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Assessing environmental dependence using asset and income measures: Evidence from Nepal

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ABSTRACT

Understanding rural environmental dependence in a rural population is an important factor in the framing of environmental policy with the dual aim of tackling poverty and conserving nature. Firstly, this study compares the assessment of environmental dependence between poverty groupings based on income and asset measures. Using a composite asset index, we were able to distinguish the asset poor from the asset non-poor. We then combined income data with the asset index, enabling us to disentangle the stochastic and structural nature of poverty. The distribution of poor and non-poor households based on income measures was significantly different from that based on asset measures. The income poor are substantially more dependent on environmental resources than the income non-poor (about 15% difference) while strikingly minimal difference was observed in environmental dependence between the asset poor and non-poor (less than 2% difference). The level of environmental dependence between the poor and non-poor households differs with the choice of welfare measure and combining two of these measures to identify wealth groups provides policy makers with better insight on the variations in environmental dependence.

1. Introduction

Though forests are an integral part of the livelihood of rural households in developing countries, not all rural households are equally dependent on environmental resources. Numerous studies have indicated that the poorer part of rural society is more reliant on the natural resource base, while the richer portion of the society extracts more resources from the environment (Angelsen et al., 2014; Babulo et al., 2009; Heubach et al., 2011; Lepetu et al., 2009; Vedeld et al., 2007; Walelign, 2013), with few notable exceptions (Uberhuaga et al., 2012). A higher dependence on environmental income means that it constitutes a larger share of total income in poorer households. Two facts that prevail in rural areas are mentioned to be responsible for this. First, rural poor households often face an uphill battle to participate in remunerative income generating activities and end up with low return from most activities they engage in. Nonetheless, forests play a more important role in the livelihood of the rural poor than the richer households. Second, poor households have restricted access to key and high value environmental resources (e.g. timber) (Adhikari et al., 2004a, 2004b). As a result, the rural poor often extract environmental products that have lower market values and lower contribution to total income accounting.

Environmental dependence involves households' reliance on the extraction of forest and other non-cultivated environmental resources as another source contributing to households' total income. It is a crucial factor in rural households' coping strategy in times of income/consumption shortfalls (e.g. agricultural slack seasons, negative shocks) and may also play a role in helping move out of poverty through contribution to the accumulation of assets (Angelsen and Wunder, 2003; Vedeld et al., 2007). These contributions of the environment are measured in monetary terms and constitute environmental income in rural households' total income accounting (see e.g. Babulo et al., 2009; Fisher, 2004). Here we use the term 'environmental income' for income from forest and non-forest environmental resources while some other papers (see e.g. Babulo et al., 2009) used the term 'forest and environmental income' instead. On a global average, rural households can exhibit a level of environmental dependence as high as 28% of their total income (Angelsen et al., 2014).

Income has been used as a basis for defining various wealth categories and for investigating the difference in the level of environmental dependence among these categories. Prado Córdova et al. (2013), Hogarth et al. (2013), Yemiru et al. (2010) and Mamo et al. (2007) used income quintiles, Rayamajhi et al. (2012) and Babulo et al. (2009) used income quartiles, Heubach et al. (2011) used income terciles and Walelign (2013) used two poverty groups. Unlike these previous studies, in this paper, we employ both asset and income welfare (instead of just income) to define wealth categories. There are two fundamental reasons for this, both related to the seasonal and transitory nature of income. First, it does not permit any prediction on long-term wellbeing of households (Nielsen et al., 2012, 2013). Accordingly, it does not reflect households' actual level of dependence on

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environmental resources as this might be determined substantially by the income shocks, whether positive or negative. Second, although income measures can provide information on who is non-poor and who is poor, it does not by itself accurately identify the various categories among the non-poor and the poor.[1]

Nielsen et al. (2012) used a method of combining income and asset information to assess environmental dependence. They first defined income and asset quintiles and then assigned households into chronic poor, transient poor, transient non-poor and chronic non-poor by comparing these income and asset quintiles. Two limitations stand out with this method. First, they simply compared the income and asset quintiles to define the wealth categories with no clear threshold defining the categorization, especially in identifying the transient poor from the chronic poor and transient non-poor from the chronic non-poor. Second, they considered only physical and financial assets (e.g. the value of implements and the value of small domestic animals) that can be easily measured and quantified. They did not consider other assets (such as human capital and social capital) in generating asset quintiles. As a result, their method does not include some very important assets in the form of human and social capital which can affect households' wealth status (see Winters et al., 2009 for detailed discussion).

In this paper, we included a wider range of assets in our assessment of households' wealth status — such as education of the household head, highest education attained in the household, age of the household head, trust and help in the community and number of household adult members. Firstly, we compare the poverty distributions (poor and non-poor) based on asset measures as opposed to income measures. Secondly, we provide a more in-depth understanding of the poor and non-poor categories in the study population by combining the traditionally used income measure with a measure of households' asset endowments. We then revisit the issue of environmental dependence and its variation between the poor and non-poor, which is important in the framing of forest policy aimed at tackling poverty and conserving nature. These objectives are achieved using a three year panel dataset, collected under the Community based Natural Forest and Tree Management in the Himalaya (ComForM) project using the Poverty Environmental Network (PEN) data collection instruments in Nepal.

One challenge of combining asset and income measures, to capture the transitory nature of poverty in our assessment of environmental dependence, is the creation of a composite asset index as different types of assets are measured in different units. In the current study we employed the livelihood weighted approach (Adato et al., 2006) to derive a single asset index as this approach has some important advantages which we highlight later. This enables us to use the combination of income and assets to add to the knowledge base on environmental dependence in rural populations through the empirical analysis of its variation among the non-poor and poor sections of the population. We used the national poverty line as a threshold to determine household's poverty status (poor or non-poor).

The remainder of the paper is organized as follows. In Section 2 we describe the distinction between the structural and stochastic nature of poverty while the methodology in presented in Section 3. The results from our case study country is presented in Section 4 and then discussed in Section 5. We conclude in Section 6.

2. Distinguishing stochastic from structural nature of poverty

Using income/consumption measures to inform on the welfare of a population was the norm for many years and is still being practiced today, although more and more with support from other measures (Adato et al., 2006; Naschold, 2012, 2013; Nielsen et al., 2012). However, asset based poverty measures are generally considered more suitable for forward looking policy design because a household's economic well-being is dependent on the composition of its asset endowments (Naschold, 2012) and can also be seen as a measure of structural well-being (Carter and May, 2001). Another forward looking approach in the literature includes the assessment of households' vulnerability to poverty (Haughton and Khandker, 2009; Ligon and Schechter, 2003; Morduch, 1994). This approach often measures the probability that households fall into income/consumption poverty based on households' income/consumption expenditure, its variance (risk) and the monetary poverty line, and on the basis of the estimated probability households are categorized into different vulnerability categories. In shortly, often a household is labelled as vulnerable if its estimated probability of falling into poverty is greater than the average of the estimated probability of falling into poverty (Haughton and Khandker, 2009). This analysis has often been entirely based on income or consumption poverty. However, the growing literature on other poverty measures has highlighted the weaknesses of monetary (i.e. income/consumption) poverty measures while trying to fill the knowledge gaps, answering questions left unanswered by these measures. Sahn and Stifel (2003) and Carter and Barrett (2006) summarized the weakness of income/consumption poverty measures as being unable to distinguish those who were poor because they did not have the required asset base to allow them to exit poverty from those who were poor because of some unexpected event (shock). Similarly, they were unable to distinguish those who were non-poor and could be expected to remain non-poor from those who were temporarily non-poor and would soon drop below the poverty line, again because they did not have the required asset base to allow them to sustain a non-poor status. The use of monetary poverty measures combined with asset poverty measures is a method that allows the distinction between these two groups of poor and non-poor in a given population (structural and stochastic poor and non-poor).

The structural poor are households that have low incomes and low asset endowments, while the stochastic poor are households that are considered poor by chance (i.e. have low incomes), but have an asset base to be non-poor in the future. The structural non-poor include households that are non-poor because of income measures and also have high asset endowments, while the stochastic non-poor are households that are registered as non-poor by chance (i.e. have high incomes) but do not have the asset base to stay non-poor in the future. By definition, these categories exhibit different characteristics and this is true in their levels of environmental dependence. The importance of identifying these groups in a population has been addressed in other studies (Adato et al., 2006; Carter and May, 2001; Naschold, 2012, 2013), however no study has thus far attempted to analyse the variation in environmental dependence between them.

Three steps were followed to distinguish the two types of poor and the two types of non-poor. Firstly, we determine households income

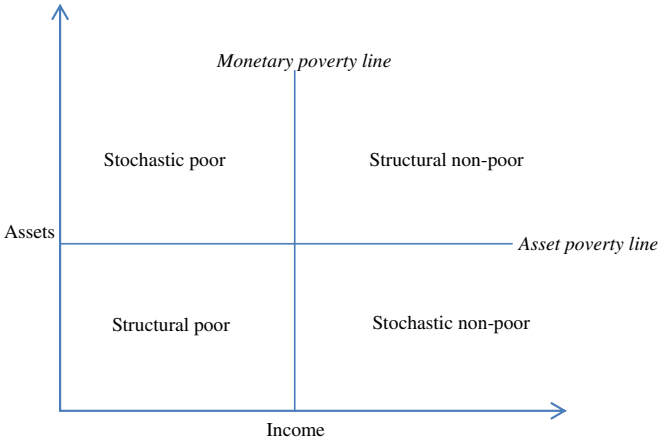

Fig. 1. Stochastic and structural poverty grouping.

[1] We acknowledge the multi-dimensional nature of poverty which may allow deprivations in health and nutrition to be considered as part of an expanded poverty concept (Morduch, 1994) that is not being accounted for in our analysis.

Table 1
Breakdown of districts, VDCs and forest management bodies targeted in the study.

District	VDC	Number of households (2006)	Sampled households (2006)	Forest management body
Chitwan	Chainpur	1542	207	Kankali Forest User Group (FUG)
Kaski	Hemja	222	114	Tibrekot Forest User Group
Mustang	Kunjo	163	88	Kunjo Forest Management Sub-committee (FMSC)
	Lete	174	98	Lete Forest Management Sub-committee

poverty status based on households total income in comparison to the monetary poverty line. Households with total income below the defined poverty line are labelled as income poor and income non-poor otherwise. Secondly, we determine households' asset poverty status based on the estimated asset index and the asset poverty line. Households with an asset index lower than the asset poverty line are labelled as asset poor and asset non-poor otherwise. Thirdly, we compared household's income and asset poverty status, to identify structural poor households from stochastic poor households as well as structural non-poor households from stochastic non-poor households (see Fig. 1).

3. Methods

3.1. Study area

The study sites consist of 4 village development committees (VDCs) in 3 districts which span across the altitudinal variations in Nepal (Larsen et al., 2014; Meilby et al., 2006). These include Lete and Kunjo VDCs in Mustang district, Hemja VDC in Kaski district and Chainpur VDC in Chitwan district. An in depth description of the study sites, sampling procedures, data collection and data treatment is available in Larsen et al. (2014). For the purpose of focusing on environmental dependence among villagers, the local forest management body in each village was targeted as the primary strata in the sampling process. Table 1 provides a breakdown of the districts, village development committees and forest management bodies targeted in this study.

3.2. Data collection

Data was collected in 2006, 2009 and 2012. Data collection and handling followed the PEN guidelines[2] to ensure consistency across sites. The PEN prototype questionnaires were translated into Nepali and thoroughly field tested before operationalization. It formed the backbone of the data collection instruments at the village and household level. Household economic data was collected on a quarterly basis (4 visits per year) to facilitate easy recall, improving the quality of the data (Angelsen et al., 2011). Household assets data and village level data was collected at the beginning and again at the end of each year.

The resulting dataset used in this study consist of a three wave panel dataset with yearly averages of household income and asset stock, among other variables. Table 2 provides a list and description of the income and asset variables used in this study. Income is defined as the value added of labour and capital (Angelsen et al., 2014). This is the total value of cash or goods obtained from the trade of goods and/or services by members of the household, less the cost of all inputs except labour provided by household members. The cost of household labour is not factored into the income calculation due to difficulties in estimation and the poor labour markets in the study sites. All goods produced or collected by the household and used for home consumption (subsistence) are 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 inter-household comparisons.

[2] The Poverty Environmental Network (PEN) is managed by the Center for International Forestry Research (CIFOR) and all PEN material, including guidelines, are available on the CIFOR/PEN website http://www1.cifor.org/pen.

The 2006 data was collected from 507 randomly selected households across the three districts in the four VDCs (Table 1). Of the 507 initial sample households, 446 were resurveyed in 2009. From the 446

Table 2
Income and asset variables used in the analysis.

Variables	Description
Income variables: (*All income calculations are in Nepali Rupees (NRs)*)	
Environment income	The sum of values (of goods) resulting from the extraction of raw material from non-cultivated areas (forest, fallows, grasslands, rivers, etc.), processing wild products and wages from forest and other environment related activities (e.g. community forest services).
Crop income	All income generated from cropping of agricultural and agroforestry land.
Livestock income	Income from the products (including the sale of live animals) and services of farm animals and fish farming, but excludes incremental changes in total stock values, which are captured as a separate asset variable.
Business income	Income from private businesses, other than farms, owned and managed by the household.
Wage income	Income from wage work, whether on or off farm, except wage work in the forestry sector which is included in environmental income.
Support income	Income from supportive government services, pension and gifts.
Remittances	Income received from family members living and working away (overseas or in developed cities such as Kathmandu).
Other income	Income from land rented out, compensation and any other income not categorized under the above groups.
Asset variables	
Education of the household head	This is the number of years of formal education completed by the household head.
Highest education attained in the household	The education level of the household member with the maximum education, in number of years completed.
No. of male adults	Number of adult male household members (age range 15 to 60 years, inclusive). These are considered capable of earning income that contributes to the household total income. Household members outside this range are considered as dependents.
No. of female adults	Number of adult female household members (age range 15 to 60)
Total land area	This is the total area of land owned by the household, including land rented out (does not include land rented in by the household).
Total livestock value	This is the total value of the household's livestock at the end of the observation period.
Total implement value	The value of all implements owned by the household — bicycles, cars, television, tools etc.
Bank savings	Total values of financial savings owned by the household, in local or national banking institutions.
Jewellery value	Total values of non-productive assets in the form of jewellery (e.g. gold, silver and precious stones) own by the household members.
Help from other households	This variable describes whether the household is able to receive help from other households in times of unexpected shocks (such as illness). Ordinal variable: 1 = no, 2 = sometimes and 3 = yes.
Trust in other households	This is an indicator of the level of trust the household has in other households in the community where the household resides. Ordinal variable: 1 = no trust, 2 = moderate trust and 3 = high.

household that were surveyed in 2009, only 415 were resurvey in 2012. This results in an attrition rate of 12% between 2006 and 2012, 7% between 2009 and 2012 and 18% over the 6 years' time. 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 can be provided upon request from the authors). This matches many other similar studies that found evidence for no serious attrition bias in developing countries (Bhatta and Sharma, 2011; Falaris, 2003; Lohano, 2011). Thus, we made use of the balanced data over the three years.

3.3. Creation of the composite asset index

Assets are measured in different units. Thus, one of the challenges of asset based poverty measures is the creation of a single asset variable. A single asset variable is important to avoid interpretation difficulties as well as the 'curse of dimensionality' (Naschold, 2013). In the literature this has been done in two ways. One way is the use of data reduction statistical tools, especially principal component analysis (PCA) (Filmer and Pritchett, 2001) — which considers the total variation of assets to fully explain the variance of the asset index — and principal factor analysis (PFA) (Naschold, 2013) — which explains the variation that the assets, that are included in the asset index, have in common. The use of data reduction methods to construct a single asset index is hampered by the difficulty of defining an asset poverty line, a threshold to identify the poor from the non-poor, which is comparable with the monetary poverty line.

The other way is the livelihood weighted asset index in which the asset index is constructed based on the following regression specification (Adato et al., 2006):

$$Y_{it}/z_t = \sum_j \beta_j(A_{ijt}) + \sum_j \beta_{jj}(A_{ijt})(A_{ijt}) + \sum_{j,m} \beta_{mj}(A_{ijt})(A_{imt}) + \beta_h H + \beta_l L + \varepsilon_{it}. \quad (1)$$

The dependent variable denotes household's income weighted by the monetary poverty line. The vector of coefficients, β_j of the regression Eq. (1) stands for the marginal contribution of asset j to the livelihood of the households, measured income in the current paper. Vectors β_{jj}, β_{mj}, β_h, and β_l are the coefficients of the squared asset terms, the asset interaction terms, household specific characteristics and location dummies respectively. Once all these coefficients are estimated, the composite asset index can be calculated from the fitted value of regression:

$$g_{it} = \sum_j \beta_j(A_{ijt}) + \sum_j \beta_{jj}(A_{ijt})(A_{ijt}) + \sum_{j,m} \beta_{mj}(A_{ijt})(A_{imt}) + \beta_h H + \beta_l L. \quad (2)$$

Some imprecisions may exist in model predictions of the asset index based from Eq. (2) for identifying the asset poor from the asset non-poor. To account for this, we constructed a 95% confidence interval of g_{it} and used the lower bound of the interval as a threshold value to identify the poor from the non-poor, thus minimizing the effects of any prediction imprecisions.

This method has three major attractive advantages over data reduction methods, such as PCA and PFA. First, its weight can be estimated quite flexibly such that the returns to assets depend on other inputs as the interaction among assets is included in Eq. (1). Assets are complementary and/or supplementary to each other and therefore ownership of one asset type influences the ownership of another one and also the ownership one asset influence the productivity of another or vice versa. The inclusion of interaction terms in the equation allows for capturing these relationships. Second, it also allows estimating the effect of having higher endowment of assets as it permits the inclusion of polynomial terms. The contribution of assets to households' livelihood diminishes for each additional unit of the asset according to the law of diminishing returns and the inclusion of the polynomial terms in Eq. (1) helps to capture this. Third, the index is expressed in a convenient livelihood metric that is directly comparable with the monetary poverty line. Y_{it}/z_t in Eq. (1) is measured in poverty line units (PLU) which is one if the household earns an income exactly at the poverty line and hence the corresponding monetary poverty line is one. Similarly, g_{it} in Eq. (2) is an asset index in PLU, and hence the asset poverty line is also one.

Another challenge of using assets as a measure of households' welfare is the choice of the asset portfolio included during the creation of the asset index. Referring to the definition an asset in the livelihoods framework (Ellis, 2000) — asset encompasses a wide spectrum of natural, physical, social, financial and human capital that are directly or indirectly used to generate survival or maintain a livelihood at different levels. It is practically impossible to incorporate the complete list of assets in creating an asset index due to estimation difficulties, leaving researchers with the hard choice of what to include. Data availability also partly determines the choice. In this paper, we included a total of ten asset variables encompassing all the five major asset categories.

We employed a fixed effects panel data model to estimate Eq. (1) due to major considerations. First, we suspected the presence of endogeneity arising from unobserved time invariant individual household characteristics that biases the asset index estimation. Second, we employed Hausman specification test to find out whether the random effects or fixed effects model is consistent and asymptotically efficient. With a Chi-squared statistic of 46.84 (P value = 0.001***), we reject the null hypothesis that the random effects model is preferred over the fixed effects estimator (estimation results can be provided upon request from the authors).

The construction of the asset index using Eq. (1) requires choosing a monetary poverty line. We used the national poverty line of Nepal[3] determined in 2010/2011 by the National Bureau of Statistics (NBS). Since our data was collected in 2006, 2009 and 2012, we converted this poverty line to those years using Consumer Price Index (CPI) of the respective years to account for the difference in price levels across the years. We also tried other indexes, such GDP deflator or inflation rate, to convert the poverty line and resulted in a similar converted value with that of CPI.

We used income, instead of consumption, as a measure of households' livelihood though it has been criticized for being seasonal and transitory in nature. Our choice is based on three reasons. Firstly, the PEN income data is of a higher quality than the consumption data. As described earlier, the income data was collected quarterly from each income generating activities — quarterly for most products and monthly for some products that are frequently extracted and consumed. Secondly, part of the focus of this paper is on environmental dependence and the use of income as a welfare measure permits us to assess the direct effect of environmental income on household's income based welfare as well as income weighted asset based welfare. Thirdly, income is a more important measure of rural livelihood than consumption in relation to understanding how households make a living from different activities (Ellis, 2000).

4. Results

4.1. Poverty grouping: based on income and assets

Table 3 presents a matrix with income poverty groups in the rows and asset poverty groups in the columns. The Chi-squared estimates compare the difference between poverty groupings (income and assets) in each year. We see that income poverty estimates are significantly different from asset poverty estimates in all three years as well as in the overall period. This indicates that there is a significant amount of

[3] The national poverty line in 2010/11 prices is 19,261 NRs. The CPI adjusted poverty lines are 13,336 NRs and 17,513 NRs for 2006 and 2009 respectively.

Table 3
Household level income and asset poverty status.

		Asset poverty			Chi(1)
	Income poverty	Non-poor	Poor	Overall	
2006	Non-poor	58.05	17.32	75.37	6.33**
	Poor	15.85	8.78	24.63	
	Total sample	73.90	26.10	100	
2009	Non-poor	62.44	20.00	82.44	10.50***
	Poor	10.00	7.56	17.56	
	Total sample	72.44	27.56	100	
2012	Non-poor	66.83	15.85	82.68	17.57***
	Poor	10.00	7.32	17.32	
	Total sample	76.83	23.17	100	
Over all^	Non-poor	62.44	17.72	80.16	31.96***
	Poor	11.95	7.89	19.84	
	Total sample	74.39	25.61	100	

^ This is an average of the three years of observation pooled together.
** Significant at 5%.
*** Significant at 1%.

stochastic poor and non-poor among our estimates. In other words, not all the households which fall below the income poverty line are expected to remain poor overtime and similarly, not all those who are recorded above the income poverty line can be expected to remain non-poor in the future.

Overall, we observe only a slight decrease in income and asset poverty from 2006 to 2012. However, in 2009 asset poverty showed an increase before dropping in 2012, when compared to 2006 levels.

The dominant group in our sample is the structural non-poor households. Over the three observation periods its share increased steadily from 58.05% in 2006 to 62.44% in 2009 and 66.83% in 2012. The results show that poverty has been declining in our study population, with more and more households becoming structurally non-poor and are hereby expected to sustain a non-poor status over time. Interestingly, the total share of stochastically poor and non-poor households showed a steady decline from 2006 to 2012 — dropping from 33.17% to 30% and then to 25.85%. This is supported by the fact that the portion of households becoming structurally non-poor far exceeds those moving up from structural poverty, indicating the possible lack of avenues for the structural poor to improve their situation. The share of structurally poor households experienced a total drop of 1.46% in six years (from 8.78% in 2006 to 7.56% in 2009 and 7.32% in 2012).

4.2. Environmental dependence and poverty measures

Table 4 presents a disaggregation of mean total income (average of all three years of observation) into the eight major income sources and the related Fig. 2 shows the relative share of each income source, by income poverty grouping. As can be observed, the poor households behave differently from the non-poor households, in relation to their level of reliance on different income sources. Non-poor households show highest reliance on business income (23.4%), while the poor households exhibit highest reliance on environmental income (28.95%). In fact the poor are twice as reliant on environmental income as are the non-poor. However, non-poor households on average earn more than three times more from environmental income than poor households.

When mean total income (average of all three years) is disaggregated by the asset poverty grouping we see a different story (Table 5 and Fig. 3). The non-poor households are still mostly dependent on business income (24.2%), while the poor households are mostly dependent of income from remittances (22.3%). Environmental income is now the fourth most important income source for the poor households, providing 15.7% of total income. The non-poor households still generate more absolute environmental income than the poor households, however they only generate about 1.5 times more.

Using a combination of income and asset poverty groupings, we are able to look at the environmental dependence among the structural and stochastic poor and non-poor (Table 6 and Fig. 4). Interestingly, the stochastic poor households are the most environmental dependent households (30%), followed by the structural poor (27%). The difference in environmental dependence between the two poor groups is highly statistically significant, $p < 0.01$. Expectedly, the two poor groups are twice as reliant on environmental income as the two non-poor groups. The structural and stochastic non-poor are most reliant on business and remittance income, respectively. They show very similar levels of dependency on environmental income (a difference of less than 1% which is statistically insignificant, $p = 0.90$).

A further analysis of environmental dependence between the four poverty groups based on first-order stochastic dominance can be visually appreciated from the cumulative density curves in Fig. 5. A stochastically dominant group is the one that – for all environmental dependence levels – has the lowest cumulative density curve and is thus the most environment dependent group. Looking at an average of the three years, we see that the stochastic poor are dominant at all levels of environmental dependence, except for the extremely low levels. Matching earlier results, the non-poor households (both stochastic and structural) are always dominated by the poor households, which suggest that they always have a lower level of environmental dependence.

Additionally, the cumulative density curves for environmental income (Fig. 6) show that the two non-poor groups are always stochastically dominant over the two poor groups. This supports our earlier results that the non-poor always obtain higher levels of absolute environmental income.

5. Discussion

5.1. Poverty and poverty measures

Both monetary and asset measures can be used to inform on the welfare of a population. However, using a combination of these two measures has the advantage of allowing us to further distinguish the stochastic poor from the structural poor and the stochastic non-poor from the structural non-poor, to develop a more in-depth understanding of household poverty. This method allows the identification of the most vulnerable groups in a population. This is of relevance to policy makers designing and targeting interventions aimed at alleviating

Table 4
Mean income (aeu) of each source over the three years by income poverty grouping.

	Environmental income	Crop income	Livestock income	Business income	Remittances	Wage income	Support income	Other income	Total income
Mean income for each major income source (NRs)									
Non-poor (n = 944)	7864.0 (361.6)	5647.7 (397.3)	8186.1 (560.5)	13012.6 (1188.3)	10321.2 (832.6)	999.5 (84.4)	4260.7 (293.4)	5405.3 (546.9)	55697.0 (1767.6)
Poor (n = 202)	2252.5 (141.5)	979.3 (204.2)	1022.4 (334.6)	449.4 (103.1)	994.3 (144.5)	835.9 (94.2)	863.4 (122.2)	384.2 (72.7)	7781.5 (342.7)
Total sample (n = 1146)	6874.9 (305.5)	4824.8 (333.4)	6923.4 (472.3)	10798.1 (989.0)	8677.2 (694.2)	970.7 (71.5)	3661.9 (245.6)	4520.2 (454.2)	47251.2 (1553.8)

Standard error of mean in parenthesis. Values in Nepali Rupees (NRs): 1 US$ = 85 NRs in 2012.

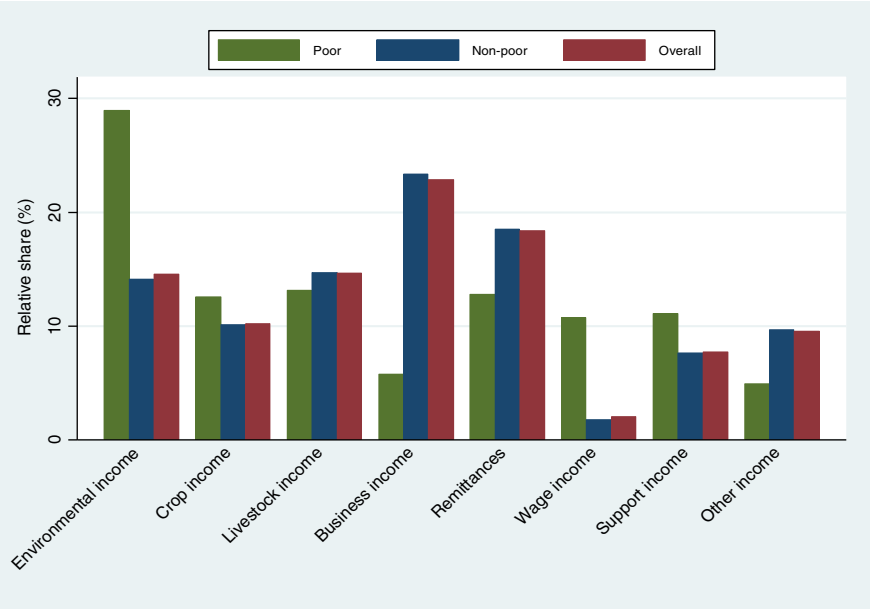

Fig. 2. Relative share of each income sources by income poverty grouping.

poverty, as the more and less vulnerable households require different interventions. Although monetary measures (i.e., income and consumption) have been more widely used, asset measures are believed to be more forward looking and policy oriented, and therefore can answer some questions left unanswered by monetary poverty measures. However, the difficulty of grouping different kinds of assets, with very different units of measurement, to produce an easy to interpret asset index has limited the use of asset based poverty measures. This study used the method proposed by Adato et al. (2006) to overcome this problem in producing a composite asset index. Our findings show that poverty grouping based on income measures produce a significantly different distribution of households, to that based on asset measures. This difference forms the basis of a structural and stochastic nature of poverty dichotomy, which is not possible to identify using any one of these measures alone. Income measures showed higher percentages of non-poor households than asset measures in all three years of observation. In a similar study, Liverpool-Tasie and Winter-Nelson (2011) also reported higher asset poverty incidence than monetary poverty incidence in Ethiopia. This could be due to the fact that assets capture long-term poverty better than the monetary welfare measures. A household can appear non-poor in terms of income/consumption in a given year if it earns/consumes more than the monetary poverty line in the same year, but if this extra income is not enough to invest in its asset portfolio, then the household will still be recorded as asset poor.

The identification of the various poverty groups based on asset measure enables better targeted policy interventions for poverty reduction. Policy interventions aimed at improving the livelihoods of the structurally poor should focus both on promotion of income generating opportunities and building their asset base, making them more resilient for coping with income shocks. Similarly, policy interventions for stochastic non-poor should focus on asset accumulation as they lack the necessary asset capital to keep up being non-poor. For example, land is an important asset in rural communities as farming is an integral part of the household economy. Securing households' rights to a minimum area for farming land can help increase their asset base, ultimately aiding in the climb out of structural poverty. On the other hand, policy interventions for the stochastic poor should focus on i) asset protection: protecting these households from depleting their asset base in times of negative shocks (e.g. crop failure, sudden remittance cut-off, unexpected health expenditures) as they already possess the minimum asset base to climb out of poverty, and ii) provision of income generating opportunities enabling them to earn higher incomes, above the poverty line. The former can be achieved through insurance schemes whereas the latter can be achieved through programs of training and skills development that enable individuals to secure employment.

5.2. Rural poverty in Nepal

Nepal remains one of the least developed countries in the world. In 2013, with the human development index score of 0.463, it was ranked 157 out of 187 countries listed in the 2013 human development report of the United Nations Development Programme (UNDP, 2013). Poverty has a rural dimension in Nepal as the incidence of rural poverty outweighs the urban poverty (Maltsoglou and Taniguchi, 2004). However, efforts are being made to tackle this problem and national statistics report that the Nepal poverty head count ratio (based on consumption measures) has been declining over the past decades — from 41% in 1995/96 to 31% in 2003/2004 and further to 25% in 2010/2011. Our results, though stemming from a rural population and therefore more representative of rural Nepal, support this general trend with the

Table 5
Mean income (aeu) of each source over the three years by asset poverty grouping.

	Environmental income	Crop income	Livestock income	Business income	Remittances	Wage income	Support income	Other income	Total income
Non-poor (n = 851)	7516.9 (389.3)	5214.8 (427.3)	7486.7 (606.9)	12726.3 (1262.4)	9203.0 (849.8)	1010.1 (90.2)	3970.1 (294.9)	5377.5 (598.3)	52505.4 (1954.5)
Poor (n = 295)	5023.0 (363.3)	3699.7 (391.7)	5298.3 (539.6)	5235.7 (1168.6)	7160.5 (1121.6)	857.0 (97.7)	2772.6 (428.5)	2047.3 (328.0)	32094.0 (1901.6)
Total sample (n = 1146)	6874.9 (305.5)	4824.8 (333.4)	6923.4 (472.3)	10798.1 (989.0)	8677.2 (694.2)	970.7 (71.5)	3661.9 (245.6)	4520.2 (454.2)	47251.2 (1553.8)

Standard error of mean in parenthesis. Values in Nepali Rupees (NRs): 1 US$ = 85 NRs in 2012.

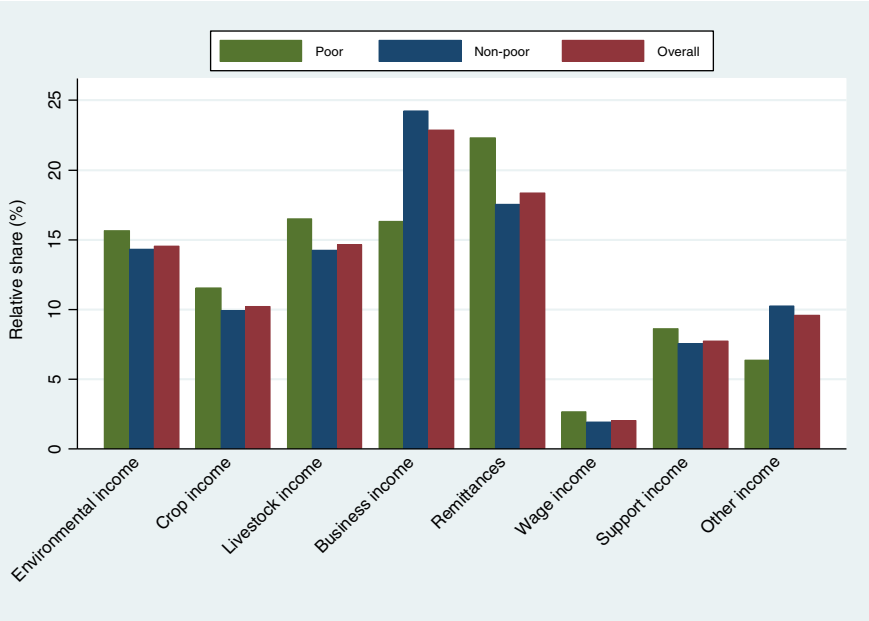

Fig. 3. Relative shares of each income sources by asset poverty grouping.

percentage of non-poor households showing a steady increase over our observation period. Other studies from Nepal also confirmed this trend. Using the national representative household survey, Bhatta and Sharma (2011) found a decline in consumption poverty incidence between the years 1995/1996 and 2003/2004, and Joshi et al. (2012) report a substantial drop in income poverty incidence between the years 2004 and 2007 in far-western rural hills of Nepal. This increase in the number of non-poor was matched by a decrease in stochastic non-poor and stochastic poor households. The stochastically poor households require an improvement in the income levels – as they already have asset endowments above the asset poverty line – to become structurally non-poor. While the stochastically non-poor households require an improvement in their level of asset endowments – as they have income levels above the income poverty line – to become structurally non-poor. Nonetheless, our findings also highlight a concern that not enough is being done to reduce the level of structural poverty, as the percentage of this group showed very little change, pointing to the possible existence of a poverty trap. These are the poorest of the poor, and they require both improvements in their income earnings as well as their levels of assets to achieve a sustainable non-poor status. Carter and May (2001) argue that the structurally poor households require specialized, targeted poverty alleviation interventions if they are to improve their welfare condition and climb out of poverty.

5.3. Poverty and environmental dependence

Studies focusing only on income measures have found that the poor are significantly more dependent on environmental income than the non-poor, while the non-poor earn much larger absolute values of environmental income (Angelsen et al., 2014; Babulo et al., 2009; Campbell and Luckert, 2002; Cavendish, 2000; Heubach et al., 2011; Mamo et al., 2007; Rayamajhi et al., 2012; Vedeld et al., 2007). Our results support these findings when we analyse environmental dependence and income based solely on income poverty measures. There is a clear pattern that the higher the households' total income, the lower its dependency on environmental income and the higher its absolute environmental income. The correlation between households' total income and environmental dependence was significantly negative (correlation coefficient of -0.0706, $p = 0.013$) while the correlation between households total income and environmental income was significantly positive in our dataset (with correlation coefficient of 0.296, $p = 0.000$). However, when the same is analysed based on asset poverty measures a different

Table 6
Mean income (aeu) of each source and relative contribution of each sources to total income over the three years by income and asset poverty measures combined.

	Environmental income	Crop income	Livestock income	Business income	Remittances	Wage income	Support income	Other income	Total income
Structural non-poor (n = 734)	8342.9 (442.9)	5853.8 (489.2)	8597.0 (689.6)	14678.1 (1450.6)	10510.6 (976.2)	1046.3 (102.8)	4466.6 (337.3)	6158.0 (689.1)	59653.1 (2150.0)
Stochastic non-poor (n = 210)	6190.5 (479.9)	4927.2 (515.1)	6749.7 (727.7)	7191.3 (1622.6)	9659.3 (1541.5)	836.1 (122.6)	3541.0 (590.0)	2774.4 (450.5)	41869.6 (2351.8)
Stochastic poor (n = 117)	2335.3 (185.1)	1206.3 (286.9)	521.1 (543.2)	482.3 (156.6)	999.7 (208.1)	783.1 (118.9)	855.7 (169.0)	481.0 (113.8)	7664.5 (510.0)
Structural poor (n = 85)	2138.4 (220.0)	666.9 (280.3)	1712.5 (256.6)	404.2 (117.5)	986.9 (190.6)	908.6 (153.1)	874.0 (175.2)	250.9 (71.6)	7942.5 (415.9)
Overall (n = 1146)	6874.9 (305.5)	4824.8 (333.4)	6923.4 (472.3)	10798.1 (989.0)	8677.2 (694.2)	970.7 (71.5)	3661.9 (245.6)	4520.2 (454.2)	47251.2 (1553.8)

Standard error of mean in parenthesis. Values in Nepali Rupees (NRs): 1 US$ = 85 NRs in 2012.

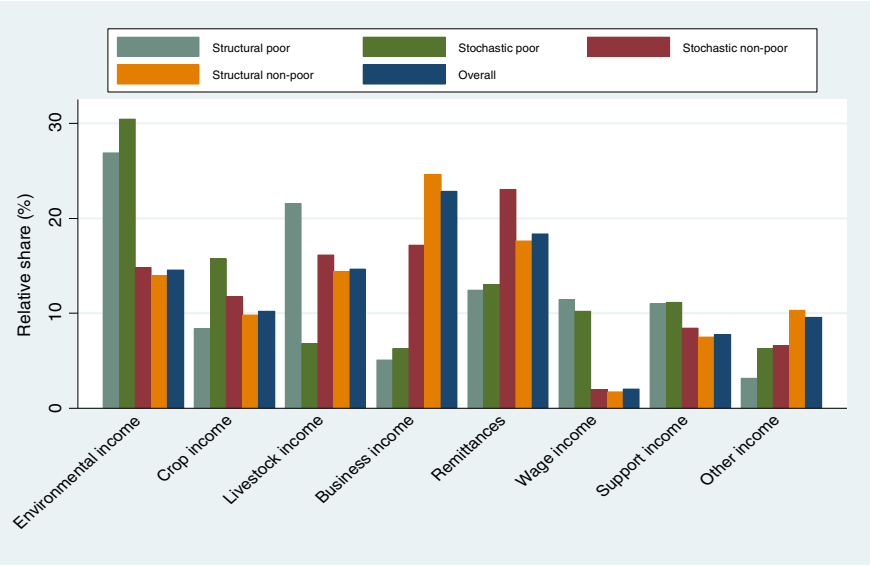

Fig. 4. Relative shares of each income sources by asset and income poverty combined.

picture is produced. First, we observe that asset poor households are not as dependent on environmental income as are income poor households. In fact, environmental dependence between asset poor and asset non-poor is not significantly different (15.65% and 14.32% respectively). Second, although the asset non-poor still earn more environmental income than the asset poor (in absolute terms), the gap is much smaller than in the case of income poor and non-poor. This hints that the existing evidence on the significant difference of environmental dependence across various poverty categories should be put into perspective as it differs with the choice of welfare indicator. These findings strongly support our chosen method of combining income and asset measures to analyse environmental dependence, not only just between the poor and non-poor (two groups), but also between the stochastic and structural poor and non-poor (four groups).

The group most reliant on environmental income are asset non-poor households who are also income poor (the stochastic poor). Fig. 5 shows that this group exhibits stochastic dominance in relation to environmental dependence. These households exhibit an even higher level of environmental dependence than the structurally poor households, who are considered to lack avenues for improving their situation and are the likely victims of poverty traps (Carter and May, 2001). They also rely more than twice as much on environmental income than the stochastic non-poor households (who are asset poor). This result supports the conclusion that environmental income serves more as a safety net which households turn to in times of income shocks (e.g. crop failure (Angelsen and Wunder, 2003) and loss of other income sources or bread winners due to illness or death (Pouliot and Treue, 2012)). Nonetheless, the biggest gainers from the environment are the structural non-poor households who earn more than three times as much as the most dependent group, while they remain the least dependent on environmental income. These households have the asset base to engage in remunerative livelihood activities (such as private business ventures in transportation, shops and lodges) and earn higher incomes which drives down their environmental dependence. Therefore, we concur with studies such as Angelsen et al. (2014) which have concluded that it would be ill advised to believe that policies or interventions in forestry will disproportionately benefit the poorest.

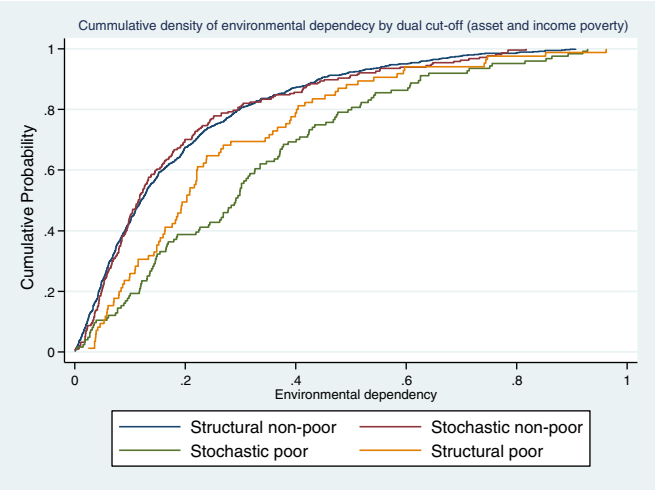

Fig. 5. Cumulative probability density of environmental dependence by dual cut-off (income and asset poverty).

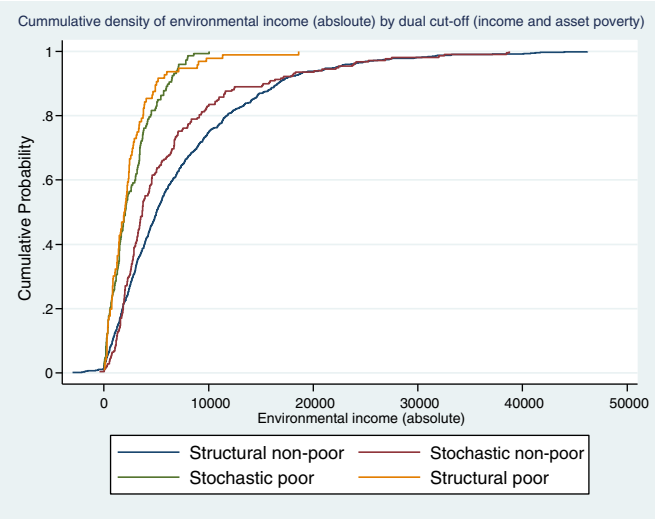

Fig. 6. Cumulative probability density of environmental income (NRs) by dual cut-off (income and asset poverty).

6. Conclusions

Following the method proposed by Adato et al. (2006) to overcome problems of producing a composite asset index, we were able to use asset measures along with income measures to describe the poverty distribution among a sample of rural households in Nepal. Our findings show that poverty grouping based on income measures produce a significantly different distribution to that based on asset measures. Additionally, the difference in environmental dependence between the poor and the non-poor varies across different poverty measures. Income measures show that the poor is about twice as dependent on environmental income as are the non-poor, while asset measures show that their levels of dependence are very similar. These findings provide even stronger evidence that the notion linking poorer households, based on income measures, with forest reduction and degradation is ill informed as it is also rather the poor that are often engage in a more sustainable use of their natural environment, reaping fewer benefits and in many cases with fewer rights to protect their claim on these resources (see e.g., Martinez-Alier, 2014). This type of thinking should not be part of any policy decision aimed at forest conservation, as richer households may extract more resources from the environment, and can cause more destruction than the poorer households. Moreover, neither will interventions in forestry benefit the poorest to a significantly greater extent than the non-poor households.

Combining income and asset measures allows for more accurate informing of the welfare and vulnerability of a population. Although there is evidence of a reduction in overall poverty in rural Nepal, the reduction of structural poverty is not being achieved. Using a combination of asset and income measures to first identify the more vulnerable structurally poor households can help policy makers improve the targeting of specialized poverty alleviation interventions. This further calls for different policy interventions for the different groups, for instance protection policies for the stochastic poor (i.e. policies that enable the non-poor household to maintain their consumption/income in times of shocks, minimizing the long-term effect of the shock resulting from the depletion of assets) and promotion policies for the structural poor (i.e. policies that enable poor households to accumulate assets to improve their livelihood).

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References

Adato, M., Carter, M.R., May, J., 2006. Exploring poverty traps and social exclusion in South Africa using qualitative and quantitative data. J. Dev. Stud. 42, 226–247.
Adhikari, B., Di Falco, S., Lovett, J.C., 2004a. Household characteristics and forest dependency: evidence from common property forest management in Nepal. Ecol. Econ. 48, 245–257.
Adhikari, M., Nagata, S., Adhikari, M., 2004b. Rural household and forest: an evaluation of household's dependency on community forest in Nepal. J. For. Res. 9, 33–44.
Angelsen, A., Wunder, S., 2003. Exploring the Forest — Poverty Link: Key Concepts, Issues and Research Implications (No. 40) (Bogor).
Angelsen, A., Larsen, H.O., Lund, J.F., Smith-Hall, C., Wunder, S., 2011. Why measure rural livelihoods and environmental dependence? In: Angelsen, A., Larsen, H.O., Lund, J.F., Smith-Hall, C., Wunder, S. (Eds.), Measuring Livelihoods and Environmental Dependence: Methods for Research and Fieldwork. Earthscan, London, pp. 1–16
Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N.J., Bauch, S., Wunder, S., 2014. Environmental income and rural livelihoods: a global-comparative analysis. World Dev. 64, S12–S28.
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. For. Policy Econ. 11, 109–117.
Bhatta, S.D., Sharma, S.K., 2011. The determinants and consequences of chronic and transient poverty in Nepal. In: Baulch, B. (Ed.), Why Poverty Persists: Poverty Dynamics in Africa and Asia. Edward Elgar, Cheltenham.
Campbell, B.M., Luckert, M.K. (Eds.), 2002. Uncovering the Hidden Harvest. Valuation Methods for Woodland and Forest Resources. People and Plants Conservation Series. Earthscan, London.
Carter, M.R., Barrett, C.B., 2006. The economics of poverty traps and persistent poverty: an asset-based approach. J. Dev. Stud. 42 (2), 178–199. http://dx.doi.org/10.1080/00220380500405261.
Carter, M., May, J., 2001. One kind of freedom: poverty dynamics in post-apartheid South Africa. World Dev. 29 (12).
Cavendish, W., 2000. Empirical regularities in the poverty-environment relationship of rural households: evidence from Zimbabwe. World Dev. 28, 1979–2003.
CIFOR, 2007. PEN Technical Guidelines. Centre for International Forestry research, Bogor, Indonesia.
Ellis, F., 2000. Rural Livelihoods and Diversity in Developing Cuntries. Oxford University Press, New York.
Falaris, E., 2003. The effect of survey attrition in longitudinal surveys: evidence from Peru, Côte d'Ivoire and Vietnam. J. Dev. Econ. 70, 133–157.
Filmer, D., Pritchett, H., 2001. Estimating wealth effects without data or tears: an application to educational enrollment in states of India. Demography 38 (1), 115–132.
Fisher, M., 2004. Household welfare and forest dependence in Southern Malawi. Environ. Dev. Econ. 9, 135–154.
Haughton, J., Khandker, S., 2009. Vulnerability to poverty. Handbook on Poverty + Inequality. The World Bank, Washington DC, pp. 231–247.
Heubach, K., Wittig, R., Nuppenau, E.-A., Hahn, K., 2011. The economic importance of non-timber forest products (NTFPs) for livelihood maintenance of rural west African communities: a case study from northern Benin. Ecol. Econ. 70, 1991–2001.
Hogarth, N.J., Belcher, B., Campbell, B., Stacey, N., 2013. The role of forest-related income in household economies and rural livelihoods in the border-region of Southern China. World Dev. 43, 111–123.
Joshi, N.P., Maharjan Lall, K., Piya, L., 2012. Poverty dynamics in Far-western Rural Hills of Nepal: evidences from panel data. International Association of Agricultural Economists (IAAE) Triennial Conference. Foz do Iguacu, Brazil, pp. 1–24.
Larsen, H.O., Rayamajhi, S., Chhetri, B.B.K., Charlery, L.C., Gautam, N., Nirajan, K., Walelign, S.Z., 2014. The Role of Environmental Incomes In Rural Nepalese livelihoods 2005–2012: contextual Information (Vol. 79) (Copenhagen).
Lepetu, J., Alavalapati, J., Nair, P., 2009. Forest dependency and its implication for protected areas management: a case study from Kasane Forest Reserve, Botswana. Int. J. Environ. 3, 525–536.
Ligon, E., Schechter, L., 2003. Measuring vulnerability. Econ. J. 113, 95–102.
Liverpool-Tasie, L.S.O., Winter-Nelson, A., 2011. Asset versus consumption poverty and poverty dynamics in rural Ethiopia. Agric. Econ. 42, 221–233.
Lohano, H.R., 2011. Poverty Dynamics in Rural Sindh, Pakistan, 1987–80 to 2004–05. Edward Elgar, Cheltenham.
Maltsoglou, I., Taniguchi, K., 2004. Poverty, Livestock and Household Typologies in Nepal.
Mamo, G., Sjaastad, E., Vedeld, P., 2007. Economic dependence on forest resources: a case from Dendi District, Ethiopia. For. Policy Econ. 9, 916–927.
Martinez-Alier, J., 2014. The environmentalism of the poor. Geoforum 54, 239–241.
Meilby, H., Puri, L., Christensen, M., Rayamajhi, S., 2006. Planning a system of permanent sample plots for integrated long-term studies on community-based forest management. Banko Janakari 16 (2).
Morduch, J., 1994. Poverty and vulnerability. Am. Econ. Rev. 84 (2), 221–225.
Naschold, F., 2012. "The Poor Stay Poor": household asset poverty traps in rural semi-arid India. World Dev. 40, 2033–2043.
Naschold, F., 2013. Welfare dynamics in Pakistan and Ethiopia — does the estimation method matter? J. Dev. Stud. 49, 936–954.
Nielsen, M.R., Pouliot, M., Kim Bakkegaard, R., 2012. Combining income and assets measures to include the transitory nature of poverty in assessments of forest dependence: evidence from the Democratic Republic of Congo. Ecol. Econ. 78, 37–46.
Nielsen, Ø.J., Rayamajhi, S., Uberhuaga, P., Meilby, H., Smith-Hall, C., 2013. Quantifying rural livelihood strategies in developing countries using an activity choice approach. Agric. Econ. 44, 57–71.
Pouliot, M., Treue, T., 2012. Rural people's reliance on forests and the non-forest environment in West Africa: evidence from Ghana and Burkina Faso. World Dev. 43, 180–193.
Prado Córdova, J.P., Wunder, S., Smith-Hall, C., Börner, J., 2013. Rural income and forest reliance in highland Guatemala. Environ. Manag. 51, 1034–1043.
Rayamajhi, S., Smith-Hall, C., Helles, F., 2012. Empirical evidence of the economic importance of Central Himalayan forests to rural households. For. Policy Econ. 20, 25–35.
Sahn, D., Stifel, D., 2003. Exploring alternative measures of welfare in the absence of expenditure data. Rev. Income Wealth (4).
Uberhuaga, P., Smith-Hall, C., Helles, F., 2012. Forest income and dependency in lowland Bolivia. Environ. Dev. Sustain. 14, 3–23.
UNDP, 2013. Human Development Report 2013. United Nations Development Program, Kathmandu, Nepal.
Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., Kobugabe Berg, G., 2007. Forest environmental incomes and the rural poor. For. Policy Econ. 9, 869–879.
Walelign, S., 2013. Forests beyond income: the contribution of forest and environmental resources to poverty incidence, depth and severity. Int. J. Agric. Sci. 3, 533–542.
Winters, P., Davis, B., Carletto, G., Covarrubias, K., Quiñones, E.J., Zezza, A., Stamoulis, K., 2009. Assets, activities and rural income generation: evidence from a multicountry analysis. World Dev. 37, 1435–1452.
Wunder, S., Luckert, M., Smith-Hall, C., 2011. Valuing the priceless: what are non-marketed products worth? In: Angelsen, A., Larsen, H.O., Lund, J.F., Smith-Hall, C., Wunder, S. (Eds.), Measuring Livelihoods and Environmental Dependence: Methods for Research and Fieldwork. Earthscan, London, pp. 127–145
Yemiru, T., Roos, A., Campbell, B., Bohlin, F., 2010. Forest incomes and poverty alleviation under participatory forest management in the Bale Highlands, Southern Ethiopia. Int. For. Rev. 12, 66–77.