allows targeting of interventions towards specific strategies and transition pathways.

Key words: Assets; income; latent Markov model; livelihood strategies; livelihood transitions; two-part model

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Introduction

Ample evidence demonstrates the heterogeneity of rural households in developing countries: they have different socio-economic characteristics, different asset endowments, and allocate their labour to different income-generating activities. The problem of rural poverty cannot be solved with a uniform package of policy measures (e.g. Ansoms and McKay 2010) and policy makers need to consider sub-groups of the rural poor population when formulating policy aiming at poverty reduction and rural development.

Rural households use their assets to engage in a variety of livelihood strategies (DFID 1999; Ellis 2000; Scoones 1998, 2009) that have been used in the attempt to answer the three research questions: (1) Which income generating activities do poor households and those who descend into poverty follow? (2) Which income-generating activities provide opportunities for households to move out of poverty? (3) Which entry barriers prevent households from engaging in activities that allow move out of poverty?

The identification of livelihood strategy groups are most commonly based on the share of income generated from different remunerative activities (e.g., Ellis and Freeman 2006; Zeneto et al. 2013). Household income is relatively simple to measure and is often perceived as a clear welfare gauge (Barrett 2005) providing insight into rural livelihoods (Ellis 2000; Fields et al. 2003; McKay 2000). Income is, however, stochastic, being subject to variations across seasons and from shocks. This means that income does not often reflect the amount of assets households choose to invest in different activities. Income is therefore not well suited to categorize household livelihood strategies (Jansen et al. 2006; Nielsen et al. 2013). Using income to categorize households into livelihood strategies also fails to acknowledge households' propensity to smooth consumption to respond to income shortfalls (Nielsen et al. 2012). To avoid problems with income-based measures of livelihoods, analysts have increasingly turned to asset-based measures (Ansoms and McKay 2010; Brown 2006; Jansen et al. 2006; Nielsen et al. 2012, 2013; van den Berg 2009). Households invest in or use a combination of their assets to generate income from various sources; as assets are not stochastic they arguably more accurately reflect household wellbeing. The use of assets as a sole welfare metric, however, does not permit an understanding of how households combine assets to generate income from a portfolio of activities.

An alternative to income and asset-based approaches is to base livelihood strategy grouping on activity choice variables, e.g. investment costs or the proportion of household assets (e.g. land, labour) allocated to the different income-generating activities (Brown et al. 2006; Jansen et al. 2006; Nielsen et al. 2013; van den Berg 2010). Household members' propensity to multi-task makes it challenging to ascribe the portion of labour, land or other assets invested in an activity (Wunder et al. 2011) and the approach overlooks the role of non-productive assets (e.g. social capital) in household's livelihood strategy choices. Ansoms and McKay (2010) offer a notable exception to this as they categorize households by livelihood strategy based on a wider spectrum of assets; however, their paper does not connect household assets to livelihood outcomes.

Household livelihood strategies change over time in response to contextual factors (policies, institutions, shocks) (Chambers 1995; Ellis 2000). Empirical evidence of the dynamics of livelihood strategy adoption exists: van den Berg (2010) reported that households in rural Nicaragua shift from relatively more remunerative strategies to more defensive strategies in the face of natural hazards; Jones and Thornton (2009) found that a change in livelihood strategies may be needed in some parts of Africa in response to climate change; Berhanu et al. (2007) observed a shift from pastoralism to a diversified livelihood in semi-arid environment of Ethiopia in response to an external shock and trends in the pastoral system; and Motsholapheko et al. (2011) showed that households in Botswana modify their livelihood strategies in response to extreme flooding. These studies represent a first step in exploring the ways people adapt to long-term changes, a major challenge for livelihoods research (de Haan and Zoomers 2005; Scoones 2009), and indicate the limited extent to which the dynamics of livelihood strategies have been quantitatively analysed. Recent research has also emphasised the importance of using environmentally-augmented dataset in order to more accurately understand rural livelihoods in the tropics and sub-tropics (Angelsen et al. 2014).

Here we propose an innovative quantitative approach which combines income and asset data to identify household activity choice variables, which then form the basis for identifying clusters of livelihood strategies and the movement of households between clusters over time. We employ Principal Component Analysis (PCA) to minimize the potential correlation among the choice variables and a latent Markov cluster analysis to identify household

livelihood strategies. We construct a livelihood transition matrix to examine households' movement among the livelihood strategies over time. Finally, we use Multinomial Logit Model (MLM) to identify the socio-economic covariates of household's livelihood strategy transition. The study thus makes two major contributions to the livelihood and rural development literature. First, it introduces a method of combining income and asset data for livelihood clustering. Second, the approach is applied to an environmentally-augmented three-wave data panel dataset to provide empirical evidence on rural livelihood dynamics in Nepal.

Conceptual framework: the dynamic livelihood framework

Figure 1 presents our dynamic livelihood strategy framework for two time periods. The main concepts used for each period are assets, activities, and outcomes. Between periods, mobile households move in or out of poverty by choosing a more or less remunerative livelihood strategy; while stationary households remain poor or non-poor, either by keeping the same livelihood strategy or by changing to an equally remunerative strategy. Households' decision of which livelihood strategies to pursue are in turn affected by their assets, the context in which they live, and the outcomes of previous livelihood strategies that determine investments and savings that in turn influence asset endowment in the next time period.

The core of the framework is composed of the activities that households choose to engage in to make a living. These choices are determined by households' asset endowments (e.g. land owned, agricultural inputs, livestock, money, education) and the context in which they live (e.g. risks and shocks, access to land and natural resources, political, economic and sociocultural contexts) (e.g. Barrett et al. 2001; Ellis 1998, 2000). Adoption of a livelihood strategy in turn influences households' livelihood outcomes.

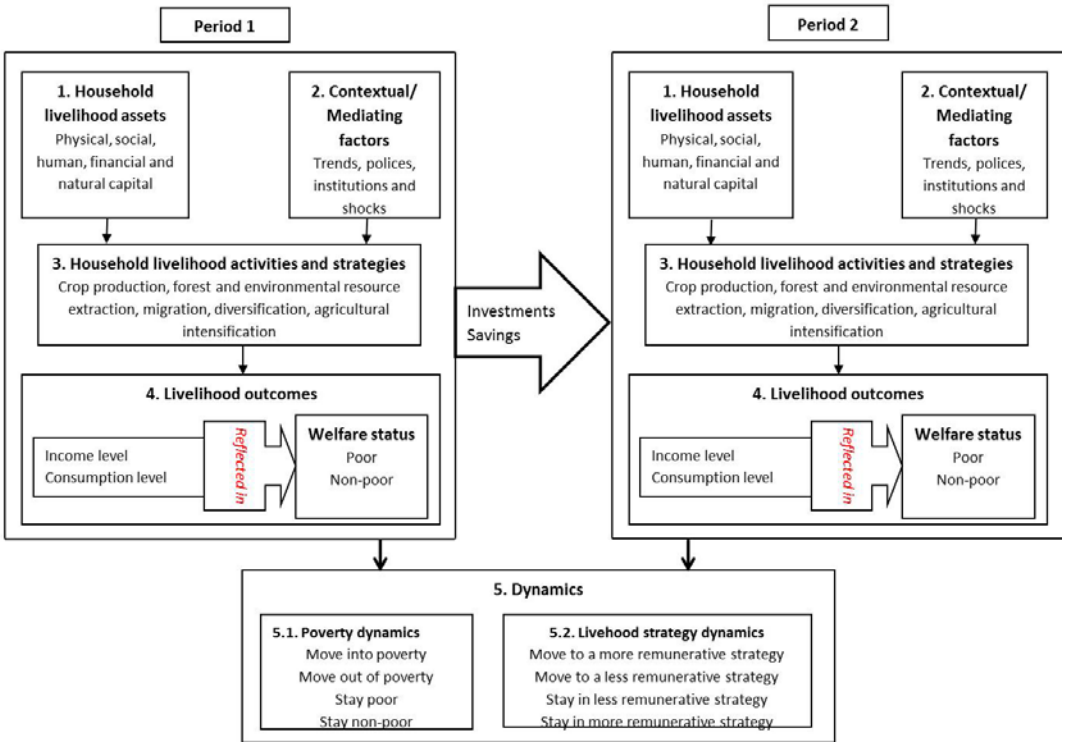

Figure 1: Household dynamic livelihood strategy framework (adapted from DFID 1999; Ellis 2000; Scoones 1998)

Methods

Study sites and data collection

The study was conducted in four village development committees (VDCs, an administrational unit) in three districts, spanning the altitudinal variation in Nepal (Larsen et al. 2014). Households engage in agrarian and non-agrarian livelihood activities, e.g. cropping and migration for work. An in-depth description of study sites, sampling procedures, data collection, and data management is available in Larsen et al. (2014). Table 1 provides an overview of sites and the number of households sampled.

Table 1: Overview of study sites and sampled number of households

District	VDC	Number of households (2006)	Sampled households (2006)	Remaining sample (2009)	Remaining sample (2012)	Livelihood activities	Elevation (metres above sea level)	Market access
Chitwan	Chainpur	1542	207	188	183	Vegetable and rice farming	350	Motorable gravel road
Kaski	Hemja	222	114	102	98	Vegetable farming	1000	Tarmac road, bus service
Mustang	Kunjo	163	88	74	71	Farming, tourism	2200-3000	2006: plane and foot 2009: motorable gravel road
	Lete	174	98	82	76			

Data was collected in 2006, 2009 and 2012. Data collection and handling followed the guidelines provided by the Poverty Environment Network (PEN) (Larsen et al. 2014) to ensure consistency across sites. The PEN prototype questionnaires were translated into Nepali and field tested before the survey. Household economic data was collected on a quarterly basis (four visits per year) to facilitate more comprehensive recall compared to standard practice of annual recall. Household asset data and village level data were collected at the beginning and again at the end of each year.

The dataset used in the present study consists of a three-wave panel dataset with yearly household income values per source (e.g. agriculture, environmental, business) and asset stock endowment. Table 2 lists and describes the asset variables used. Income is defined as the value added of labour and capital (Angelsen et al. 2014). This is the total value of cash and goods obtained from the trade of goods and services by members of the household, less the cost of all inputs except labour provided by household members. All goods produced or collected by the household and used for home consumption (subsistence) were valued using appropriate valuation techniques (Wunder et al. 2011) and counted as part of household income (CIFOR 2007). All income and liquid asset values are reported in adjusted adult equivalent units (aeu) to allow for inter-household comparisons, with all 2009 and 2012 values converted to 2006 level using the Consumer Price Index (CPI).

We had an attrition rate of 12 percent between 2006 and 2009, four percent between 2009 and 2012 and 16 percent over the six year period. A binary probit assessment of the effects of attrition on the estimates from the data indicates that it is not significant for the current

analysis (the results of the probit regression is available upon request from the authors). One household was excluded from analysis because of its huge total income in 2012.

Data analysis

Combining income and asset variables to create activity choice variables

One challenge of combining income and asset choice variables for livelihood clustering is that they are measured in different units. We therefore employed a statistical method in which all asset types were regressed against the income earned from each income generating activity. The regression model for livelihood activity q can be specified as:

$$Y_{iq} = \sum_j \beta_j (A_{ijt}) + \beta_l L + \varepsilon_{it} \qquad (6)$$

The dependent variable denotes household i's income from livelihood activity q. A_{ijt} is households i's possession of asset j at time t and β_j is the associated vector of coefficients – the marginal contribution of asset j to income from livelihood activity q, L is vector of location dummies and β_l is the associated vector of coefficients and ε_{it} is an error term. The equation is estimated for the five productive livelihood activities that a household can engage in: environmental resource extraction, crop production, livestock rearing, business ownership, and wage employment. Households do not allocate any of their current assets to earn income from non-productive income generating activities (e.g., remittances). As a result, we did not estimate the equation for income from remittances or any other transfers, e.g. pensions. Once all the coefficients are estimated, the composite asset index used in generating the income from livelihood activity q can be calculated from the fitted value of the regression:

$$g_{iq} = \sum_j \beta_j (A_{ijt}) + \beta_l L \qquad (7)$$

This method of combining income and asset data has two major advantages over data reduction methods, such as PCA and Principal Factor Analysis (PFA). First, it shows the contribution of each asset type to income generated from each livelihood activity.

Households invest a combination of their assets into different livelihood activities and the individual assets used as well as their contribution to income are not equally important. The individual regression coefficients reflect this. Second, the index is expressed in a convenient livelihood metric, i.e. money (Nepalese rupees, Rs) that is directly comparable with income, consumption and other monetary indicators of welfare.

A second challenge is the choice of estimator for Equation (6). Since households earn a negative income from some income generating activities and not all households participate in all possible income-generating activities, the use of Ordinary Least Squares (OLS) to estimate equation (6) results in a negative prediction of equation (7). To minimize negative predictions, we modelled equation (7) using a two-part model[2] (Cameroon and Trivedi 2005). The first part is a probit model that predicts a binary outcome of a negative/zero income and positive income, while the second model predicts the positive income using an OLS estimator. Following Cameroon and Trivedi (2005), the two-part model, that has the same explanatory variables in each part, can be specified as:

$$\text{Prob}(\text{Y}_{\text{iq}} > 0) = \sum_j \beta_j (A_{ijt}) + \beta_l L + \varepsilon_{it1} \quad (8)$$

$$Y_{iq} = \sum_j \beta_j (A_{ijt}) + \beta_l L + \varepsilon_{it2} \text{ if } \text{Y}_{\text{iq}} > 0 \quad (9)$$

Equation (8) models the probability that a household earns an income from productive livelihood activity q whereas equation (9) models the income of a household from productive livelihood outcome q, conditional on the household earning an income (>0) from that livelihood activity. The two models have their own error terms, namely ε_{it1} and ε_{it2} that are estimated separately so that $E(Y_{iq}) = \text{Prob}(\text{Y}_{\text{iq}} > 0)\text{E}(\text{Y}_{\text{iq}} \mid Y_{iq} > 0)$ which means that the predicted values are expectations of the second regression weighted by the probability of earning an income from each income-generating activity. We ran the two-part model for the five income generating activities that require household asset investment and the resulting

[2] The natural alternative to the two-part model is a Tobit model. However, in the case of some income types (e.g. business and wage income), a non-negligible number of households earn negative or zero income, which results in a highly skewed and heteroscedastic distribution. The use of a Tobit model is in this case inappropriate since it relies on normality and homoscedasticity in its underlying latent variable model. The Tobit model also assumes that the independent variables have the same influence on the two processes.

predictions were labelled as asset index used in each of the five activities (i.e., asset index used in environmental resource extraction, crop production, livestock rearing, wage employement and business ownership). These were our choice variables to identify the livelihood strategy categories in addition to income from transfers. Hence, in total, we used six activity choice variables to generate livelihood strategy clusters.

Table 2: Asset variables used in the two-part model.

Variables	Description
Household head education	Number of years of formal education completed by the household head.
Age of household head	Age of the household head; an indicator of household experience.
Maximum household education	Number of years of formal education completed by the household member with most years of schooling.
Number of adults	Number of male and female adult household members (age range 15 to 60 years, inclusive). These are considered capable of earning income that contributes to the household's total income.
Total land area	Total number of hectares of land owned by the household, including land rented out (does not include land rented in by the household).
Total livestock value	Total value of the household's livestock at the end of the observation period.
Total implement value	Total value of all implements owned by the household – bicycles, cars, television, tools, etc.
Bank savings	Total value of household's financial savings, in local or national banking institutions.
Jewellery value	Total values of household's non-productive assets in the form of jewellery (e.g. gold, silver and precious stones).
Debt	Total value of money the household owed to other households and financial institutions.
Help from other households	Ordinal variable describing whether the household is able to receive help from other households in times of unexpected shocks (such as illness): 1 = no, 2 = sometimes, and 3 = yes.
Trust in other households	Ordinal variable indicating the level of trust the household has in other households in the community of residence: 1 = no trust, 2 = moderate trust, and 3 = high trust.
Head belong to the largest cast	Indicator of ethnicity of the households head: 1= household head belongs to the largest caste/ethnic group; 0 otherwise
Forest user group (FUG) activities attendance	Ordinal variable indicating whether the household actively participate in FUG activities: 1 = the household actively participates in forest user group activities; 0 otherwise.

Principal component analysis and latent Markov cluster analysis

To minimize the distortion due to the likely correlation and measurement as well as scale effects among the six activity choice variables (Jansen et al. 2006; Hair et al. 1998), PCA was employed to generate a new set of uncorrelated variables called component scores. The latent

root criterion and visual interpretation of the scree plot indicated that three component scores were optimal. The three component scores collectively explain about 69 percent of the variation in the original choice variables.

We used latent class analysis to group the households into livelihood strategies. This method, compared to other clustering methods (such as hierarchical cluster analysis and k-means algorithms), is less arbitrary as it minimizes within cluster variation by assigning each household membership probabilities for each cluster solution. This model-based method also provides information and significance tests for the selection of the optimal number of clusters (Haughton et al. 2009; Magidson and Vermunt 2002). Since our data is longitudinal, we employed a latent Markov model that allows households to switch livelihood strategies between the three years. Following Vermunt and Magidson (2013), the latent Markov model for multiple indicators for household i, y_{it} with covariates z_i has the form:

$$\pi(y_i / z_i) = \sum_{x_0=1}^{K}\sum_{x_1=1}^{K}...\sum_{x_T}^{K}\pi(x_0 \mid x, z_i)\prod_{t=1}^{T_i}\pi(x_t \mid x_{t-1}, z_{it})\prod_{t=0}^{T_i}\pi(y_{it} \mid x_t, z_{it}) \qquad 10$$

Where x_t is the latent livelihood state variable at time t which runs from 0 to T_i and K is the number of latent states. Time was the only covariate included in the model and allowed to influence state transitions but not initial probabilities. There are three sets of parameters and associated probabilities: distribution of indicators ($\pi(y_{it} \mid x_t, z_{it})$), initial state probabilities ($\pi(x_0 \mid z_i)$), and transition probabilities ($\pi(x_t \mid x_{t-1}, z_{it})$). The distribution of indicators was modelled through a normal distribution function while the initial state probabilities and the transition probabilities were parameterized using a standard logit regression model and a transition logit regression model, respectively (Vermunt and Magidson 2013).

Three major assumptions underlie equation (10) (Paas et al. 2007; Vermunt and Magidson 2005a). First, it assumes first-order Markov transitions, meaning that household livelihood states at time t depends only on the livelihood states at time $t-1$, not on livelihood states at earlier periods. This is a strong assumption, but since the data has three waves and only one wave implies a second order transition, we argue that higher order transition could not significantly improve the estimation results and the first order transition should be sufficient.

Second, it assumes independent classification error, meaning that the indicators at time t depend on the latent states and the covariates at time t, but not on the latent states, the indicators or the covariates at other points in time. Third, it assumes local independence among the indicators given the latent states, meaning that the indicators should be mutually independent in each livelihood strategy. This assumption is measured through residual dependence among indicators, bivariate residuals (BVRs), which are the Pearson residual of the indicators (Oberski et al. 2013). A significantly large value of BVR suggests violation of this assumption which leads to model misfit and requires extremely large number of latent states to get an acceptable fit model. One way to proceed in case of violation of the assumption is to increase the number of latent states until a well-fit model is obtained. The other option is to relax the assumption by introducing direct effect (associations) among indicators and between indicators and covariates via the BVRs (Vermunt and Magidson 2005a). Since we obtained high BVRs, we employed the latter approach to relax the assumption.

Since our indicators are continuous, chi-squared statistics of the log-likelihood ratio (L^2) and the associated significance level are not valid for comparison of alternative models (Vermunt and Magidson 2005b). Thus, in this paper, model selection was based on Bayesian Information Criteria (BIC) for logarithm of the likelihood function (LL) and the lower the BIC, the better the fit of the model. The added advantage of BIC is that it accounts for the parsimony of the model in addition to the fit of the model by introducing a penalty for the number of parameters j and observations N : $BIC_{LL} = -2LL + j \log N$. The analysis was carried out using Latent Gold 5.0 (Vermunt and Magidson 2005b, 2013).

Econometric model specification: Multinomial Logit Model (MLM)

In order to identify the determinants of households' livelihood strategy movement, we employed Multinomial Logit Model (MLM). It is based on the underlying theory of random utility maximization theory of household's livelihood choice, and derived from an unobserved latent variable (i.e. household utility). It is an appropriate model to determine the influence of a set of explanatory variables on a response variable with more than two unordered outcomes (Cameron and Trivedi 2005; Wooldridge 2002). Generally, MLM can be

specified in terms of the probability of occurring outcome j given the independent variables as:

$$\Pr ob(Y_i = j) = \frac{e^{X_i B_k}}{1 + \sum_{k=0}^{m} e^{X_i B_k}} = F_j(X_i, B) \qquad (11)$$

Where $j = 0,1,2,.....,m$; $i = 1,2,3,....., N$ and $B_0 = 0$, X_i is vector of explanatory variables and B_j is the associated vector of coefficients;, and Y_i is households' choice of livelihood strategies. F_j is the cumulative density function of the error term assumed to follow logistic distribution. Any other continuous distributions are also possible that results in, for instance, Multinomial Probit Model (MPM). But MLM is preferred in many applications since it is very convenient and easy for modelling probabilistic choices (Cameroon and Trevedi 2005; Wooldridge 2002). Included explanatory variables were whether the household head was born in the village, number of children and elder household members, households' experience of moderate and severe shocks, whether the household head was married, and distance of residence to village centre. No physical and financial assets were included in the set of explanatory variables to avoid reverse causality (as they were used in deriving the choice variables used to identify the livelihood strategies).

Results

Livelihood clusters

The variation in households' combined income and asset activity variables was best described with seven clusters: the BIC was lowest (6775.322) for the seven latent state and one latent class Markov model (Appendix A).

Livelihood strategy clusters were named after the activities in which households invested most relative to members of other clusters (Table 3). For example, households in the fifth cluster invested relatively more in businesses and therefore this cluster is labelled "Business owners". "Small-scale farmers" had low mean values in all asset index categories, while "small-scale farmers with remittances" had similar asset index values except for transfer income which was more than three times higher. "Diversified farmers" invested resources into each activity except for wage employment. "Medium-scale livestock producers and petty traders" invested a relatively high amount of their assets in livestock and business, while households in the "Medium-scale farmers and wage employment" cluster invested relatively more in agriculture and wage employment. "Business operators and large scale farmers" had a panoptic asset investment strategy. The mean differences of all the asset indices and income from transfers were significantly different between the identified livelihood strategies (see Appendix B); this suggests that the choice variables used in this study are suitable for distigiushing between the seven livelihood strategies.

Table 3: Means of asset indexes for each livelihood activity and total transfers by livelihood strategy cluster; values in parenthesis are standard deviation of the mean.

Livelihood strategies	Environment asset index	Crop asset index	Livestock asset index	Business asset index	Wage asset index	Transfer income	Number of households			
							2006 (n=427)	2009 (n=427)	2012 (n=427)	Overall (n=1281)
Small-scale farmers (Cluster 1)	3072.9 (1576.6)	4013.4 (3615.5)	6378.8 (4566.4)	7846.5 (11159.4)	1166.8 (623.0)	3430.9 (4730.8)	167	78	67	312
Medium-scale livestock producers and petty traders (Cluster 2)	21796.4 (7070.7)	10818.3 (10461.7)	18132.5 (18878.9)	39282.9 (44917.0)	2466.6 (1079.2)	5759.7 (8379.9)	81	65	130	276
Small-scale farmers and remittances (Cluster 3)	4064.3 (1322.9)	5154.4 (5701.2)	8430.6 (4069.0)	5602.4 (6603.4)	2941.1 (1507.8)	12263.0 (12402.1)	16	81	91	188
Diversified farmers (Cluster 4)	8276.0 (4727.0)	11406.3 (7656.4)	10029.7 (5355.7)	13367.4 (14559.4)	614.5 (412.1)	7633.6 (7784.1)	115	63	7	185
Business owners (Cluster 5)	12368.6 (8603.3)	23802.5 (23855.4)	23335.1 (14662.6)	104246.2 (139143.7)	559.5 (577.3)	32224.1 (29366.8)	33	72	48	153
Medium-scale farmers and wage employment (Cluster 6)	27143.3 (10684.7)	12498.0 (15491.2)	14895.2 (17095.3)	18255.9 (25404.3)	5974.2 (2770.6)	13881.7 (16458.7)	9	58	67	134
Business operators and large-scale farmers (Cluster7)	30033.4 (32367.1)	72579.1 (199124.5)	451405.3 (1260412.0)	386277.7 (512239.6)	2418.9 (5254.8)	83741.5 (92423.9)	6	10	17	33
ANOVA	288.2***	25.3***	25.9***	93.6***	240.3***	113.0***				
Average (overall) (n=1281)	12326.6 (12055.2)	11732.1 (35463.3)	24120.1 (211483.4)	37439.1 (116544.2)	2090.1 (2179.5)	12436.9 (24630.1)				
Average (2006) (n=427)	10247.2 (11524.2)	12315.3 (55229.3)	33734.3 (334209.3)	19080.9 (49898.1)	1309.9 (1297.9)	8498.7 (19045.5)				
Average (2009) (n=427)	11237.5 (11204.3)	19635.1 (24149.0)	24711.9 (149509.8)	12946.3 (29916.3)	1913.1 (1828.9)	16921.1 (25949.8)				
Average (2012) (n=427)	15495.2 (12756.8)	3246.0 (3201.7)	13914.0 (11800.1)	80290.2 (186137.0)	3047.2 (2772.0)	11890.8 (27398.0)				

Livelihood strategies, outcomes and asset endowments

Average total income per main source per livelihood strategy (Table 4) shows that Business operation and large-scale farming and Business owners (clusters 5 and 7) were highly remunerative livelihood strategies. Small-scale farming with and without remittances (clusters 1 and 3) were the least remunerative strategies. A further analysis of total average income differences between livelihood strategies based on first order stochastic dominance shows that Business operators and large-scale farming (cluster 7) is a stochastically dominant livelihood strategy in terms of income – the cumulative density for total average income lies below the cumulative density curves of the other strategies for every possible total average income (Figure 2). Oppositely, Small-scale farmers with and without remittances (clusters 1 and 3) were statistically dominated livelihood strategies. The cumulative density curves of total income for the individual years followed the pattern in Figure 2.

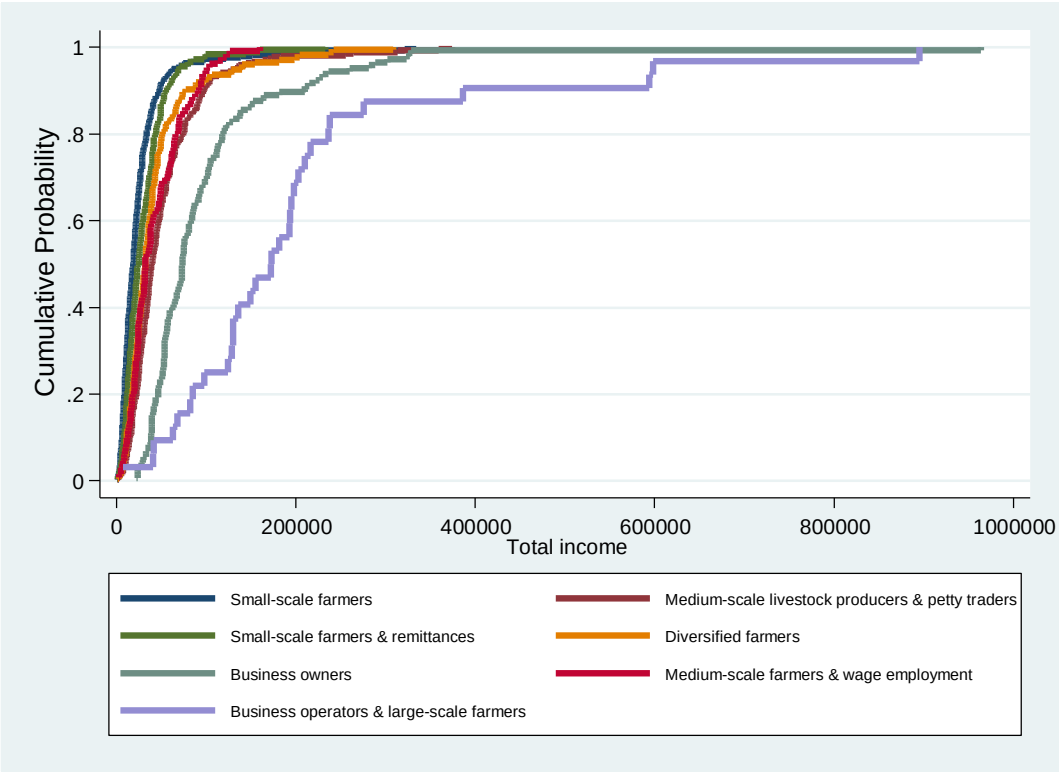

Figure 2: Cumulative density functions of total average income by livelihood strategy.

The contribution of different sources of income to total annual household income for each livelihood strategy cluster (Table 4) generally correlates with the asset index values on which clustering was based. For example, Business operators and large-scale farmers (cluster 7)

showed the highest average agricultural income (crops and livestock) as well as the highest average business income, which were significantly different from the averages of other livelihood strategy clusters (Appendix C) and Medium-scale farmers and wage employment (cluster 6) showed the highest average wage income, which was also significantly different from the averages of the other livelihood strategies (Appendix C). Business operators and large-scale farmers (cluster 7) was by far the livelihood strategy with the highest absolute average environmental income though Small-scale farmers with and without remittances (clusters 1 and 3) had the highest reliance on environmental income. Unexpectedly, households pursuing the Medium-scale farmers and wage employment strategy (cluster 6) had negative average business income.

Average asset endowments for the different livelihood strategy groups (Table 5) showed that households following the highly remunerative livelihood strategies (Business operators and large-scale farmers, Business owners), on average, possessed more of all asset types, except number of female household members. Households following the least remunerative livelihood strategies (Small-scale farmers with and without remittances) were, on average, the asset poorest, and these differences were significant (Appendix D).

Table 4: Mean of income (in 2006 prices in Rs, aeu adjusted)(total and by source) for livelihood strategy clusters; values in parenthesis are standard deviation of the mean

Livelihood strategies	Environmental income	Crop income	Livestock income	Remittances	Support income[1]	Other income	Business income	Wage income	Total income	Total income rank		Total income (2006)	Total income (2009)	Total income (2012)
Small-scale farmers (CLU-1)	3862 (6583)	3057 (4561)	5737 (11886)	1810 (3754)	1621 (3275)	3303 (18111)	1815 (38067)	1004 (2261)	22208 (47179)	7		21370 (27478)	12766 (64348)	35292 (58972)
Medium-scale livestock producers and petty traders (CLU-2)	11660 (13666)	6326 (19574)	7798 (8662)	2931 (6733)	2829 (6080)	5195 (11275)	19311 (105385)	892 (2147)	56941 (107241)	3		61911 (49703)	33727 (21908)	65451 (149622)
Small-scale farmers and remittances (CLU-3)	2929 (3218)	2492 (5080)	2011 (33363)	9370 (11946)	2894 (5878)	2998 (17420)	2318 (11484)	1334 (3101)	26345 (43513)	6		29961 (29197)	30173 (29534)	22301 (54631)
Diversified farmers (CLU-4)	5679 (6469)	7528 (8210)	6199 (6551)	3019 (6275)	4615 (6011)	4018 (12408)	6026 (50230)	279 (812)	37363 (53278)	5		35556 (60512)	34919 (28832)	89035 (75144)
Business owners (CLU-5)	6024 (9935)	7550 (10831)	9616 (15594)	20622 (30112)	11602 (18394)	15646 (71708)	35766 (298149)	281 (1733)	107107 (307626)	2		93789 (73918)	136715 (431217)	71850 (136722)
Medium-scale farmers and wage employment (CLU-6)	10686 (19911)	4891 (7343)	6943 (13615)	10522 (15630)	3360 (7055)	1445 (4860)	-189 (28952)	2000 (3511)	39657 (36009)	4		378345 (18427)	41926 (35100)	37937 (38727)
Business operators and large-scale farmers (CLU-7)	28170 (121547)	6896 (7607)	25239 (72476)	76169 (92906)	7572 (18216)	43053 (161226)	53979 (125168)	196 (570)	241274 (271197)	1		250852 (169291)	214821 (245759)	253454 (321771)
ANOVA	10.07***	6.96***	7.26***	86.4***	26.22***	7.76***	2.76**	10.7***	20.7***			30.02***	4.83***	9.81***
Average (overall)	7266 (22433)	5151 (11217)	6793 (20306)	8409 (23380)	4028 (9145)	6073 (38586)	11456 (119745)	921 (2377)	50096 (136219)			42371 (60021)	52120 (189349)	55796 (127287)
Average (2006)	8195 (13197)	5160 (6513.3)	7384 (22037)	6026 (18704)	2473 (5220)	3046 (8900)	9246 (42486)	841 (2056)	42371 (60021)					
Average (2009)	6624 (34858)	8129 (9291)	7617 (14109)	10496 (23796)	6425 (12235)	4653 (43668)	7390 (176133)	786 (1920)	52120 (189349)					
Average (2012)	6978 (11022)	2165 (15214)	5377 (23477)	8706 (26761)	3185 (8088)	10520 (49563)	17731 (100971)	1134 (2999)	55796 (127287)					

*significant at 10 percent, **significant at 5 percent, ***significant at 1 percent [1] Support income includes income from governmental and non-governmental support, pension and gifts.

Table 5: Mean asset endowment by livelihood strategy; values in parenthesis are standard deviation of the mean.

Livelihood strategies	Total livestock (values)	Total implements (values)	Total land (square meters)	Bank saving (values)	Jewellery (values)	# of male members	# of female members	Head education (years)	Max. HH education (years)
Small-scale farmers (CLU-1)	21706 (28808	5811 (11848)	1113 (1825)	3657 (12324)	8239 (39793)	1.85 (1.13)	1.84 (0.97)	3.38 (4.09)	9.11 (3.67)
Medium-scale livestock producers and petty traders (CLU-2)	39668 (100220)	9863 (10103)	2088 (2467)	18201 (38048)	24976 (45976)	1.74 (1.07)	1.72 (0.99)	3.68 (4.12)	8.99 (3.69)
Small-scale farmers and remittances (CLU-3)	21637 (21330)	5539 (6137)	891 (1102)	3218 (13193.0)	6185 (10871.4)	1.74 (1.17)	1.97 (1.09)	2.16 (3.60)	8.47 (4.07)
Diversified farmers (CLU-4)	30286 (41530)	13694 (18925)	1600 (2586)	10106 (24484)	8924 (20184)	1.58 (0.92)	1.77 (0.99)	5.58 (4.81)	10.45 (3.12)
Business owners (CLU-5)	36109 (42948)	37873 (43976)	2375 (2925)	35158 (93569)	34318 (64999)	1.64 (1.02)	1.82 (0.93)	6.37 (5.54)	12.14 (3.69)
Medium-scale farmers and wage employment (CLU-6)	19106 (47324)	5957 (7596)	1848 (3413)	10678 (24221)	16063 (36091)	1.77 (1.36)	1.55 (1.03)	1.14 (2.60)	6.62 (4.08)
Business operators and large-scale farmers (CLU-7)	178006 (439338)	41008 (49488)	4989 (12785)	31223 (58478)	35230 (39560)	1.76 (1.00)	1.76 (0.97)	5.70 (5.99)	11.09 (5.32)
ANOVA	15.65***	63.26***	12.19***	14.21***	13.75***	1.41	2.68**	29.46***	31.95***
Average (overall)	32279 (92600)	12534 (23065)	1689 (3181)	12865 (41902)	16271 (41157)	1.73 (1.11)	1.79 (1.00)	3.77 (4.55)	9.34 (4.02)
Average (2006)	41536 (135027)	8772 (16299)	2150 (4545)	13575 (50445)	10900 (42479)	1.72 (1.09)	1.74 (1.00)	3.81 (4.46)	8.71 (3.67)
Average (2009)	34660 (82882)	12621 (24288)	1498 (2517)	9141 (29880)	15121 (37845)	1.74 (1.07)	1.81 (0.97)	3.66 (4.46)	9.49 (3.96)
Average (2012)	20643 (20873)	16209 (26744)	1417 (1756)	15878 (42599)	22792 (42191)	1.74 (1.17)	1.81 (1.04)	3.83 (4.73)	9.80 (4.35)

*significant at 10 percent, **significant at 5 percent, ***significant at 1 percent

Livelihood transitions

The prominence of different livelihood strategy clusters shows variation through time (Table 6). In 2006, the majority of the households were Small scale farmers (cluster 1) (about 39 percent), Diversified farmers (cluster 4) (about 27 percent) and Medium-scale livestock producers and petty traders (cluster 2) (about 18 percent); Business operators and large-scale farmers (cluster 7) was the smallest group (about 1.4 percent of households). Hence, a majority of households were small or medium-scale farmers (about 84 percent) in 2006. In 2009, the distribution of households across the livelihood strategies was more equal, except for Business operators and large-scale farmers (cluster 7) which again comprised few households. In 2012, the Medium-scale livestock production and petty trading strategy (cluster 2) was the largest (20 percent of households) and the Business operators and large-scale farmers strategy (cluster 7) persisted in being the smallest. The distribution of households across the livelihood clusters was significantly different between 2006 and 2009, 2009 and 2012, and 2006 and 2012 with a chi-squared statistic of 760, 612 and 379, respectively. This indicates that the size of the clusters was not stable through the years and that livelihood transition pathways can be identified.

The majority of the households (more than 50 percent) changed livelihood strategy cluster between 2006 and 2009 or 2009 and 2012. Between 2006 and 2009, the main transition observed was between Small-scale farmers (cluster 1) and Small-scale farmers with remittances (cluster 3); this shows that many small-scale farmers started having access to remittance income during that period. Another notable transition in the 2006-2009 period is between the Medium-scale livestock producers and petty traders strategy (cluster 2) and Medium-scale farmers with wage employment (cluster 6), showing that medium-scale farmers gradually invested more labour in wage employment. Between 2009 and 2012, households continued shifting from small-scale farming (cluster 1) to small-scale farming with remittances (cluster 3) but a new important transition was observed between Medium-scale farmers with wage employment (cluster 6) and Diversified farmers (cluster 4) to Medium-scale livestock producers and petty traders strategy (cluster 2), seemingly showing the establishment of small business enterprises.

Table 6: Livelihood transition matrices (% of households, 2006-09 and 2009-12), values in parenthesis are number of households.

Livelihood strategies		2009								
		CLU-1	CLU-2	CLU-3	CLU-4	CLU-5	CLU-6	CLU-7	Overall	
2006	(CLU-1)	15.93 (68)	3.51 (15)	17.10 (73)	0.00 (0)	0.23 (1)	2.34 (10)	0.00 (0)	39.11 (167)	
	(CLU-2)	0.00 (0)	7.96 (34)	0.00 (0)	0.94 (4)	0.23 (1)	9.60 (41)	0.23 (1)	18.97 (81)	
	(CLU-3)	1.87 (8)	0.00 (0)	1.41 (6)	0.00 (0)	0.00 (0)	0.47 (2)	0.00 (0)	3.75 (16)	$X^2(36) = 760***$
	(CLU-4)	0.00 (0)	3.75 (16)	0.00 (0)	12.88 (55)	9.37 (40)	0.00 (0)	0.94 (4)	26.93 (115)	
	(CLU-5)	0.00 (0)	0.00 (0)	0.23 (1)	0.94 (4)	6.56 (28)	0.00 (0)	0.00 (0)	7.73 (33)	
	(CLU-6)	0.47 (2)	0.00 (0)	0.00 (0)	0.00 (0)	0.23 (1)	1.17 (5)	0.23 (1)	2.11 (9)	
	(CLU-7)	0.00 (0)	0.00 (0)	0.23 (1)	0.00 (0)	0.23 (1)	0.00 (0)	0.94 (4)	1.41 (6)	
	Overall	18.27 (78)	15.22 (65)	18.97 (81)	14.75 (63)	16.86 (72)	13.58 (58)	2.34 (10)	100 (427)	
Livelihood strategies		2012								
		CLU-1	CLU-2	CLU-3	CLU-4	CLU-5	CLU-6	CLU-7	Overall	
2009	CLU-1	7.26 (31)	0.00 (0)	9.37 (40)	0.00 (0)	1.17 (5)	0.47 (2)	0.00 (0)	18.27 (78)	
	CLU-2	0.70 (3)	9.84 (42)	0.00 (0)	0.00 (0)	0.23 (1)	4.45 (19)	0.00 (0)	15.22 (65)	
	CLU-3	6.09 (26)	0.00 (0)	9.60 (41)	0.00 (0)	0.23 (1)	2.81 (12)	0.23 (1)	18.97 (81)	$X^2(36) = 612***$
	CLU-4	0.70 (3)	11.71 (50)	0.00 (0)	0.00 (0)	1.64 (7)	0.00 (0)	0.70 (3)	14.75 (63)	
	CLU-5	0.94 (4)	3.04 (13)	2.34 (10)	0.00 (0)	7.49 (32)	0.70 (3)	2.34 (10)	16.86 (72)	
	CLU-6	0.00 (0)	5.62 (24)	0.00 (0)	0.70 (3)	0.00 (0)	7.03 (30)	0.23 (1)	13.58 (58)	
	CLU-7	0.00 (0)	0.23 (1)	0.00 (0)	0.94 (4)	0.47 (2)	0.23 (1)	0.47 (2)	2.34 (10)	
	Overall	15.69 (67)	30.44 (130)	21.31 (91)	1.64 (7)	11.24 (48)	15.69 (67)	3.98 (17)	100.00 (427)	

*significant at 10 percent, **significant at 5 percent, ***significant at 1 percent

Characterizing households with household livelihood transitions

On the basis of Figure 2 and Table 4, three broader livelihood strategies can be identified: Low remunerative livelihood strategies (clusters 1 and 3), Medium remunerative livelihood strategies (clusters 2, 4 and 6) and High remunerative livelihood strategies (clusters 5 and 7). Tables 7 and 8 present average changes in income and assets between 2006 and 2009, and 2009 and 2012. Results are presented by movement type (downward movements to a lower remunerative livelihood strategy, stays, and upward movements to a higher remunerative livelihood strategy). Downward movements from high remunerative strategies was

particularly associated with loss of income from remittances and, for households moving from hight to intermediate incomes, with loss of environmental income. Livestock assets were reduced as were jewellery assets. One third of downward moving households jumped directly from high to low remunerative strategies. Household staying at the same livelihood strategy showed little income variation across all income sources; there was a tendency for more well-off households to reduce their livestock assets and increase their jewellery assets. Upward movements to more remunerative strategies was conditioned by access to remittances and business income, with the latter only being important for movement to high remunerative strategies. Upward mobility was associated with increased bank savings and more implement assets. Very few households (n=8) moved directly from low to high remuneration strategies.

Table 9 presents the results of the MLM on socio-economic covariates of household livelihood movements. Households staying in low remunerative livelihood strategies form the base category group for the regression. We used the pooled data of the transition between 2006 and 2009 and 2009 and 2012 and we included a period dummy to control for livelihood movement differences between the two periods. Results show that households which experienced a severe shock (in the form of illness or death of adult household member, crop failure, livestock loss) were more likely to stay in a low remunerative livelihood strategy than to experience downward movement (from high to low), upward movement (from low to high) or to stay in a high or medium remunerative strategy. Likewise, households which experienced a moderate shock (in the form of illness of adult household member, partial crop failure livestock loss) were more likely to stay in a low remunerative strategy than to experience downward movement or upward movement (low/medium to him). Those households were also shown to be more likely to stay in a medium remunerative strategy than to stay in a low remunerative strategy. When head of households were born in the village of residence, households were more likely to experience upward movement (from medium to high or low to medium), stay in a high or medium remunerative strategy, or a move downwards (from high to medium) than stay in a low remunerative livelihood strategy. Results also show that households with a large number of children were less likely to experience a downward movement, upward movement (except from low to high) or to stay in a high remunerative strategy than to stay in a low remunerative livelihood strategy. A similar

pattern was observed for households with a married head. Also, households located further away from the center of the village were less likely to experience an upward movement (from medium to high) and less likely to stay in a high returm strategy than to stay in a low remunerative strategy. Remote households were however more likely to experience an upward movement (low to medium) than to stay in a low remunerative strategy.

Table 7: Mean of change in income (Rs, aeu adjusted) (total and from each source) of households in different livelihood transition groups (mean value of changes between years); values in parenthesis are standard deviation of the mean

		Environmental income	Crop income	Livestock income	Remittances	Support income[1]	Other income	Business income	Wage income	Total income
Downward movement	high to low (n=16)	2548.0 (3602.5)	-6367.9 (8735.7)	4170.1 (11674.7)	-41134.1 (43371.7)	-2330.3 (10235.0)	15208.4 (47209.7)	9087.5 (37545.6)	66.6 (612.5)	-18751.6 (82451.0)
	medium to low (n=8)	-3584.3 (9251.8)	-1931.9 (3831.7)	-419.0 (4427.9)	636.4 (3143.5)	-985.4 (10374.7)	35766.2 (90865.2)	8948.5 (15189.0)	-143.2 (898.6)	38287.4 (111532.7)
	High to medium (n=26)	-28714.8 (137714.8)	-8454.7 (10765.5)	-720.5 (16094.1)	-45472.7 (57491.1)	-5017.9 (11174.8)	544.2 (15959.7)	13452.6 (77772.5)	-61.7 (396.0)	-74445.6 (182133.5)
	Sub-average (n=50)	-14689.8 (99568.8)	-6743.3 (9485.2)	892.7 (13485.1)	-36706.9 (50383.0)	-3512.6 (10670.4)	10872.3 (46428.9)	11335.1 (59627.6)	-33.7 (562.0)	-38586.2 (150195.1)
Stay	Stay in low (n=293)	345.1 (3597.2)	-1241.0 (6997.3)	-1192.2 (29372.0)	1558.6 (11637.3)	42.0 (5117.3)	1596.5 (17356.0)	-1082.5 (39444.5)	325.6 (3068.2)	352.0 (54337.6)
	Stay in medium (n=323)	-1722.3 (19604.2)	-941.6 (19811.8)	-316.2 (13071.8)	-139.9 (13552.4)	741.5 (7383.1)	1284.2 (13788.0)	5081.8 (106651.7)	203.0 (2823.7)	4190.6 (108299.5)
	Stay in high (n=79)	286.3 (7797.1)	-4569.9 (14206.5)	-5525.7 (36037.5)	1414.5 (39641.2)	-6202.6 (22377.0)	-3432.2 (100634.6)	-4249.9 (570992.7)	217.3 (2411.4)	-22062.1 (587236.4)
	Sub-average (n=695)	-622.4 (13843.7)	-1480.2 (15054.7)	-1277.6 (24304.7)	752.8 (17874.8)	-342.7 (9854.2)	879.7 (36818.3)	1422.3 (206369.0)	256.3 (2884.0)	-411.8 (213320.4)
Upward movement	Low to medium (n=41)	-2533.1 (21309.2)	894.9 (5949.5)	-4449.4 (20275.7)	3796.0 (12720.9)	1564.8 (6938.1)	-240.8 (2492.8)	-1013.8 (7978.7)	-656.8 (3594.0)	-2638.2 (34747.1)
	medium e to high (n=60)	12141.1 (90550.2)	1819.4 (12475.9)	2215.9 (14441.0)	31242.1 (52512.3)	10316.2 (20431.1)	33547.4 (163208.8)	26495.7 (83615.1)	-294.2 (1511.7)	117483.6 (230262.3)
	low to high (n=8)	2802.6 (6154.3)	-7356.6 (6827.6)	4463.8 (8568.8)	53316.1 (119965.5)	4317.6 (16172.3)	4220.7 (26263.3)	64984.7 (142888.5)	-836.3 (1901.1)	125912.7 (166462.4)
	Sub-average (n=109)	5936.0 (68551.1)	798.2 (10328.1)	-126.3 (16812.2)	22538.5 (52390.6)	6584.1 (16748.2)	18685.7 (121954.7)	18973.0 (74204.1)	-470.4 (2511.4)	72918.8 (186244.0)
Overall average (n=854)		-608.9 (36571.8)	-1497.6 (14330.3)	-1003.6 (22961.1)	1340.2 (29930.7)	355.8 (11282.4)	3737.4 (56107.2)	4242.8 (188648.5)	146.6 (2764.8)	6712.7 (208405.1)

[1] Support income includes income from governmental and non-governmental support, pension and gifts.

Table 8: Household assets in different livelihood transition groups (mean value (Rs and aeu adjusted) of changes between years); values in parenthesis are standard deviation of the mean

		Total livestock	Total implements	Bank saving	Jewellery	Total value of financial and physical assets
Downward movement	high to low (n=16)	-10372 (20949)	-4741 (26247)	-8029 (25483)	-10486 (52280)	-33628 (83963)
	medium to low (n=8)	-13666 (9989)	2084 6775	1092 (26393)	-582 (18061)	-11073 (33289)
	High to intermediate (n=26)	-22822 (69808)	-8428 30887	1107 (39331)	-8918 (97442)	-39060 (192543)
	Sub-average (n=50)	-17373 (51662)	-5566 26802	-1819 (33258)	-8086 (75757)	-32844 (146045)
Stay	Stay in low (n=293)	1920 (24221)	3147 11648	2686 (11793)	3694 (32386)	11447 (44591)
	Stay in medium (n=323)	-14202 (85704)	1785 10464	1192 (33247)	5602 (38874)	-5623 (99411)
	Stay in high (n=79)	-47723 (177948)	7927 54689	-7315 (111898)	23012 (79397)	-24099 (227035)
	Sub-average (n=695)	-11216 (86270)	3058 21154	855 (44584)	6776 (43424)	-527 (106541)
Upward movement	Low to medium (n=41)	-13784 (64423)	2122 6760	642 (21837)	-4918 (48918)	-15938 (76901)
	Medium to high (n=60)	5821 (43500)	20159 39727	7287 (44021)	18425 (18497)	51691 (86340)
	low to high (n=8)	-5238 (17146)	4071 62800	2047 (7469)	-16405 (58438)	-15525 (89193)
	Sub-average (n=109)	-2365 (51742)	12193 34834	4403 (35345)	7088 (38230)	21319 (88985)
Overall average (n=854)		-10447 (80957)	3719 23949	1151 (42905)	5946 (45400)	370 (107630)

Table 9: Socio-economic determinants of households' livelihood movements (2006-09 and 2009-12), values in parenthesis are standard deviation of the coefficients

	Downward movement from				Upward movement from				Stay in		
	high to medium	medium to low	Hgh to low		low to high	medium to high	low to medium		high	Medium	low
Head born in the village	1.517*** (0.290)	0.999 (0.609)	-0.204 (0.538)		-0.392 (0.808)	1.611*** (0.313)	1.027*** (0.368)		1.947*** (0.313)	2.286*** (0.204)	
Number of children	-0.405** (0.180)	-0.713*** (0.271)	-0.347** (0.153)		-0.273 (0.199)	-0.338** (0.134)	-0.297** (0.130)		-0.446*** (0.108)	0.031 (0.070)	
Number of elders	-0.283 (0.332)	0.091 (0.450)	-0.668 (0.589)		0.075 (0.477)	-0.174 (0.255)	-0.297 (0.324)		0.325 (0.201)	-0.024 (0.152)	
Shock: severe	-1.175 (1.110)	-0.266 (0.945)	-14.942*** (0.424)		-14.910*** (0.451)	-0.400 (0.521)	-0.547 (0.605)		-1.287* (0.755)	-0.732* (0.395)	Base category
Shock: Moderate	-0.936** (0.459)	-1.669* (0.901)	-15.230*** (0.336)		-1.808* (0.967)	-0.669* (0.369)	-0.075 (0.352)		0.367 (0.297)	0.748*** (0.208)	
Head married	-1.774*** (0.312)	-2.166*** (0.423)	-1.577*** (0.378)		-2.159*** (0.489)	-0.528 (0.382)	-2.089*** (0.300)		-1.488*** (0.343)	-1.461*** (0.231)	
Distance from village center	-0.017 (0.019)	-0.021 (0.013)	-0.010 (0.010)		-0.013 (0.010)	-0.012** (0.006)	0.015*** (0.004)		-0.024*** (0.008)	-0.0003 (0.003)	
Period:dummy	0.317 (0.474)	-0.168 (0.617)	0.380 (0.515)		-0.134 (0.422)	-1.667*** (0.399)	-1.010*** (0.371)		0.278 (0.304)	0.146 (0.197)	
Joint test of model $X^2(64)$	66809.28***										
# of observations	854										

*significant at 10 percent, **significant at 5 percent, ***significant at 1 percen

Discussion

Households' livelihood strategies

We identified seven distinct livelihood strategy clusters. The results offer empirical evidence that households utilize their asset-base to engage in different livelihoods strategies (Ellis 2000; DFID 1999; Scoones 1998). Major differences in outcomes (income) between livelihood strategies were observed. Other empirical studies from Nepal (Nielsen et al. 2013; Rahut and Scharf 2012; Rahut et al. 2014) and elsewhere (Ansoms and McKay 2010; Jansen et al. 2006; Zenteno et al 2013) offer similar results.

In average, small-scale farming (cluster 1) was the lowest remunerative livelihood strategy. Households which adopted this strategy displayed a high degree of income diversification; the strategy was most common in 2006. The second less remunerative livelihood strategy was small-scale farmers with remittance (cluster 3); this strategy was similar to cluster 1 but a higher share of remittance income contributed to higher average household income. While cluster 3 was not very prominent in 2006 (four percent of households), it gained importance and was the second most important livelihood strategy in 2012 (21 percent). This is in line with findings documenting the increasing importance of remittances to Nepali rural households in this period (Thangunna and Acharya 2013). Diversified farming (cluster 4) was the third less remunerative strategy; the average contribution of different sources of income to total income was very similar to that of cluster but average total household incomes were 68 percent higher than for cluster 1. Asset endowment for cluster 4 households is higher than for cluster 1; the most remarkable example is education levels which are similar to those of higher remunerative livelihood strategies. Education increases access to information, which is said to enhance farmers' ability to increase their income (Bhandari 2013) and this could explain the difference in income obtained between clusters 4 and 1 households. Households selecting Medium-scale livestock producers and petty trading (cluster 2) and Medium-scale farming with wage employment (cluster 6) each have an additional dominant source of income; while cluster 6 households depend heavily on wage employment, cluster 2 households engage in petty trading. Also noteworthy, households in cluster 6 showed the highest average share of environmental income, possibly reflecting their needs for agricultural inputs in the form of composted manure and fodder, and had negative average

business income. Many of the households in this cluster own a business which is engaged in the tourism industry (e.g. hotel, restaurant); tourism has been heavily affected during the post-conflict years in Nepal (e.g. Upadhayaya et al., 2011) and this could be a reason for the negative business income values (i.e. running costs are higher than revenues). The Beni-Jomsom road construction in Mustang has also affected tourism in the region: local households report that the increased accessibility to the district has resulted in a loss of value of the area for trekkers who attach high importance to remoteness, isolation from markets, and insular economy and culture of mountain areas (Nepal and Chipeniuk, 2006). Both cluster 2 and cluster 6 gained in importance through time as more households transited to those strategies. This phenomenon of rural households changing their livelihood strategies by shifting their farming occupation to non-farm activities, also called farm exit, has been observed in Nepal by Bhandari (2013). The most remunerative livelihood strategies were, in average, Business ownership (cluster 5) and Business operation and large-scale farming (cluster 7). Again, income diversification is the norm for those livelihood strategy groups. The two highly remunerative livelihood strategies gained in prominence with time: while cluster 5 and cluster 7 accounted for only eight percent and one percent of the sample in 2006, 11 percent and four percent used those livelihood strategies in 2012. Only a minority of households adopted the higher remunerative livelihood strategies; this is consistent with the fact that rural areas of developing countries are predominantly inhabited by asset poor households which have few other options than to adopt a lower or intermediate remunerative livelihood strategies (Abdulai and CroleRees 2001; Barrett et al. 2001; Skees et al. 2002). It is also in line with the national realities in Nepal where the majority of the households are practicing small-scale subsistence farming (IFAD 2013).

Household's livelihood transitions

Similarly to Bhandari (2013), our results show that households commonly shift livelihood strategy through time. Households belonging to the less remunerative livelihood strategies more commonly shifted to another low remunerative strategy (e.g. from cluster 1 to cluster 3 and the other way around). Limited direct transition between a low remunerative livelihood strategy and a high remunerative livelihood strategy was observed within a three year period. This suggests that production and cash generation in the low remunerative livelihood

strategies is too low over three years to allow for asset accumulation and investments into new and more remunerative activities. However, shift from low to intermediate remunerative livelihood strategy was common over the study period, and a few households who were in a low remunerative strategy in 2006 made it to a high remunerative strategy in 2012 which could be due to positive shocks that build rural households asset base (e.g. sudden remittance inflow).

Very few households belonging to the most remunerative livelihood strategies in 2006 and 2009 (i.e. cluster 5 and cluster 7) transited directly to low remunerative livelihood strategies. This might be explained by the relative resilience of those strategies to shocks. For example, cash accumulation through high net agriculture and business income can be saved and used in times of needs or invested further in household livelihood assets, beyond household consumption needs. Still, movement between the high remunerative livelihood strategies and the intermediate strategies were commonly observed, and a few households who were in cluster 5 or cluster 7 in 2006 dropped to a low remunerative livelihood strategy over time, especially if they were hit by a severe shock depleting household's livelihood assets (e.g. livestock loss).

Interestingly, intermediate remunerative livelihood strategies (cluster 2, cluster 4, and cluster 6) appeared as a stepping stone for households in the low remunerative livelihood strategies trying to move out of poverty. However, not all intermediate remunerative strategies equally served that purpose. Results show that households in the low remunerative livelihood strategies transited to cluster 2 and cluster 6 more often than to cluster 4. This trend suggests that cluster 2 and cluster 6 have relatively fewer entry barriers than cluster 4. For example, households in cluster 2 and cluster 6 have similar educational endowment, comparable to that of households in low remunerative livelihood strategies, while cluster 4 households have higher head education and maximum household education levels. It thus appears that households belonging to cluster 4 use their educational endowment to optimally diversify their limited assets to different livelihood activities (Khatun and Roy 2012) and that lack of education could be an entry barrier for poor households to access cluster 4. Moreover, while households belonging to cluster 4 were plentiful in 2006 (27 percent of households), this livelihood strategy group was depleted through time and only seven households belonged to

this group in 2012. Households mainly moved into business (cluster 5) and petty trading (cluster 2), which become more attractive through time. During the six years covered by our study, we were however not able to witness any substantial movement of households from the low remunerative livelihood strategies to the high remunerative livelihood strategies (via the intermediate livelihood strategies); this hence emphasizes the importance of multiple wave panel data collection. As asset accumulation and livelihood transitions occur slowly (e.g. Naschold 2012), adding another wave to this panel data might increase the number of observations of households who were initially poor but succeeded in transiting to one of the high remunerative livelihood strategies.

In general, households' livelihood transitions matched households' livelihood outcomes and accumulation of physical and financial assets: households who experienced an upward movement, on average, had a higher positive increase in income and households who experienced a downward movement, on average, had a higher decrease in income. Similarly, households that made a downward movement experienced a decline in asset endowment, while households that made an upward movement increased their asset endowment. This result is in line with studies that report the importance of assets as a pathway to engage in more remunerative livelihood strategies (Nielsen et al. 2013; Reardon et al. 2000) to move out of poverty (Barret 2001; Carter and Barret 2006; You 2014). This has implication for rural poverty reduction interventions. Households that witness an increase in asset endowment are more likely to escape poverty (Krishna 2006) via adoption of more remunerative livelihood strategies. Consequently, policy measures to increase asset accumulation would enable rural households to pursue a more remunerative, resilient and sustainable livelihood strategy.

In addition to assets, the findings also show that households' experience of shocks, in severe or moderate form, is associated with both persistence in and movement into the low remunerative livelihood strategies. This could be through household depletion of assets (Quisumbing 2011) to cope with income/consumption shortfalls. Hence households could be pushed to and remain in poverty if they are unable to protect their asset base from unexpected shocks (Abro et al. 2014). Other household and household head characterstics (i.e., head born

in the village, head married, and number of children) and location had also a role in modifying household livelihood transitions.

The method of combining income and assets for livelihood clustering

Income and assets each have their merits and demerits in measuring rural welfare and livelihood (Fields et al. 2003; McKay 2000; Moser and Felton 2007). Combining income and assets allows a better welfare or livelihood understanding as one overcomes the limitations of the other (Nielsen et al. 2012). We employed a regression-based statistical approach to regress income from each livelihood activity against each asset type in order to create a set of activity choice variables. A similar approach has been used by Adato et al. (2006), Giesbert and Schindler (2012), and Quisumbing and Baulch (2013) to create a composite asset index to understand the nature of poverty traps and asset convergence. This method has been reported as superior to other data reduction statistical methods, such as PCA and PFA, as it has attractive advantages with roots in economic theory (Adato et al. 2006; Giesbert and Schindler 2012). The coefficients of the individual assets indicate the marginal contribution of the assets to income from the livelihood activity under consideration. Extensions to include polynomial terms of the individual assets and interaction terms between assets in the regression model captures the concept of diminishing marginal productivity of assets and complementarity between assets, respectively. However, choosing the set of assets to be utilized for the creation of the asset index is a major challenge with the current approach, as it is practically impossible to incorporate the complete list of assets in creating asset index choice variables due to estimation difficulties and data availability, leaving researchers with the hard choice of what to include. Considering this, in the current paper, we included a total of 14 asset variables spanning five major asset categories: physical, financial, human, natural and social.

We undertook statistical analysis to judge the performance of our approach in clustering households into different livelihood strategies. We ran a similar latent Markov model to cluster households using income and asset choice variables separately (the BIC suggested the 1 class-7 state and 1 class-6 states model for both income and asset approaches, respectively, Appendix E) and compared the performance of our approach with income as well as assets. We estimated intra-cluster correlation coefficients for income and asset variables – as a

measure of the similarity of households in a cluster and the results are presented in Appendix F. The results suggest that income and asset based approaches sets the two extremes in livelihood strategy clustering: using an income approach, households in a cluster are relatively more similar in income variables, except remittances, livestock, and support income and less similar in asset variables; while using an asset approach households in a cluster are relatively more similar in asset variables, except bank saving, households education and maximum household education and less similar in income variables, except livestock income. The combined income-asset approach forms a middle ground: households in a cluster are relatively similar in asset variables compared to the income approach, and income variables compared to asset approach. In addition, the combined income-asset approach resulted in more similar households within cluster than the two other approaches when it came to the previously deviating asset variables (bank saving, households education and maximum household education) and income variables (remittances and support income).

We also compared the mean total income of each cluster for the three approaches using Bonferroni multiple comparison tests. The mean total income was significantly different for the five (from 15 possible pairs), 10 (from the 21 possible pairs) and 12 pairs (from the 21 possible pairs) of livelihood strategies using asset, income and combined income-asset approach, respectively (Appendix G). This indicates that our approach better distinguishes the livelihood strategies identified compared to both the income and the asset approach.

Conclusion

This study presents a novel approach to studying the dynamics of livelihoods: it uses combined asset and income data from a unique environmentally-augmented three-wave panel dataset from 427 rural housholds in three locations of Nepal to identify seven distinct livelihood strategies. The identified livelihood strategies were shown to have distinct levels of remuneration and adoption of one of the livelihood strategies with the lowest economic returns was common. On the other hand, households adopting a high remunerative livelihood strategy were rare. The prominence of different livelihood strategy clusters showed variation through time, and most households changed their livelihood strategy between 2006 and 2012.

Lack of asset endowment was shown to be the most important entry barrier preventing households to move directly from low remunerative livelihood stragies into high remunerative livelihood strategies. Shocks, household composition, and closeness to market centers were found to reinforce or lessen the enty barriers. This study shows that many households appear to be on a pathway out of poverty: they are typically moving away from small-scale farming and into wage work (including migratory work) and petty trading. Conversely, other households were found to fall back into poverty by adopting small-scale farming Multi-faceted policies should be promoted at the individual household and community level. For example, promotion policy for households with low asset endowment and protection policy for those households on the pathway out of poverty are important at the individual level while construction of roads and schools and introduction of effective family planning policies are important at the community level.

The proposed approach to studying livelihood dynamics allows to better distinguish between livelihood strategies than more commonly used approaches based on income or assets and is hence suitable for livelihood strategy-based targeting. This novel approach statistically combines income and asset variables on the basis of their relationship outlined in the livelihood framework and the rural household income optimization theory. While stochasticity weakens the traditional income-based approach and while the asset-based approach does not pay attention to the link between assets and livelihood outcomes in defining livelihood strategies, we argue that combining asset and income benefits from the advantages of both the income and asset-based approaches while minimizing their disadvantages. The proof of success, however, is whether the proposed approach will stimulate research that is empirically richer than in the past and whether the resultant outomes will contribute to improve targeting of interventions towards specific strategies and transition pathways.

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Appendices

Appendix A: Optimal livelihood cluster determination test results based on latent Markov cluster analysis

Model	LL	BIC(LL)	Npar	Class.Err.
1-State 1-Class	-6021.69	12079.73	6	0
2-State 1-Class	-4367.95	8838.87	17	0.0396
3-State 1-Class	-3612.12	7418.052	32	0.0519
4-State 1-Class	-3441.3	7191.5	51	0.0802
5-State 1-Class	-3260.39	6968.983	74	0.1087
6-State 1-Class	-3139.92	6891.575	101	0.1096
7-State 1-Class	-2987.91	6775.322	132	0.1029
8-State 1-Class	-2885.04	6781.569	167	0.1009
9-State 1-Class	-2833.85	6915.405	206	0.1077
10-State 1-Class	-2660.03	6828.201	249	0.1028

Appendix B: Bonferroni multiple comparison test of mean values of attributes used for clustering by year and cluster

	Environment asset index	Crop asset index	Livestock asset index	Business asset index	Wage asset index	Transfer income
1vs2	***			***	***	
1vs3					***	***
1vs4	***				***	
1vs5	***	***		***	***	***
1vs6	***				***	***
1vs7	***	***	***	***	***	***
2vs3	***	***		***	**	**
2vs4	***				***	***
2vs5	***			***	***	***
2vs6	***				***	***
2vs7	***	***	***	***		***
3vs4	***				***	
3vs5	***	***		***	***	***
3vs6	***				***	
3vs7	***	***	***	***		***
4vs5	***	**		***		***
4vs6	***				***	
4vs7	***	***	***	***	***	***
5vs6	***	*		***	***	***
5vs7	***	***	***	***	***	***
6vs7	***	***	***	***	***	***

*significant at 10 percent, **significant at 5 percent, ***significant at 1 percent

Appendix C: Bonferroni multiple comparison test of mean income (from each source) among livelihood strategies

	Environmental income	Crop income	Livestock income	Remittances	Support income	Other income	Business income	Wage income	Total income
1vs2	***	***							**
1vs3				***					
1vs4		***			***			**	
1vs5		***		***	***	**	*	**	***
1vs6	*			***				***	
1vs7	***		***	***	***	***			***
2vs3	***	***	**	**					
2vs4	*								
2vs5				***	***				***
2vs6				***				***	
2vs7	***		***	***	*	***			***
3vs4		***		**				***	
3vs5		***	**	***	***	**		***	***
3vs6									
3vs7	***		***	***	*	***			***
4vs5				***	***				***
4vs6				**				***	
4vs7	***		***	***		***			***
5vs6				***	***	**		***	***
5vs7	***		***	***		***			***
6vs7	***		***	***		***		***	***

*significant at 10 percent, **significant at 5 percent, ***significant at 1 percent

Appendix D: Bonferroni multiple comparison test of mean asset endowment among livelihood strategies

	Total livestock	Total implements	Total land	Bank saving	Jewellery	Number of male	number of female	Head education	Max. Head education
1vs2			***	***	***				
1vs3								**	
1vs4		***						***	***
1vs5		***	***	***	***			***	***
1vs6								***	***
1vs7	***	***	***	***	***			*	*
2vs3			***	***	***			***	
2vs4					***			***	***
2vs5		***		***				***	***
2vs6								***	***
2vs7	***	***	***						*
3vs4		***						***	***
3vs5		***	***	***	***			***	***
3vs6							***		***
3vs7	***	***	***	***	***			***	***
4vs5		***		***	***				***
4vs6		**						***	***
4vs7	***	***	***		**				
5vs6		***		***	***			***	***
5vs7	***		***						
6vs7	***	***	***					***	***

*significant at 10 percent, **significant at 5 percent, ***significant at 1 percent

Appendix E: Optimal livelihood cluster determination test results based on latent Markov cluster analysis for income and asset approach

	Income approach					Asset approach			
	LL	BIC(LL)	Npar	Class.Err.		LL	BIC(LL)	Npar	Class.Err.
1-State 1-Class	-5664.58	11365.51	6	0		-8035.47	16119.4	8	0
2-State 1-Class	-3387.3	6913.899	23	0.0301		-7566.6	15278.57	24	0.0777
3-State 1-Class	-2869	5986.33	41	0.0854		-6333.14	12950.94	47	0.0426
4-State 1-Class	-2707.56	5778.522	60	0.0984		-5362.52	11136.91	68	0.0139
5-State 1-Class	-2591.96	5686.632	83	0.0946		-5262.67	11088.62	93	0.021
6-State 1-Class	-2473.19	5612.619	110	0.1216		**-5060.89**	**10860.71**	**122**	**0.0213**
7-State 1-Class	**-2358.14**	**5570.282**	**141**	**0.1204**		-5068.26	11075.32	155	0.0256
8-State 1-Class	-2285.45	5636.898	176	0.129		-4927.52	11017.94	192	0.0429
9-State 1-Class	-2197.3	5696.805	215	0.1459		-4881.7	11174.63	233	0.0185
10-State 1-Class *	-2145.09	5852.824	258	0.1349		-	-	-	-

*the 10-State 1-Class model for the asset approach does not converge at all and it is not presented here.

Appendix F: Intra-cluster correlation of the three approaches for asset and income variables; Values in parenthesis are standard errors of the intra-cluster estimate

Approach	Environmental income	Crop income	Livestock income	Remittances	Support income	Other income	Business income	Wage income	Total income
Income	0.064 (0.043)	0.213 (0.115)	0.060 (0.041)	0.290 (0.140)	0.125 (0.076)	0.010 (0.010)	0.042 (0.030)	0.540 (0.168)	0.157 (0.091)
Asset	0.001 (0.004)	0.066 (0.049)	0.087 (0.062)	0.000 (0.003)	0.006 (0.007)	0.044 (0.034)	0.001 (0.004)	0.010 (0.010)	0.035 (0.028)
Income and asset	0.049 (0.032)	0.033 (0.023)	0.034 (0.24)	0.326 (0.141)	0.125 (0.072)	0.036 (0.025)	0.010 (0.009)	0.052 (0.034)	0.100 (0.060)
	Total livestock	Total implements	Total land	Bank saving	Jewelry	# of male members	# of female members	Head educ.	Max. HH edu.
Income	0.061 (0.041)	0.073 (0.048)	0.063 (0.042)	0.049 (0.034)	0.050 (0.035)	0.006 (0.007)	0.026 (0.020)	0.035 (0.025)	0.039 (0.028)
Asset	0.295 (0.158)	0.353 (0.174)	0.299 (0.160)	0.069 (0.051)	0.075 (0.055)	0.026 (0.022)	0.033 (0.027)	0.002 (0.004)	0.054 (0.041)
Income and asset	0.082 (0.050)	0.261 (0.124)	0.060 (0.038)	0.070 (0.044)	0.067 (0.043)	0.002 (0.005)	0.009 (0.009)	0.139 (0.078)	0.149 (0.083)

Appendix G: Bonferroni pairwise multiple comparison test of livelihood strategies; Values in parenthesis are standard errors of the intra-cluster estimate

	1vs 2	1vs 3	1vs 4	1vs 5	1vs 6	1vs 7	2vs 3	2vs 4	2vs 5	2vs 6	2vs 7	3vs 4	3vs 5	3vs 6	3vs 7	4vs 5	4vs 6	4vs 7	5vs 6	5vs 7	6vs 7
Asset					***					***				***			***		***		
Income		***				***	***				***	***	***	***	***			***			***
Income and asset	**			***		***			***		***		***		***	***		***	***	***	***

*significant at 10 percent, **significant at 5 percent, ***significant at 1 percent