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Analysis

# Combining income and assets measures to include the transitory nature of poverty in assessments of forest dependence: Evidence from the Democratic Republic of Congo

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ABSTRACT

A considerable amount of research on poverty–environment relations in developing countries under the CIFOR-PEN initiative focuses on household income generation from forests, using total annual income as a measure of poverty. However, income alone produces a static picture in a snapshot of time while poverty is a dynamic state that can be a transitory phenomenon. Using income only also fails to consider that households can liquidate asset to overcome income shocks. Here we show that using asset quintiles, measured by value of assets, produce a distinctly different pattern than the commonly observed negative relation between income and forest dependence. We then present an approach, enabling categorization of households as chronic or transient poor, transient rich and rich providing a more nuanced picture than that provided by CIFOR-PEN studies so far. The validity of groupings is tested by comparing household characteristics and exposure to shocks. We then show that the chronic poor are most reliant on forest income, while the transient poor consume a higher share of harvested forest products. The transient rich have higher agricultural productivity and absolute forest income. Rich households relies more on business. Based on the results we suggest recommendations for improving future studies on poverty–environment relations.



## 1. Introduction

A considerable amount of research on the relations between poverty and the environment in developing countries has been initiated under the Poverty Environment Network (PEN) coordinated by the Centre for International Forestry Research (CIFOR). This global survey in 25 countries, involving about 30 institutions and 50 individuals (PhD students and their supervisors) (Angelsen et al., 2011), focuses on household income generation from forests and the environment outside forests. Most of the research done in this field uses income as a measure of household poverty (e.g. Ambrose-Oji, 2003; Appiah et al., 2009; Babulo et al., 2008; Cavendish, 1999; Fisher, 2004; Mamo et al., 2007; Shackleton et al., 2007; Yemiru et al., 2010). Here we argue that this approach fails to consider that poverty can be a transitory phenomenon as a result of an array of push and pull factors, and that households can also draw on their assets to cover income short-falls in response to various income shocks. The importance of asset wealth has long been acknowledged in development economics (see for example Carter and May, 2001) but appears to have been largely ignored in the poverty–environment research. We therefore present a simple approach to assess forest dependence in relation to both income and asset wealth, providing a more dynamic perspective on poverty, within the limitations of the data available in standard CIFOR-PEN studies. We test and attempt to verify our approach using data collected in a typical CIFOR-PEN study in the Democratic Republic of Congo.

A meta-analysis of 51 case studies in developing countries has established the general importance of forest income in terms of providing on average 22% of total annual income (Vedeld et al., 2007). The meta-study also found that low income households tend to obtain a higher proportion of total annual income from forest resource use than high income households, but that high income households obtained higher absolute income from forest resources (Vedeld et al., 2007). However, a number of shortcomings may be anticipated in studies on the relationship between poverty and the environment that rely exclusively on income as a measure of poverty. Income data has limitations in both accuracy and measurement due to (i) temporal fluctuations in income (ii) inaccuracy in recollection (iii) lack of knowledge about other household members true income and (iv) sensitivity of certain types of income (e.g. illegal extraction), indicating that it may not be an optimal indicator of poverty in a snapshot of time (Mosser and Felton, 2007). Income data also fails to represent the full amount of available resources, as households can also rely on liquidation of productive assets (e.g. livestock) and on the capitalization of financial assets (i.e. savings) to cover income shortfalls (Brandolini et al., 2010; Narain et al., 2005). Assets are therefore increasingly promoted to complement income based measures of wealth in order to extend the understanding of the character of poverty and

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the complexity of processes underlying poverty reduction (Adato et al., 2006; Carter and May, 2001; Filmer and Pritchett, 2001; Maltzahn and Durrheim, 2007). Assets provide a better picture of long term wealth because they are accumulated over time, last longer and contribute to the productive capacity of a household through its resource stock (Marlier and Atkinson, 2010; Nolan and Whelan, 2010; Sullivan et al., 2008). Asset based poverty classifications have thus been shown to better predict future income, expenditure and asset poverty than income and consumption measures (Saweda et al., 2011) and have been empirically identified as the most important determinant of households in relation to choice of livelihood strategy (Babulo et al., 2008; Demissie and Workneh, 2004; Ellis and Freeman, 2004; Tefera et al., 2004).

Poverty is furthermore a dynamic state that can be a transitory phenomenon where households temporarily fall into poverty on the basis of random events (Carter and Barrett, 2006; Carter and May, 2001; Green and Hulme, 2005; Harriss, 2007; Saweda et al., 2011; Wood, 2003). Indeed several case studies have found that the transient poor comprise a large share of the overall poor (Baulch and Hoddinott, 2000; Hoddinott, 2003). Households with income levels above the poverty line can be vulnerable if they lack the assets base (and access to credit) to diversify their livelihoods or otherwise compensate for income shocks. Conversely, households with earnings below the poverty line, but who are rich in assets, may suffer less change in living standards from a sudden income drop if the household can liquidate accumulated wealth in assets (or borrow money). Investment in livestock is for instance a common strategy amongst rural households as a form of risk mitigation, to be drawn upon in times of income shocks (Delacote, 2007; Pattanyak and Sills, 2001). Assets and liabilities are hence fundamental to smoothing consumption when income is volatile (Brandolini et al., 2010). Indeed the accumulation of wealth via precautionary savings is the primary means for households to self-insure against income decline and the possession of tangible and intangible assets (material and intellectual endowments) is a major determinant of the long-term trajectory of households and individuals (Brandolini et al., 2010).

Thus, by relying solely on an income-based approach to assessing the relationship between poverty and forest dependence, CIFOR-PEN studies to date provide limited opportunity to understand forest use in relation to the dynamics of poverty, in terms of enabling households to construct a pathway out of poverty or avoiding sinking further into poverty (i.e. chronic or structural poverty). In this paper, we therefore argue for including and combining asset and income-based categorizations of households in analyzing forest dependency. Based on household-level income and asset data collected in the Democratic Republic of Congo (DRC), we here demonstrate that using wealth instead of income-based quintiles produces a distinctly different result with regards to forest dependency than the often observed pattern of decreasing forest reliance with increasing income (i.e. Vedeld et al., 2007). We then present a simple approach to categorizing households as chronic and transient poor, transient rich and rich based on the relation between their net total income and asset holdings. We then examine the validity of these groups by testing general assumptions about households' socioeconomic and demographic characteristics and number of shocks experienced as the main push factor shifting households between these levels of poverty. Finally we proceed to evaluate the dependence on forests by households in each of these groups and the role that forest products play in their livelihoods. The results provide plausible explanations for the observed patterns that support our categorization of households in the various poverty groups and it is found that the chronic poor are most reliant on forest income, while the transient poor appear to consume a higher share of harvested forest products in the household and the transient rich has the highest absolute forest income.

The standard CIFOR-PEN methodology does not measure consumption or enable us to explicitly test for the occurrence of poverty traps defined as a self-reinforcing state where a household is unable to generate a surplus to improve its situation (e.g. Carter and Barrett, 2006) and this is therefore not addressed in this paper. Furthermore, although asset-based approaches theoretically permit evaluation of whether there exists a minimum configuration of assets or economic conditions required for households to ultimately engineer their own escape from poverty (Carter and Barrett, 2006), we make no such attempt. Acknowledging further limitations of the standard CIFOR-PEN approach, we suggest a number of recommendations in order to improve future studies on the poverty–environment relationship.

## 2. Study Area

DRC is one of the poorest countries in the world and had a Gross Domestic Product per capita of USD 264 per annum in 2008 (World Bank, 2008) with absolute poverty affecting 71% of its 66 million people (DFID, 2008; IMF, 2007; Whiteman and Lebedys, 2006). Approximately 35 million people are residing in or dependent upon DRC's forests, which cover 62% of the country (World Bank, 2002 in Counsell, 2005; Debroux et al., 2007). War and civil strife has left the country's infrastructure and institutions in ruins.

Field work was conducted in five communities around the Luki Biosphere Reserve (05°30′ to 05°45′S and 13°07′ to 13°15′E), Bas-Fleuve district (Lower-River) in the province of Bas-Congo (Lower-Congo) (Fig. 1) located approximately 565 km from the capital Kinshasa on National Road No. 1, connecting Kinshasa to Boma. In 1976 it was formally designated as a UNESCO Biosphere Reserve aiming to facilitate conservation and rural development (Inogwabini et al., 2005; UNESCO, 2007). The reserve is 330 $km^2$ divided into core, buffer and transition areas. Approximately 83,500 people resided in villages inside the reserve (Nijiang et al., 2005). Some villages are illegal settlements whereas others are on community land belonging to indigenous clans. The majority of the population is engaged in shifting slash and burn cultivation producing mainly rice, maize, cassava, yam and plantain for subsistence. Few households complement agriculture with small domestic animal keeping (e.g. poultry, pigs). Other sources of income include forest resource extraction and trade, remittances, and business (small scale trade and processing of agricultural products). All areas where forest products are harvested are de facto open access, although the State is the de jure owner.

The five study villages were chosen on the basis of the representativeness of villages in the area, capturing a wide variety of demographics, availability of physical infrastructure, market access as well as geography around the Luki Biosphere Reserve. Village populations ranged from 317 to 4900 people and the villages differed in relation to year of establishment, location in relation to the National Road No. 1 and the reserve border and in legal status. 220 households were randomly selected producing an overall sampling intensity of 13%. Final sample size was 175 households after excluding all households that were not present to complete all four quarterly surveys (i.e. 20% attrition).

## 3. Methods

The data used for this paper is part of the dataset of the 'Poverty Environment Network' coordinated by the Centre for International Forestry Research (CIFOR) focusing on income generation from forests and other environmental resources in developing countries. The conceptual basis underlying the study is the livelihoods approach, which argues that the choice of livelihood strategy is a function of the household's assets and abilities (DFID, 1999; Ellis, 2000; Scoones, 1998). The livelihood framework focuses on five categories of assets – natural, physical, human, social and financial assets – as a stock of capital that can be stored, accumulated, exchanged or allocated to generate a flow of income or subsistence products upon which livelihoods are built (DFID, 1999; Radoki, 1999; Scoones, 1998).

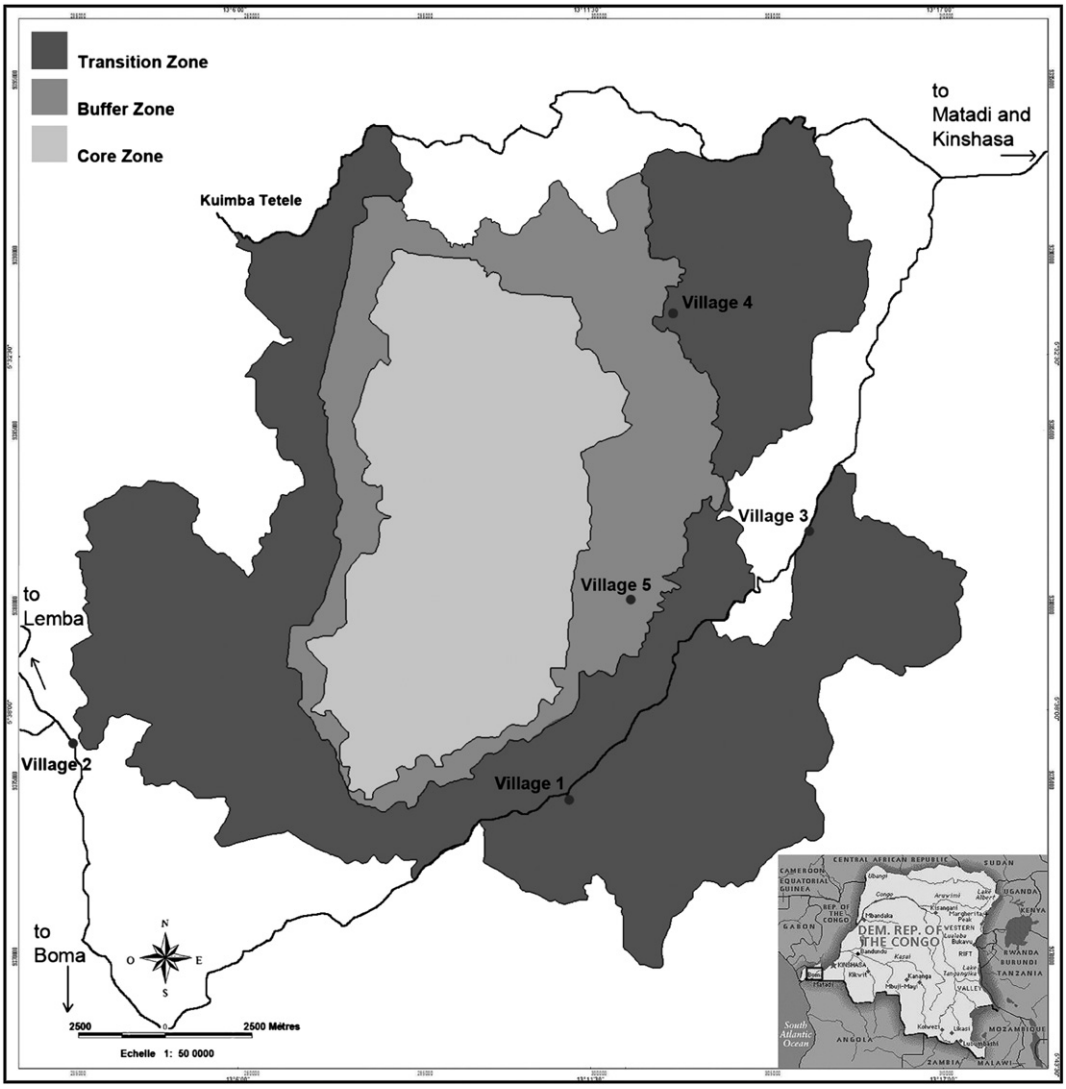


**Fig. 1.** Map of study area and its location within the Democratic Republic of Congo.

### 3.1. Data Collection

Fieldwork was undertaken from November 2007 to August 2008 and interviews covered a full year of income. Data collection includes focus groups, annual surveys and four quarterly surveys (PEN, 2007). Focus group discussions with village leaders and elders aimed at assessing village demographics and infrastructure, local climatic and other stochastic variations. The annual surveys collected information about age, gender and education level, land holdings, selected assets and savings of each household and its members. Quarterly surveys collected information on household input and income from agriculture, livestock, forests and the surrounding environment, wage labor and business. Quarterly recall periods were used for livestock and crop income to avoid missing harvests and livestock sales. One month recall periods were used for forest products, other environmental resources, wage income and businesses to ensure sufficient detail.

Accounting methods draw primarily on Cavendish (2000, 2002). Total net income was defined as the sum of cash income (incl. from environmental products), subsistence 'income' and net gifts/transfers minus costs of input materials and hired labor. Family labor was not deducted due to difficulties in identifying relevant labor shadow prices in this location where formal wage labor markets are absent (c.f. Campbell and Luckert, 2002; Sjaastad et al., 2005). All environmental goods income was calculated based on average own-reported values. This was straightforward as most environmental products are traded locally or at least regionally. Using own-reported values furthermore has the advantage of collecting 'real' as opposed to inflated urban prices and has been shown to work even for commodities with limited or no market value (Cavendish, 2000). For all items it was checked that own-reported values: (1) clustered closely around the mean, with standard deviations below half the value of the mean, (2) had closely related mean, median and mode indicating limited skewness, and (3) that corresponding prices matched their respective ratio of quantities. Values of household assets were determined as own-reported accepted sale price of the assets today triangulated against the items age and purchase price. Missing values were given an average of own-reported current values of similar assets, accounting for the age of the asset.

### 3.2. Data Analysis

All income measures were converted to international dollar using a PPP conversion factor of 66.6 Congolese Franc per international dollar (IMF, 2007). Results were furthermore divided by Adult Equivalent Units (AEU) and adjusted in order to account for differences in household composition and size and possible effects of economies of scale based on Cavendish (2002). Following common practice (Cavendish, 2000; Kamanga et al., 2009; Vedeld et al., 2004; Yemiru et al., 2010), the sample was then divided into five equally sized income quintiles

(n = 35) based on total annual income. Similarly, five equally sized asset quintiles were constructed and ranked based on the sum of the value of selected households assets (incl. domestic animals, business capital, bank savings or debts, and other implements (e.g. plow, cart, etc.)) as proxies of household asset wealth. Mainly productive and easily tradable assets were used to construct the asset quintiles in order to overcome valuation problems (e.g. trying to estimate the value of one additional year of education, etc.). However, agricultural land and buildings (i.e. housing) were not included due to non-existing markets for these, inhibiting estimation of reliable values. In both cases, quintile one is the poorest and quintile five is the richest. The Gini coefficient was computed using the Whitehouse inequal command in STATA version 11.2. Relative forest income (RFI) was calculated as the proportion of total income originating from forest use and plotted with total income and absolute forest income against both income and asset quintiles in order to examine whether this produce different patterns.

A matrix tabulating income quintiles against asset quintiles was made to decompose households into four groups. Following Carter and May (2001), households are defined as chronic or structurally poor if they rank lowest in both income quintile and asset quintiles. Similarly, we define households as rich if they rank highest in both income quintile and asset quintiles. Transient poor were defined as households that ranked high in asset quintile but low in income quintile (the two lowest income quintiles and the two highest asset quintiles were used due to low sample size) indicating a loss of an income source that initially enabled them to accumulate a higher assets capital. Following this we extend Carter and May's classification and define households in the two highest income and two lowest asset quintiles as transient rich (i.e. households that, at least temporarily, have found a higher income source and hence a potential pathway out of structural poverty) (for clarification see Table 2). Whether the definition of chronic poor and rich represents a truly chronic condition (incl. a poverty trap for the poor households) cannot be determined based on the data available from a typical CIFOR-PEN one-year income survey. The remaining households represent a group with average income and asset that we hereafter refer to as 'regular' households. We do not examine this group explicitly here as this does not contribute to validating or rejecting the suggested approach.

We subsequently examine the validity of this approach by testing a number of general assumptions about the characteristics of households in these poverty groups. The relevant assumptions are based on the livelihoods framework (Ellis, 2000) and the results of a large amount of empirical research as outlined in Table 1. A multinomial regression model was constructed to examine the effect of theses and other demographic, contextual and stochastic variables on the likelihood of households being categorized in the various poverty groups. Variables representing monetary values of assets were not included in the model to avoid endogeneity (i.e. circular conclusions in relation to the variables used to generate the asset quintiles). Stepwise exclusion was used to reduce the number of variables in the initial model. Thus the resulting model is a multinomial regression model according to which the likelihood of the dependent variable, status ($s$) as either chronic poor, transient poor, transient rich, or rich ('regular' households are used as base category) is a function of the effect of the following independent variables:

$$\ln\left(\frac{p(s=i)}{p(s=5)}\right) = \ln\left(\frac{p_i}{p_5}\right) = \beta_{i,1} + \beta_{i,2}La + \beta_{i,3}P + \beta_{i,4}F + \beta_{i,5}E + \beta_{i,6}D \quad i = 1\ldots5 \tag{1}$$

where $La$ is the hectares of land owned, $P$ is the productivity of the land measured as crop income per hectare, $F$ reflects whether the household is female headed, $E$ is the average number of years of education of household members above 15 years of age and $D$ is the distance from the center of the village to the nearest major market. Variables describing age of household head, ethnicity, status as immigrant and distance to the forest were dropped from the model as they were insignificant. The regression was run with the VCE option to provide heteroskedasticity-robust estimates. Interpretation of results was aided by computing the marginal change in probability due to a unit change in an explanatory variable conditional on specified values of remaining explanatory variables.

Following the standard PEN approach, households were asked whether they had experienced a shock during the past 12 months. No major covariate shocks occurred in the location in this period. Idiosyncratic shocks were defined as: major crop failure; death or serious illness rendering a productive adult household member unable to work for more than a month; major loss of land, livestock or other major household assets due to theft, drought or fire; loss of wage employment; delayed payment of income from trade or salary work; wedding or other costly social event; and finally fines and court cases. Respondents were furthermore asked to rate experienced shocks as either moderate or severe. These aspects were also used to assess the validity of categorization of households into the different poverty groups.

Finally the characteristics of the dynamic poverty groups were explored in terms of sources of income and particularly forest dependence. Shares of total income were examined instead of absolute income to avoid circular conclusions. As several of these variables were highly correlated, one-way ANOVA with Bonferroni test was applied to compare between groups. The share of income from different forest products was compared between groups in terms of cash and subsistence income, using similar means.

## 4. Results

### 4.1. Forest Dependence of Income Quintiles

The average annual income per AEU was US$ 2626 (CI 95% ±464) but 34% of households were below the national poverty line defined as US$ 1466 per AEU (IMF, 2007). The Gini index of total income in the sample was 0.48. The largest increase in Gini coefficient, to 0.56, occurred if forest income was excluded from the comparison. On average forest income provided 33% (CI 95% ±5) of total household income.

**Table 1**
Expected relations between poverty and variables included in the multinomial regression model after model reduction.

| Abbreviation | Variables | Correlation with poverty | Brief description |
|---|---|---|---|
| *F* | Female headed households | + | Female-headed households have lower work capacity and are more likely to be marginalized |
| *E* | Average years of education of household members above 15 | ÷ | Education provides access to better income generating opportunities |
| *La* | Amount of land owned | ÷ | Higher amount of land owned per AEU provides basis for higher income from agricultural production or rent |
| *P* | Productivity of land (income per hectare) | ÷ | Higher income per acre increases profit and higher income provides means for investing in crop improving measures (pesticides and fertilizers) |
| *D* | Distance to market | + | Lower access to market reduces profit or inhibits opportunity for bringing products to markets and generating income |

Selected references: Cavendish, 1999, 2000; Bigsten et al., 2003; Paumgarten, 2005; Mamo et al., 2007; Vedeld et al., 2007.

The results show the commonly observed pattern with low income quintiles obtaining higher relative forest income and higher income quintiles obtaining higher absolute forest income (Fig. 2). The lowest income quintile obtained on average 42% of their total income from the forest compared to 27% for the highest income quintile who in turn obtained eight times higher absolute forest income than the lowest income quintile.

### 4.2. Forest Dependence and Asset Quintiles

The average value per AEU of selected household assets was US$ 270 (CI 95% ±66) increasing from the lowest to the highest asset quintile. Value of these assets was primarily accumulated in: small domestic animals (i.e. poultry) by low asset quintile households; implements (incl. furniture and household items, machines and farm tools) by intermediate asset quintiles; and business capital (current value of capital stock) by the high asset quintile households. Using asset quintiles to assess the poverty–environment relations produces a distinctly different picture than using income quintiles (Fig. 3). This reveals that asset quintiles two and three, and not the poorest asset quintile, have the highest RFI and that asset quintile three instead of five has the highest absolute forest income. In addition the figure illustrates that the value of households' assets and income are not directly related.

### 4.3. Identifying Poverty Groups

Comparing income and asset quintiles enables identification of chronic poor, transient poor, transient rich and chronic rich households (Table 2). Twenty households were categorized as transient poor (i.e. low income but high asset quintile). Similarly 17 households were categorized as transient rich (i.e. high income but low assets). Thirteen households were categorized as chronic poor (i.e. both low income and asset quintiles). Finally, 16 households were categorized as rich (i.e. both high income and asset quintiles). The remaining 109 households we consider 'regular' in terms of having average income and assets values. The distribution of these poverty groups in relation to total income and assets values are presented as a scatter plot in Fig. 4 instead of using the approach in Figs. 2 and 3, as it not clear which transient group should be considered wealthiest (i.e. those with high income or high assets values).

The basic characteristics of households in the poverty groups are presented in Table 3. None of the transient rich or rich households had experienced severe shocks, whereas at least some of the chronic poor and transient poor households had experienced events considered as severe shocks. A significantly higher proportion of the transient rich and chronic poor households are female headed. As may be expected, both total annual income per AEU and combined value of households' monetary assets show a consistent increase along the income continuum from chronic poor, transient poor, regular and transient rich to the rich households. Forest income per AEU follows a similar pattern with the exception of the transient rich households who obtained the highest absolute income from forest resources. The results also reveal that the chronic poor and rich have no debts or savings. Having examined the basic differences between households belonging to the different poverty groups, we proceed to test assumptions about the characteristics of households in the various poverty groups.

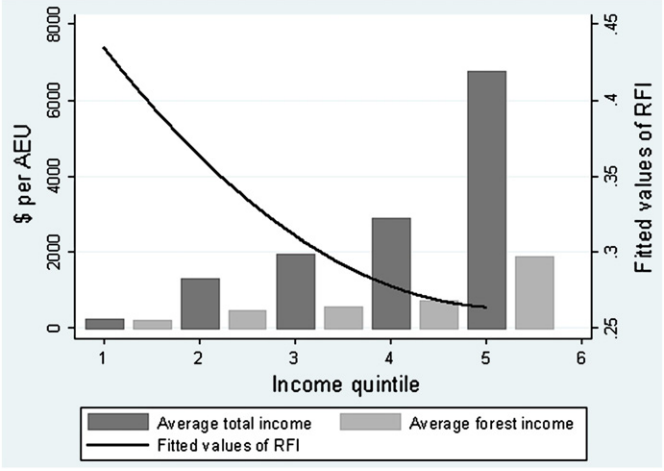


**Fig. 2.** Average total income, average absolute forest income and fitted values of relative forest income (RFI) in $ for income quintiles constructed based on total annual income.

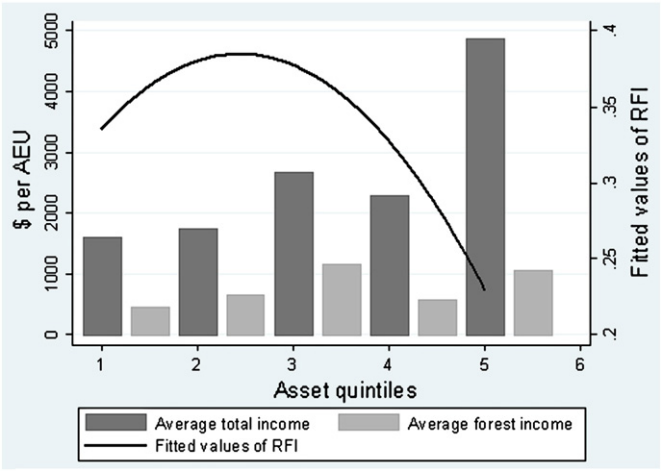


**Fig. 3.** Average total income, average absolute forest income and fitted values of relative forest income (RFI) in $ for asset quintiles constructed based on value of selected assets.

### 4.4. Characterizing Poverty Groups

#### 4.4.1. Demographic, Contextual and Stochastic Descriptors

The multinomial regression model reveals that the chronic poor were best characterized by owning significantly fewer hectares of land and secondly by residing in villages at further distance from a market (Table 4). There were no significant variables characterizing the transient poor households, which is consistent with the theoretical expectation that this group consists of a wider spectrum of households that are experiencing an income shortfall due to a shock. The transient rich households were characterized by having a significantly higher agricultural income per hectare. Finally the rich households were characterized primarily by being significantly less female-headed, by having

**Table 2**
Comparison of households' rank in income and asset quintiles (1 is lowest). Households in the top left and lower right corners are defined as chronic poor and rich respectively. Households in the top right and lower left corner are defined as transient poor and transient rich respectively (the two lowest/highest income quintiles and the two highest/lowest wealth quintiles were used due to low sample size). The remaining households are considered 'regular'.

| Income quintiles | Asset quintiles | | | | | Total |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| 1 | 13 | 9 | 4 | 5 | 4 | 35 |
| 2 | 9 | 8 | 7 | 9 | 2 | 35 |
| 3 | 5 | 9 | 10 | 7 | 4 | 35 |
| 4 | 5 | 4 | 7 | 10 | 9 | 35 |
| 5 | 3 | 5 | 7 | 4 | 16 | 35 |
| Total | 35 | 35 | 35 | 35 | 35 | 175 |

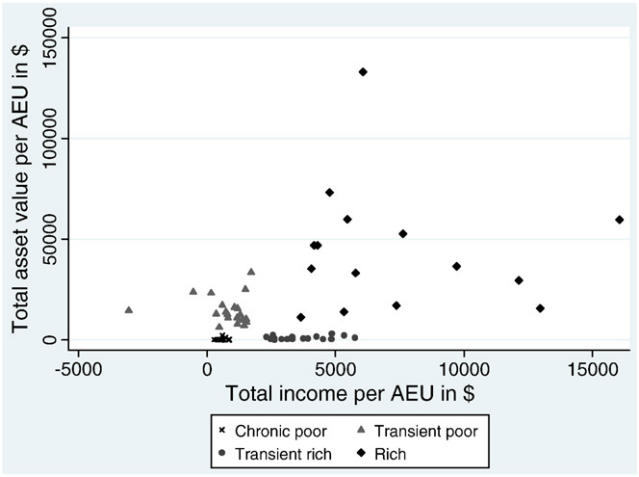


**Fig. 4.** Scatter plot of total income per AEU and total assets values per AEU for the constructed poverty group ('regular' households and one outlying rich household were omitted for clarity of illustration).

significantly higher average years of education and by owning significantly more agricultural land compared to the regular households.

Comparing the predicted and observed outcomes of the multinomial logistic regression model (Eq. (1)) reveals that the model predicts accurately 63% of observations. As mentioned the transient poor were not characterized by significant difference in any of the included variables. A Wald test furthermore indicate that the transient poor and the 'regular' households are not different samples and thus could be combined ($chi^2 = 7.52$; $P > 0.1$). This is not surprising given that the transient poor are assumed to be more or less 'regular' households that have experienced a shock that has deprived them of an important income source.

*4.4.2. Shares of Income from Different Sources*

The share of income from different sources was compared between the poverty groups using one-way ANOVA (Table 5). The comparison shows that the chronic poor obtain a significantly higher proportion of their income from forests than the rich and depend more on forest resources than the rest. The transient poor use a significantly higher proportion of extracted forest resources for subsistence use than most other groups. Inspection of mean income from various sources furthermore reveals that the transient poor as a group had negative mean crop income indicating that at higher proportion of members in this group experienced a crop failure. It is not perfectly clear what distinguishes the transient rich in terms of income source but this group appears to obtain a high share of income from crops (not significant), which is consistent with the high agricultural productivity for this group. They also had the highest proportion of salary income from labor of any of the groups. Finally the rich households obtained a significantly higher share of their income from business, compared to the transient rich and poor.

*4.4.3. Forest Product Use*

As revealed by the comparison in Table 3, forest income increased from the chronic poor, transient poor, over the rich to the transient rich. Examining individual forest products reveals that the rich households obtained a lower share of forest income from fuelwood per AEU than the chronic poor (one-way ANOVA with Bonferroni $F = 2.49$; $P < 0.1$) but a higher share from poles and timber than the transient rich (one-way ANOVA with Bonferroni $F = 16.53$; $P < 0.05$).

There were also signs of specialization in harvesting particular forest products. A higher proportion of the transient rich households hunted bushmeat than the chronic poor (Table 6). In addition, it appears that a higher proportion of the transient rich and rich households harvest wild foods and poles and timber than the poorer households (chronic and transient). This suggests that primarily the richer households along the income continuum are engaged in harvesting the most valuable forest products although it is not possible to assess the profitability of these activities, as information on time spent on each activity is not available. Furthermore, the results do not indicate any significant difference in income from the various products obtained as cash vs. subsistence income between the groups. More than 92% of income from all forest products in each poverty group was obtained as subsistence 'income' (i.e. examining each product individually) suggesting a very subsistence-oriented forest product extraction.

## 5. Discussion

### 5.1. Identifying and Characterizing the Dynamics of Poverty

In this paper we set out to test a simple approach that provides a perspective on the dynamic relations between income and asset poverty and forest dependence. We have shown that using asset-based

**Table 3**
Basic characteristics of households in the poverty groups. Means are compared using one-way ANOVA with Bonferroni test for parametric variables and Kruskal-Wallis equality of populations rank test for non-parametric variables. Numbers in brackets are standard deviation of the mean. NS = not significant.

| Variable | Chronic poor (1) (n = 13) | Transient poor (2) (n = 20) | Transient rich (3) (n = 17) | Rich (4) (n = 16) | Test statistics |
|---|---|---|---|---|---|
| Age of household head | 49.23 (12.82) | 46.60 (13.93) | 48.31 (18.14) | 46.00 (10.97) | NS |
| Proportion female headed | 38% | 10% | 41% | 0% | $F = 4.68^{***}$<br>1 > 4<br>3 > 4 |
| AEU | 4.21 (1.09) | 3.87 (1.31) | 2.92 (1.85) | 3.78 (2.08) | NS |
| Average education above 15 years | 3.33 (1.36) | 4.55 (2.34) | 3.91 (3.23) | 5.23 (2.28) | NS |
| Average hectares land owned per AEU | 0.30 (0.28) | 0.71 (0.63) | 0.67 (0.63) | 0.95 (1.01) | NS |
| Forest income per AEU | 246.47 (126.90) | 340.73 (206.68) | 890.70 (469.66) | 836.58 (642.77) | $F = 9.95^{***}$<br>1 < 3, 4<br>2 < 3, 4 |
| Total income per AEU | 607 (183) | 1050 (456) | 3677 (1086) | 5694 (1785) | $F = 74.06^{***}$<br>1 < 3 < 4<br>2 < 3 < 4 |
| Debts per AEU | 0 | 66.71 (186.60) | 94.57 (315.00) | 0 | NS |
| Savings per AEU | 0 | 20.49 (91.64) | 0 | 0 | NS |
| Total assets value per AEU | 1238 (1805) | 51,373 (17,963) | 3569 (4332) | 87,887 (43,799) | $F = 50.12^{***}$<br>1 < 2 < 4<br>2 > 3, 3 < 4 |
| Proportion experiencing severe shock | 8% | 5% | 0% | 0% | NS |
| Proportion with negative crop income | 15% | 25% | 0% | 6% | NS |

*, ** and *** signify statistical significance at 0.1, 0.05 and 0.01 levels, respectively.

**Table 4**
Multinomial regression comparing poverty groups and 'regular' households (base category) in various demographic and contextual aspects. First number represents the regression coefficient and numbers in brackets are robust standard error terms.

| Variables | Chronic poor | Transient poor | Transient rich | Rich |
|---|---|---|---|---|
| Land[a] | −2.57 (1.01)** | 0.26 (0.43) | −0.14 (0.44) | 0.86 (0.43)** |
| Crop income/ha | $5\times10^{-4}$ ($1\times10^{-3}$) | $2\times10^{-3}$ ($2\times10^{-3}$) | $1\times10^{-3}$ ($5\times10^{-4}$)** | $2\times10^{-3}$ ($1\times10^{-3}$) |
| Female headed | 0.59 (071) | −0.38 (−0.88) | 0.70 (0.69) | −15.45 (1.58)*** |
| Average education above 15 | −0.01 (0.11) | 0.07 (0.10) | −0.05 (0.16) | 0.18 (0.11)* |
| Distance to mkt. | 0.04 (0.02)** | 0.03 (0.02) | $-5\times10^{-3}$ (0.02) | $2\times10^{-2}$ (0.02) |
| No. observations | 174 | | | |
| Wald $Chi^2$ | 1589.41 | | | |
| Prob > $Chi^2$ | 0.00 | | | |
| Pseudo R-squared | 0.1084 | | | |

*, ** and *** signify statistical significance at 0.1, 0.05 and 0.01 levels, respectively.
[a] Log transformed.

measures of wealth, which provides a longer-term measure of poverty because assets are accumulated over time and considers the full amount of resources available to households in terms of the productive capacity of their assets, produces a distinctly different result than the commonly observed pattern of a negative relation between income and forest dependence and a positive relation with absolute forest income (Vedeld et al., 2007). Acknowledging that using income and asset based measures of wealth separately both provides static pictures of poverty, we have gone one step further and combined these two measures to identify rich households with high income and asset values, and chronic poor households that neither have the income to accumulate assets or the productive capacity in their asset base to obtain higher household income and theoretically may be in a poverty trap (although we cannot show this empirically). We have also identified transient poor households as households that theoretically are likely to have experienced some degree of idiosyncratic shock that has reduced their income but not required them to liquidate their assets yet, and transient rich households that may (at least temporarily) have found a source of income that may eventually enable them to construct a pathway out of poverty, but without having led to accumulation of assets yet.

Identifying and separating the chronic poor from the transient poor has important implications for targeting poverty alleviation efforts towards the worst-off households as opposed to just mitigating poverty for households that are temporarily experiencing hard times. As the transient poor households have more asset endowments, they are better equipped to recover from the temporary decrease in income they are experiencing (Vatsa, 2004). Previous studies have found that the transient poor comprise a large share of the overall poor (Baulch and Hoddinott, 2000). Our results support this finding although our transient poor group, due to low overall sample size, includes households in the two highest asset quintiles and the two lowest income quintiles instead of just the most extreme quintiles (i.e. cells in Table 2). We acknowledge the possibility that the chronic poor households can eventually find a source of income allowing them to invest in assets and thereby construct a way out of a poverty (Carter and Barrett, 2006), but we do not have the temporal data needed for such analyses. However, the ability of people to climb out of poverty on their own initiative is severely curtailed, particularly in a context of poorly functioning market and insecurity, as is the case in DRC due mainly to the civil unrest that has been afflicting the country since 1997. The poor often face difficulties in accumulating assets through commercialization of their production (Ellis and Freeman, 2004).

The outlined approach does not unambiguously enable disentanglement of the cause and effect of the observed dynamics (i.e. why households are categorized in the individual groups). This is due to the lack of temporal data and because households have both ex post and ex ante strategies to insure against and accommodate shocks (Delacote, 2009; McSweeney, 2004; Owens et al., 2003). It is furthermore not meaningful to directly compare the constructed poverty groups to income or asset quintiles, as these are different by the nature of how they are constructed and therefore clearly produce different results. Nevertheless, there are clear theoretical arguments for including dynamic aspects of poverty in poverty–environment studies as we outlined in the introduction. Furthermore, we find plausible explanations for the observed patterns that support our categorization of households in the various poverty groups. These includes that the chronic poor households own less land, live at greater distance from the market and are more forest dependent, which is likely to be a coping strategy of the chronically poor to support current consumption (e.g. Angelsen and Wunder, 2003) in response to whatever situation let them to lose their assets or be unable to accumulate capital and assets in the first place. The result that primarily the chronic poor depend on forest income further suggests that they are unable to accumulate assets or cash based on this livelihoods strategy (see Belcher, 2005; Sunderlin et al., 2005) and that these households may be trapped into low return forest extraction activities and are deprived

**Table 5**
Comparison of mean share of income (%) from different sources of the poverty groups using one-way ANOVA and Bonferroni test. Numbers in brackets are standard deviation. Households with negative total annual income were omitted from the tests. NS = not significant.

| Income type | Chronic poor (1) | Transient poor (2) | Transient rich (3) | Rich (4) | F-test Bonferroni |
|---|---|---|---|---|---|
| Forest income (RFI) | 42 (20) | 37 (19) | 29 (18) | 22 (18) | F = 3.35** 1 > 4 |
| Subsistence forest income | 26 (8) | 29 (15) | 14 (6) | 10 (6) | F = 15.09*** 1 > 3, 4. 2 > 3, 4 |
| Environmental | 8 (21) | 11 (15) | 6 (7) | 6 (6) | NS |
| Salary | 2 (5) | 1 (4) | 7 (12) | 5 (8) | NS |
| Business | 14 (13) | 24 (49) | 15 (13) | 32 (22) | F = 5.21*** 1 < 4, 2 < 4, 3 < 4 |
| Crop | 25 (31) | 21 (27) | 34 (24) | 26 (22) | NS |
| Domestic animal | 0 (4) | 1 (5) | 0 (1) | 0 (4) | NS |
| Remittance | 1 (3) | 0 (0) | 2 (4) | 0 (1) | NS |

*, ** and *** signify statistical significance at 0.1, 0.05 and 0.01 levels respectively.
Note: The income collapsed category 'other'* consisting of pension, gifts, compensation etc. was omitted from the table as no significant differences were observed in any aspect.

**Table 6**
Comparison of the proportion of each poverty group obtaining income from categories of forest products.

| Product category | Chronic poor (1) (n = 13) | Transient poor (2) (n = 20) | Transient rich (3) (n = 17) | Rich (4) (n = 16) |
|---|---|---|---|---|
| Fuel wood | 100 | 100 | 100 | 100 |
| Bushmeat | 8 | 35 | 59 | 44 |
| Wild food | 62 | 70 | 94 | 88 |
| Poles/timber | 0 | 0 | 6 | 6 |
| Other | 8 | 0 | 6 | 13 |

of other development opportunities (Delacote, 2007). However, this does not negate the observation that some chronically poor can use forest income to attempt to climb out of poverty, for instance by investing in education of their children (Shackleton et al., 2008).

As a higher proportion of the transient poor have negative crop income, it is plausible that they have experienced a crop failure (i.e. idiosyncratic shock). This may explain why this group has a relatively high dependence on forest and environmental products and consume a significantly higher proportion of these products in the households. This implies that forests perform a safety net function for the transient poor (Angelsen and Wunder, 2003; McSweeney, 2005), whereas it appears to support current consumption for the chronic poor who by nature of their situation are more susceptible to shocks (Bates et al., 2004). Despite, few households considering having experienced severe shocks (which there may be several explanations for that we will return to below), the fact that the proportion was highest in the chronic and transient poor groups supports the results and the underlying theoretical assumptions (Carter and Barrett, 2006).

The transient rich on the other hand may be in the process of constructing a pathway out of poverty through a number of different strategies that diversify their income base. They have high income from agriculture as a result of a significantly higher agricultural income per hectare. They also have higher salary income. Finally they have the highest absolute forest income of any of the groups and are more likely to hunt bushmeat, which is a high value product per unit weight (de Merode et al., 2004). Bushmeat is a significant source of cash income in this area of the DRC as preferences and demand is high in the growing populations of nearby urban areas of Kinshasa and Boma (Draulans and van Krunkelsven, 2002; Wilkie and Carpenter, 1999). The potential of forest product extraction to actually pull households out of poverty is debated (Almeida, 1996; Angelsen and Wunder, 2003; Cavendish, 2000; Fisher, 2004; Godoy et al., 1998; Shackleton et al., 2008; Wunder, 2001). But these results reveal that forest income may play some role in perhaps inevitably enabling some households in this group to construct a pathway out of poverty.

The rich households are characterized by higher education levels, owning more land and, obtaining a higher share of their income from business. They are also less likely to be female headed, which in other studies has been found to determine the variety of environmental resource extraction activities that households engage in, namely less lucrative forest product exploitation (Cavendish, 1999; Paumgarten, 2005).

We have made no attempt to examine the 'regular' households that logically must be a more diverse group of households that either have not (recently) experienced any of the type of shocks that negatively affected the trajectories of the transient poor households, but have not (yet) been able to accumulate an asset base or establish a steady income base comparable to the rich households. This may include households that are in some stage of transition between the poor and the rich groups.

Apart from natural resource endowments (incl. forest), access to social networks and capital are important determinants of household's ability to cope with shocks and construct a pathway out of poverty (Carter et al., 2007; Paumgarten and Shackleton, 2011 but see Godoy et al., 2007). Studies have shown that the ability to escape poverty traps depend on the degree to which a household has access to credit, insurance and savings either formally or through social networks (Carter and Barrett, 2006). However, formal credit and insurance markets are not common or uniformly available in rural areas of developing countries (Delacote, 2007; Rosenzweig, 1988; Townsend, 1994; Winter-Nelson and Temu, 2005). Our results in this respect reveal that the chronic poor households in our sample do not have access to formal loans or social networks that could provide this service. Making such safety nets available, whether formally or informally, and ensuring that loans have a fixed and reasonably low interest rate, is therefore an important policy objective in order to prevent vulnerable households from losing their assets (Carter et al., 2007) and might offset some of the pressure on forest resources (Anderson et al., 2002).

### 5.2. Delimitations and Recommendations

This paper is based on a typical study of poverty–environment relations conducted using highly standardized methods developed for the global CIFOR-PEN survey. We have therefore used the common practice in such studies of dividing the randomly selected sample of households into five equally large income quintiles based on total annual income (Kamanga et al., 2009; Yemiru et al., 2010; see also Cavendish, 2000; Vedeld et al., 2004). We have used the same method in constructing an asset based measure of wealth. However, the delimitation of quintiles based on a fixed percentage of the sample (20% in this case) is arbitrary and ignores any natural clusters within the sample. Income is for instance more likely to be normally distributed or perhaps highly left skewed depending on the location. This practice thus entails a high risk of placing some households in one income quintile although they have more in common with households in the next income quintile, in which case the very poor and very rich quintiles will be artificial groups. A solution to this problem is to use latent class modeling to construct income and asset groups that consider the actual clusters in the sample. Although we attempted this and observed the same trends as reported in the result, the low sample size in the wealthier groups prevented formal statistical analysis. As a result we had to resort to the approach described here. In addition, low sample size made it necessary to categorize more cells as transient groups in the income vs. assets quintile matrix (Table 2) compared to the chronic groups. The transient groups thus included households that in essence more likely are regular households. This adds more noise (i.e. variation) in these groups making it difficult to establish significant differences in comparison to other groups. Future studies using this approach could ensure an adequate number of households in each poverty group by employing a stratified random sampling strategy, perhaps based on a participatory wealth ranking exercise, instead of the commonly employed random sampling method.

We have tried to validate our theoretical assumptions about the relationship between income, assets and forest dependence by comparing the incidence of shocks between our defined poverty groups using data collected in standard PEN studies. This had only limited success for a number of reasons: (i) there may be a number of push and pull factors other than shocks *per se* that determine the transition between poverty groups; (ii) the effect of shocks on household poverty is not necessarily observed within the one year period; (iii) it does not consider the effect of multiple shocks; (iv) the definition of a shock is likely to be culturally determined; (v) and the severity of its impact relative between households (i.e. what is considered a minor anticipated stress that the household has *ex ante* prepared to mitigate may constitute a severe shock to another household) (e.g. Ellis, 2000; McSweeney, 2004; Pattanyak and Sills, 2001; Paumgarten and Shackleton, 2011; White et al., 2001). A more culturally specific definition of shocks with a standardized measure of its impact (e.g. proportion of crops lost) may therefore be needed in order to improve this part of the analysis.

In addition it cannot be excluded that households differ in their disposition to saving and investment rather than emphasizing current consumption. Hence the transient poor group could be explained as households with a preference for investing (low) income in assets (i.e. low consumption), and the transient rich group could be explained by low preference for investing (high) income in assets (i.e. high consumption), rather than effects of push and pull factors. Households also differ in risk adversity/taking behavior and the poor are generally assumed to be risk adverse (Ellis, 2000). However, when poverty becomes extreme willingness to take risks may increase as households have little left to lose. Risk taking behavior may furthermore lead both to poverty and to wealth depending on the outcome and hence it is not uniformly clear how this aspect affects transition between poverty groups. Future

studies applying our suggested approach would need to collect additional information to exclude these explanations.

Finally, household's income generating activities may be conditioned by the assets at their disposal and hence represent a self reinforcing situation (Babulo et al., 2008; Tesfaye et al., 2011). However, attempting to validate or reject the poverty groups through their activity specific asset endowment (i.e. establishing typologies), is complicated by the fact that high forest income is not necessarily related to the value of particular assets. Bushmeat hunters can for instance use string traps with very low value and harvesting other NTFPs does not require specialized tools beyond what most farmers possess. Similarly business income may be related to high capital invested in buildings and product stock or conversely simply be determined by the ownership of a mobile phone, a large social network and trade skills. In this case business activities mainly revolved around the trade of processed crops, which does not involve specialized assets but only require storage facility often in the household and regular agricultural tools that have little value. However, a multinomial regression model according to which the likelihood of categorization in the various poverty groups is a function of the effect of the value of business assets, agricultural implements and domestic animals (as available and relevant asset/activity typologies), most importantly revealed no significant effects for the transient poor that could suggest that their low income was conditioned by the assets at their disposal (results available from the corresponding author).

## 6. Conclusion

In this paper we have developed a simple approach based on the PEN methodology to evaluating the relation between poverty and the environment in developing countries that includes both asset values and income. We have grouped households as chronic poor, transient poor, transient rich and rich, examined their characteristics and found plausible explanations for their categorization within a theoretical framework of shocks and supported by the literature on forest dependence. Overall the results indicate that forest resources play an important role in supporting current consumption in the livelihood strategies of the chronic poor; constitute a security net for the transient poor in response to shocks (i.e. crop failure); and have some role in the transient rich households' efforts to construct a pathway out of poverty. The categories defined are furthermore to some extent supported by a higher occurrence of severe shocks in households in the chronic and transient poor categories.

Overall the results reveal the importance of including asset-based measures of wealth in studies of poverty–environment relations and indicate the potential of our approach, combining income and asset-based measures of wealth, in providing a more dynamic perspective on poverty. However, we suggest that future research using this approach should base their income and asset groups on latent class modeling to more explicitly consider the natural clusters in the sample. This will require a larger sample size in order to get a sufficient number of households in each poverty group. Another solution would be to base surveys on a stratified random sampling strategy that includes a participatory wealth ranking exercise in order to ensure an adequate number of households in each group.

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