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Safety Nets, Gap Filling and Forests: A Global-Comparative Perspective

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Summary. — In the forest–livelihoods literature, forests are widely perceived to provide both common safety nets to shocks and resources for seasonal gap-filling. We use a large global-comparative dataset to test these responses. We find households rank forest-extraction responses to shocks lower than most common alternatives. For seasonal gap-filling, forest extraction also has limited importance. The minority of households using forests for coping is asset-poor and lives in villages specialized on forests, in particular timber extraction. Overall, forest resources may be less important as a buffer between agricultural harvests and in times of unforeseen hardship than has been found in many case studies.

Key words — livelihoods, risk, shocks, coping strategies, income, diversification

1. INTRODUCTION

In developing countries, high rates of livelihood insecurity place major restrictions on welfare improvements (Wood, 2003). Rural livelihoods are particularly prone to uncertainties, be they related to the vagaries of weather and climate, or to injuries and illness, patterns of crime, or shifts in commodity prices or government policies (World Bank, 2001). Rural households usually adapt to these uncertainties both *ex ante* (before the shock) and *ex post* (in its aftermath). *Ex ante*, they may accumulate extra assets (livestock, monetary savings, etc.) with the explicit purpose to buffer future shocks. Similarly, they may hold buffer stocks of consumption items as an informal insurance. They may forgo potentially profitable but risky activities and may diversify production in order to reduce their exposure or any individual shock. Alternatively, they may organize themselves into networks based on social groups or institutions that allow them to pool risks. *Ex-post* coping strategies therefore also depend on the ex-ante plans employed. *Ex-post* responses may include income and consumption smoothing, asset sales, and reallocation of production factors, in particular labor (finding off-farm work or other more remunerative tasks, increase labor time, take children out of school and into work, etc.). The choice of coping strategy will depend on the type and size of the shock, individual household characteristics and factor endowments, and broader contextual factors such as the characteristics of local markets, availability of insurance, and the provision of public services (Beegle, Dehejia, & Gatti, 2006; Dercon, 2000; Hoogeveen, 2003; World Bank, 2001).

In the livelihoods literature, forests are often identified as a prominent safety-net source, accessed principally by reallocating more household labor to forest extraction. Natural forests and other wildlands with non-cultivated natural resources are supposed to provide households (especially asset-poor households) with additional flexible options in times of trouble. The effective conservation of forests and wildlands, often threatened by expansion of agricultural frontiers, is thus also legitimized as a natural insurance against calamities. In this paper, we study stated household responses to shocks, and their explanation. We also scrutinize *de facto* gap-filling patterns in responses to predictable seasonal fluctuations, as a distinct but related mechanism of making up for income shortfalls.

In both cases, our analyses draw on the Poverty and Environment Network (PEN) global dataset. The PEN

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database includes cross-sectional data, gathered by 33 PEN researchers during the period from January 2005 to May 2010, encompassing interviews with 8,301 households in 333 villages and 58 sites spread over 24 developing countries across three continents. Of these, 7,978 households answered the final survey containing a question about shocks suffered during the last 12 months (the remainder constituting attrition).[1] The PEN project emphasized a careful, quarterly recording of all environmental incomes (including both cash and subsistence components, from forests and other extractive, non-cultivated sources, as well as other major cash and subsistence income sources (agriculture, livestock, wages, remittances, etc.). Short (1–3 months) recall periods were used, with quarterly visits to households, distributed over one full year (Angelsen, Larsen, Lund, Smith-Hall, & Wunder, 2011). The PEN data cover all major developing country regions on three continents (Latin America, Asia, Sub-Saharan Africa). It can be seen as fairly representative of smallholder-dominated rural landscapes in which households have at least some access to forests.[2]

The remainder of the paper is structured as follows. In Section 2, we synthesize the literature on shocks, safety nets, seasonal gap-filling, and their relation particularly to forests and other environmental resources, in the process developing hypotheses for subsequent empirical testing. Section 3 presents evidence on the universe of shocks covered in the PEN data and describes the stated household responses. Section 4 provides a multivariate analysis explaining household decisions about whether or not to use forest and other extractive sources as their primary safety-net responses. In Section 5, we scrutinize briefly to what extent the intra-annual profile of households' forest extraction can be said to serve as a seasonal gap-filler. Our main conclusions and a discussion of the results close the paper (Section 6).

2. SHOCK RESPONSES: LITERATURE AND HYPOTHESES

A large literature has evolved on the risk management and adaptation strategies of rural households (e.g., Alderman & Paxson, 1992; Coate & Ravallion, 1993; Deaton, 1997; Dercon, 2005; Foster, 1988; Morduch, 1995; Udry, 1990). Households often cope by smoothing income through the diversification of agricultural or other activities. Reardon, Delgado, and Matlon (1992), for example, find evidence that households in Burkina Faso smooth income through participating in livestock husbandry, and Debela, Shively, Angelsen, and Wik (2012) report evidence of households in Uganda changing labor allocation in response to shocks. Smoothing consumption, on the other hand, can require access to insurance, borrowing or saving, or depletion of productive assets. Evidence generally supports the view that consumption smoothing is important, but generally incomplete (e.g., Binswanger & McIntire, 1987; Rosenzweig & Wolpin, 1993; Wolpin, 1982).

Research in many rural settings in developing countries has shown that the use of forests, both for cash and subsistence, can provide a natural form of insurance to many rural households, especially the poor (Angelsen & Wunder, 2003). Wealthier households tend to have more options, both to prepare for shocks (e.g., by building stocks of assets that are easily liquidated) and to choose between suites of response options (Dercon, 1998). For coping with shocks, therefore, forest resources often are more important in poverty-stricken areas than savings or credit access (Godoy, Jacobson, & Wilkie, 1998). One form of natural insurance provided by forests is as reserve areas for agricultural conversion. For example, in the case of floods, fires or pests reducing cropped areas, households may fall back on converting forestlands and its stored soil nutrients (Sunderlin, Angelsen, & Wunder, 2003). However, more commonly the literature focuses on the household's option to increase extraction of forest products. Many non-timber forest products (NTFPs) are found to be important, for food, medicines, game, etc. Since these resources are typically located in quasi open-access areas, they can be harvested when needed, including by landless people (e.g., Almeida, 1996; Falconer, 1990; Godoy *et al.*, 2000; Ogle, 1996; Shively, 1997). However, timber resources may also be an important source of emergency cash income, e.g., selling boards from a valuable tree to raise cash for medicine, or using timber directly to reconstruct damaged houses (Chambers & Leach, 1989). Hence, opinion is divided as to how important NTFPs are for responding to shocks.

Foraging and other forms of forest dependence by rural households often increase in the wake of unanticipated misfortune (Falconer & Arnold, 1989; Ogle, 1996; Scoones, Melnyk, & Pretty, 1992; Towson, 1994), as confirmed by case studies in Africa (Campbell-Platt, 1980; Debela *et al.*, 2012; Falconer, 1990, 1992; Fisher & Shively, 2007; Khundi, Jagger, Shively, & Sserunkuuma, 2011), Asia (Gunatilake, Senaratine, & Abeygunawardena, 1993; Liswanti, Sheil, Basuki, Padmanaba, & Mulcahy, 2011; Völker & Waibel, 2010), and Latin America (Godoy *et al.*, 1998; Hecht, Anderson, & May, 1988; McSweeney, 2004; Pattanayak & Sills, 2001; Takasaki, Barham, & Coomes, 2004). For example, Pattanayak and Sills (2001) show for the Brazilian Amazon how the number of forest collection trips is positively correlated with both agricultural shocks and expected agricultural risks. Debela *et al.* (2012) highlight for rural Uganda how large losses from shocks lead households to rely more on forests to cover both their subsistence and cash needs. McSweeney (2004) found in rural Honduras that young households with few liquid assets sold forest products when crops failed. In Peru, both forest extraction and conversion to new cropland was found to be important for coping with floods (Takasaki *et al.*, 2004), a situation that was quite similar during floods in East Kalimantan (Liswanti *et al.*, 2011). However, research has also shown substantial diversity among rural populations' use of natural resources in times of crisis (Barham, Coomes, & Takasaki, 1999; Byron & Arnold, 1999), including the degree to which households pursue income-smoothing mechanisms, rather than reducing consumption or temporarily depleting assets (Morduch, 1995; Rosenzweig & Binswanger, 1993). We can summarize these observations in a basic hypothesis:

Hypothesis 1. In times of crises and economic shocks, rural households in developing countries turn to forests and other environmental resources as important safety nets, increasing the extraction of forest products, or converting more forests to cropland than in normal times.

Secondly, the shock type could also shape forest responses. Covariate shocks (e.g., climatic events, price fluctuations) are defined as those that affect most or all households in a community. Idiosyncratic shocks (e.g., illness, death) affect single (or small groups of) households only. Those idiosyncratic shocks that reduce adult labor availability (e.g., illness, death) will naturally reduce the likelihood of labor-intensive responses, including forest extraction. When covariate shocks arise, moreover, safety-net mechanisms that depend on the community (e.g., selling labor, borrowing money) may become less

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viable, as relatives, friends, neighbors, and traders all may be negatively affected by the same shock. For the same reason, we may expect forests to be more important as a means to deal with severe shocks. In Vietnam, for example, severe weather shocks led households to allocate more labor to forest extraction, whereas the response to health shocks depended on how severely the household's labor supply was affected, since forest extraction can be labor-intensive (Völker & Waibel, 2010). We can summarize these observations as:

Hypothesis 2. The frequency and/or amount of forest and other environmental uses as safety nets increases with shock severity, and is higher in response to covariate than to idiosyncratic shocks, especially vis-à-vis labor shocks such as death and illnesses.

Third, clearly some households use forests as safety nets more than others. Often income- and asset-poor households rely more on forest-based shock responses than households with more substantial buffers (Anderson, May, & Balick, 1991; Chambers & Leach, 1989; Kant, Nautiyal, & Berry, 1996; McSweeney, 2004): extracting forest products usually requires little human, financial, or physical capital, making it a suitable fallback option (Neumann & Hirsch, 2000). In previous studies, households that turned to forests and forest resources as a coping mechanism were found to be more likely to be headed by young males (Fisher & Shively, 2005; McSweeney, 2004), to hold less land, and to have larger households and thus extra labor available (McSweeney, 2004; Takasaki *et al.*, 2004). Households that use forests to cope are often in the early stages of their household life cycle i.e., young families that have not yet accumulated sufficient land and/or physical capital to serve as a buffer (Perz, 2001). However, these households may also turn to off-farm sources as shock responses (Ellis, 1998). Households with higher education levels have been found to extract comparatively less from forests following shocks, typically because they gain access to more remunerative response options (Fisher, Chaudhury, & McCuske, 2010; Völker & Waibel, 2010).

Location also matters for household shock responses. Isolation tends to be positively correlated with forest access and negatively correlated with access to alternative, market-based coping opportunities (Godoy *et al.*, 1998). Conversely, household proximity and easy access to good-quality forests increases their use as safety nets (Fisher & Shively, 2005; Fisher *et al.*, 2010; Hegde & Bull, 2008; Pattanayak & Sills, 2001; Vedeld, Angelsen, Sjaastad, & Berg, 2004). We can thus summarize our expectations regarding between-household differences in forest coping as:

Hypothesis 3. The importance of forests and other environmental resources as safety nets is higher for households that are: (a) younger, (b) male-headed, (c) asset-poor (in terms of education, land, and physical capital), (d) income-poor, (e) located close to abundant forests, and (f) far away from markets.

Fourth, forests are often seen as important gap-fillers in the event of seasonal shortages (Sunderlin, 2004), because they provide a diversity of products that can be readily collected between crop harvests (Byron & Arnold, 1999; Pattanayak & Sills, 2001). In these off-seasons, forests allegedly "can make the difference between good and bad nutrition, between recovered health and prolonged illness, or between food security and starvation" (Angelsen & Wunder, 2003: 23). Increased extraction of forest products between crop harvests could thus help smoothening out recurrent and predictable intra-annual income fluctuations, both in terms of subsistence uses (in particular, food security concerns) and raising cash (de Beer & McDermott, 1996; Wickramasinghe, Ruiz Perez, & Blockhus, 1996). We therefore identify a fourth and final hypothesis, namely:

Hypothesis 4. Forests and other environmental resources are used as seasonal gap fillers, i.e., extraction of products from the wild is higher during intra-annual periods of predictably low incomes, especially between crop harvests.

3. RISKS AND SHOCKS IN THE STUDY SAMPLE

(a) *Evidence regarding shock types*

Consistent with much of the literature (but see Fisher & Shively, 2005), we consider only negative shocks. Our main response variable derives from the second (final) PEN annual household survey, where households were asked to report shocks, including large unexpected expenses they had suffered during the past 12 months. Respondents selected from a list of 11 pre-identified shock categories (e.g., "serious crop failure") and an open-ended "other" option. For each line, respondents were asked to provide:

(a) confirmation whether a certain type of shock had occurred (*incidence*),
(b) a binary ranking of shock degree between "severe" and "moderate" (*severity*), and
(c) three shock responses ranked by importance (*coping strategy*).

For (c), we offered 21 pre-identified and one open-ended response options. [3]

In addition to household responses, village group interviews were used to learn about the incidence and severity of covariate shocks and crises over the same previous 12-month period covered by the household surveys. Qualitative information about shocks was also included in the site narratives prepared by PEN partners. Some examples illustrate the range of events captured by the surveys. In one Brazilian site, jaguars killed many domestic pigs, which adversely affected various families. In others, Brazil nut trees had been burnt and nuts from other trees had been stolen, thus curbing normal forest income. In 2007, an environmental agency temporarily prohibited farmers in an extractive reserve to burn their fallows, which was followed by heavy rains that left households with a shortage of agricultural fields for that year, precipitating food purchases from outside. Storms, droughts, and floods were recorded in multiple sites worldwide. In Ethiopia, respondents suffered from a long drought that affected browsing, causing widespread livestock losses. At the same time, they experienced a macroeconomic shock from rapidly accelerating inflation. In Bangladesh, crops were infested with rats and as a result harvests declined markedly. In Burkina Faso, refugees arriving from conflict areas in Cote d'Ivoire caused a crisis in the survey villages.

In sum, the covariate shocks in our sample cover a large variety of causes and livelihood effects. However, if we compare the context of our surveys with those conducted where catastrophic events were observed, such as following Hurricane Mitch and devastating floods in Kalimantan and Peru, we lack comparable once-in-a-lifetime catastrophic calamities that destroyed huge stocks of assets. Even the

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shocks subjectively auto-classified by households as "severe" seem to be more representative of the types of shocks that rural people likely experience multiple times throughout their lives; they represent substantial but not necessarily ruinous losses of assets and incomes.[4]

How many shocks were the PEN households exposed to? Out of 7,978 households with valid responses to the shock questions, 5,103 (64%) reported to have suffered some kind of shock during the 12-month study period (Table 1). The total number of shocks reported was 7,962, reflecting that households often reported suffering from multiple shocks during the previous year (average: 1.56). Yet, there were large differences across continents. In Latin America, shock incidence was lowest; 57% of households reported moderate shocks and 16% reported severe shocks. For Asia, 56% reported moderate shocks, while somewhat more households (26%) reported severe shocks. In Africa, shock intensity was much higher, with 76% recording moderate shocks and 39% reporting severe shocks. This may be due to both climatic factors (more dry zones in the African sample), but could also reflect greater asset poverty that exposes African households more to fluctuations (see next section).

What types of shocks did respondents report? Figure 1 provides an overview from the pooled sample, giving the percentage ranges of shocks observed in each of the underlying 35 case studies. Crop failure is the single most important type. Although individual farmers might experience idiosyncratic harvest failures, these shocks tend mostly to be covariate by nature, caused by unfavorable weather, local diseases, and pest infestations—as shown in the qualitative description of shocks above, and also supported by some sample-wide empirical indicators.[5] On average, one third of the shocks reported by PEN partners were labeled as covariate. Human illnesses are the second-most cited shock, and together with the death of a household member constitute idiosyncratic labor shocks. Together, almost four fifths of the shocks are either (mostly) covariate crop failures or idiosyncratic labor shocks. Remaining reports (loss of animals, land, or other assets) are best characterized as "other idiosyncratic shocks."

(b) *Shock responses*

How did households respond to these shocks? Figure 2 shows the primary (first-ranked) responses to different shock types. For covariate shocks, more than one third of all respondents (36%) reacted primarily by reducing consumption, which is a much higher share than for labor shocks (17%) and other idiosyncratic shocks (26%). The reverse is true for responses of seeking extra-household assistance: for labor (19%) and other idiosyncratic shocks (17%), these shares are more than double the covariate shock share (7%). Conversely, extraction from forests and other environmental sources scores about double the respondent share (14%) than for labor (6%) and other idiosyncratic shocks. This pattern supports Hypothesis 2: idiosyncratic shocks allow households to draw more on social and economic networks (friends, neighbors, or informal money lenders). But when covariate shocks hit an entire village, region, or country, then the more difficult option of suffering through the event by drastically reducing consumption comes more to the forefront, as do forest- and wildland-based options of drawing more on common pool resources.

Besides the differences in responses to different shock types, we also need to pay close attention to the absolute ranking of responses. Particularly noteworthy is that forest- and other wildland-based coping options do not appear at the top of respondents' lists of coping strategies. Of the five main response categories, wild sources rank fifth and last for the two idiosyncratic shock types (6% and 8% of responses), and fourth for covariate shocks (14%). Labor reallocation to other sectors (e.g., off-farm work, agriculture) is more important, as are downward adjustments in asset holdings and consumption. For idiosyncratic shocks, seeking help from local social and economic networks is also a more important option than forests (17% and 19%).

Are our findings at odds with Hypothesis 1, expecting forest-based safety nets to be important for people's livelihoods? These forest-based responses could still be present, but other shock responses rank significantly higher in people's crisis reactions. Again we also see some important continental differences (Table 1 above). 10.4% of households in the full sample used environmental resources as their primary shock response, of which forests were the clearly dominating source (7.8%). However, in Asia these shares were higher (18% and 13.6%, respectively); compared to both Latin America and Africa.

Could a higher share possibly be linked to the poorest households relying more on forests, as also suspected in Hypothesis 3? Surprisingly, in the simple direct correlations, the opposite pattern is dominant: among the poorest income

Table 1. *Shock incidence and environmental responses across continents*

Continents	Latin America	Asia	Africa	Total
Number of shocks reported	833	2,007	5,122	7,962
Households affected by shocks	565	1,366	3,172	5,103
Households in sample	1,140	2,462	4,376	7,978
Share of households affected by shock	50%	55%	72%	64%
Total shocks per household	0.73	0.82	1.17	1.00
1st ranked response – forest share	6.5%	13.6%	5.7%	7.8%
1st ranked response – environmental share	8.0%	18.0%	7.8%	10.4%
1st ranked response – forest share (poorest quartile)	13.6%	11.0%	5.0%	5.6%
1st ranked response – environmental share (poorest quartile)	13.6%	11.7%	7.6%	8.0%
Number of 2nd ranked responses	240	1,365	2,390	3,995
2nd ranked response – forest share	5.4%	8.4%	3.4%	5.2%
2nd ranked response – environmental share	6.7%	13.2%	6.9%	9.0%
Number of 3rd ranked responses	117	872	1456	2445
3rd ranked response – forest share	3.4%	5.8%	3.6%	4.4%
3rd ranked response – environmental share	3.4%	10.3%	6.1%	7.5%

Note: Forest and environmental responses to the question: Q. "How did you cope with the income loss or cost?"; R1. "Harvest more forest products" (forest response); R2. "Harvest more wild products, not in the forest" (other environmental response).

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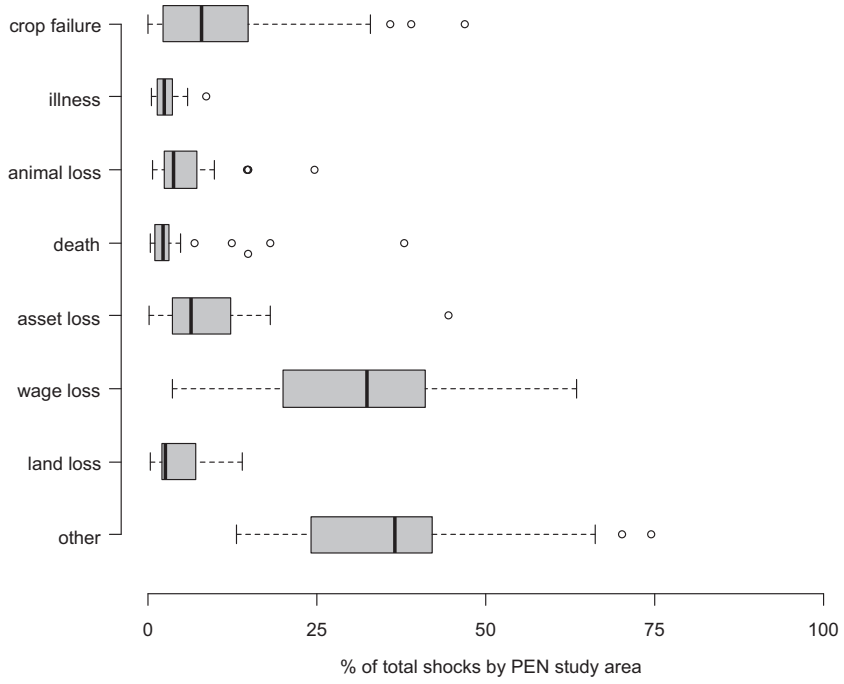

Figure 1. *Types of shocks reported by sample households that reported at least one shock (n = 5,103).*

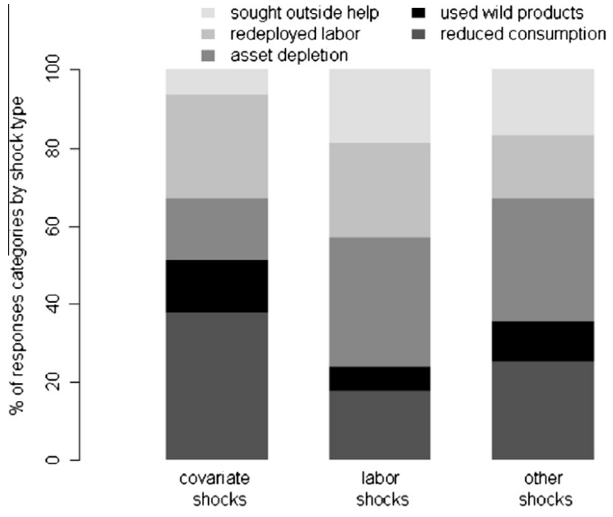

Figure 2. *Coping strategies reported by sample households affected by shocks. Note: We classified shock types as follows: 1. Covariate shocks: Serious crop failure, major livestock loss (theft, drought, etc.), other major asset loss (fire, theft, flood, etc.). 2, Labor (idiosyncratic) shocks: Serious illness in family, death of productive age-group adult. 3. Other (idiosyncratic) shocks: Land loss (expropriation, etc.); lost wage employment; fine from environmental regulation agency; delays in receiving payments; other shocks.*

quartile, a slightly lower share of households than in the total sample ranked both forest extraction and other environmental responses as their first crisis response. This holds for the total sample (5.7% *vs.* 7.8% forest-response share, 8.1% *vs.* 10.4% total environmental-response share), as well as the African and Asian subsamples; only in Latin America is the ranking the reverse. We will return to welfare-conditioned responses below, focusing on asset poverty.

Yet, the above results only referred to the reported primary shock responses. Environmental resources might still be important in the lower-ranked responses. However, extending the analysis to the second and third ranked responses (Table 1) does not change the picture: actually the share of forest-based and environmental sources in lower-ranked responses is even lower, though default responses also rise.[6]

Finally, Hypothesis 1 also refers to the safety net response that households choose to clear more forestland for crops, for instance when cropland is lost due to fires, diseases, or floods. The PEN questionnaire did not differentiate responses in a way that allows us to isolate this type of reaction. Yet, we do have data for reported forest clearing over both the last 12 months and the last 5 years. We calculated the share of the former in the latter (i.e., expressing whether extraordinarily high forest clearing took place last year), and checked correlation coefficients with the incidence and severity of shocks. For moderate shocks, there is no relation; for severe shocks, there is a weakly significant positive coefficient. In principle, people suffering severe shocks might have cleared somewhat more forest than usual. However, this cursory examination must be supplemented by a more comprehensive test of the shock variables within a proper forest-clearing model (see Babigumira, Angelsen, Buis, Bauch, Sunderland, & Wunder, 2013, this volume).

4. WHO USES FOREST COPING STRATEGIES?

We already saw some evidence from the descriptive statistics supporting Hypothesis 2 that forest harvesting is more likely to be a response option for covariate shocks. Hypothesis 3 can be viewed as a conjecture that statistically significant differences exist in households' use of environmental resources as safety nets, with respect to differences in spatial, demographic, and socioeconomic features of the household. Both notions will be further tested in this section, using multivariate analysis. As we saw in the previous section, forests and other

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environmental resources are not primary safety nets in our global sample, but for the minority of households with forest extraction as the primary response, which special scenarios dominate?

To shed light on this question, we use all shocks (moderate and severe), and focus as above on households' first-ranked responses.[7] To identify and measure the importance of household- and village-level contextual factors, we employ a hierarchical regression model. We used a binary dependent variable, taking the value "one" if the household used forests or other environmental sources as their primary safety-net response, and "zero" otherwise. The hierarchical model introduces random intercept terms at the village level. This is similar to village-level dummy variables, but adjusts village-level intercepts for the number of observations in each village (Gelman & Hill, 2007). It also accounts for potentially correlated residuals at the village level, and is thus the most adequate for our purposes.

Given the large data set, we are able to incorporate a comprehensive set of relevant control variables, from those highlighted in the shock literature review of Section 2 broader factors pointed to in the livelihoods literature. This includes not only household-specific characteristics, but also village-level variables, in recognition that responses in a large global-comparative dataset like ours are likely to be locally conditioned by social, institutional, and collective contexts. Table 2 lists the variables used, their mean, standard variation, and expected sign in the regression (see below for discussion). We use variables for shock types (dummies for covariate, labor, and severity), household demographics (size, head's age, sex, and ethnicity), assets (education, cropland, physical and monetary asset values, and as an innovative measure, social capital), and location (distance to forest). We include village-level variables, such as distance to markets, presence of infrastructure (health center, formal, and informal credit institutions), and forest resource base (products affected by degradation) and land tenure (share of private land).

Finally, we also test for the importance of village-level forest specialization, in terms of size of forest income, the share of timber in it, and the diversity of forest products in the other households we interviewed locally (random village sample). That is, we aggregate all respective village income data except for household *i*, so that problems of endogeneity caused by the shock are avoided, especially in smaller village samples. This is a model specification that has been used in the nutrition literature (e.g., Alderman & Garcia, 1993; Sahn, van Frausum, & Shively, 1994). We can thus interpret this household-specific customized village aggregation as a "neighbor" variable.

Table 3 reports results for our multivariate regression model. Column 1 shows the variable names, subgroups, and aggregation levels, columns 2–4 report the estimated coefficients with standard errors and significance levels, column 5 displays

Table 2. *Shock responses: descriptive statistics for dependent and potentially explanatory variables*

	Unit	Mean	Standard deviation	Expected sign
0. Dependent variable				
Forest use after shock	Yes (1)/no (0)	0.1	0.3	
I. Household level				
(a) Shock type				
Covariate shock	Yes/no	0.5	0.5	+
Labor shock	Yes/no	0.4	0.5	−
Shock severity	0 = moderate, 1 = severe	0.3	0.5	+
(b) Demographics				
Age of household head	Years	45.9	14.4	−
Household size	Number	6.4	3.4	+
Female-headed household	Yes/no	0.1	0.3	−
Member of major ethnic group	Yes/no	0.7	0.5	+/−
(c) Assets				
Education of household head	Years	4.0	4.1	−
Asset value per capita	USD PPP	199.2	1154.5	−
Social capital (trust in village members)	Yes/no	0.5	0.5	−
Cropland	ha	2.8	6.1	−
(d) Forest income type and composition				
Forest income share (neighbors)	Share	0.2	0.1	+
Share of timber in forest income (neighbors)	Share	0.1	0.1	+/−
Forest income diversity (neighbors)	Index	0.4	0.2	+
(e) Location				
Household distance to forest	Min	33.2	44.0	+
II. Village				
Village distance to district center	Min	97.6	112.2	+
(f) Physical, social infrastructure				
Health center	Yes/no	0.3	0.5	−
Informal credit access	Yes/no	0.5	0.5	−
Formal credit access	Share of village members	0.2	0.3	−
(g) Forest resource base & land access				
Number of forest products affected by degradation	Number	2.4	1.7	−
Share of private land	Share	0.1	0.3	−

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Table 3. *Household primary shock responses: regression results (dependent variable: "household used more environmental resources after a shock—yes = 1; no = 0")*

	Coefficient	SE		Expected sign	Evaluation[a]
I. Household-level variables					
(a) Shock type					
Covariate shock	0.7	0.2	***	+	Yes
Labor shock	−0.2	0.3		−	n.s.
Shock severity	0.02	0.2		+	n.s.
(b) Demographics					
Age of household head	−0.1	0.1		−	n.s.
Household size	−0.2	0.2		+	n.s.
Female-headed household	−0.02	0.2		−	n.s.
Member of major ethnic group	0.1	0.2		+/−	n.s.
(c) Assets					
Education of household head	−0.6	0.2	***	−	Yes
Asset value per capita	−2.1	0.9	**	−	Yes
Asset value per capita (squared)	9.6	4.8	**	n.a.	n.a.
Cropland	−0.9	0.4	**	−	Yes
Social capital (trust in village members)	−0.4	0.2	***	−	Yes
(d) Forest income type and composition					
Forest income share (neighbors)	0.8	0.2	***	+	Yes
Share of timber in forest income (neighbors)	0.7	0.8	***	+/−	n.a.
Forest income diversity (neighbors)	0.9	0.3	***	+	Yes
(e) Location					
Household distance to forest	0.1	0.2		−	n.s.
II. Village-level variables					
Village distance to district center	−0.4	0.2	*	+	No
(f) Physical, social infrastructure					
Health center (dummy)	−0.03	0.3		−	n.s.
Informal credit access (% of households)	0.3	0.3		−	n.s.
Formal credit access (% of households)	−0.1	0.3		−	n.s.
(g) Forest resource base and land access					
Forest products affected by degradation	0.04	0.3		−	n.s
Share of private land	0.1	0.3		−	n.s.
Intercept	−2.9	0.2	***	n.a.	n.a.
	Variance	Std. Dev			
Village (random) intercept	1.5	1.2			
Log-likelihood		−957			
Deviance		1,913			
AIC		1,642			
Households		3,379			
Villages		253			

Notes: n.a. – not available; n.s. – not significant.
Shocks: 5,157.
[a] Evaluation of estimated *versus* expected sign.
* Significance level: $p < 0.1$.
** Significance level: $p < 0.05$.
*** Significance level: $p < 0.01$.

expected signs for hypothesized relationships, and column 6 evaluates whether these expectations were met.

(a) *Household shock types*

Results suggest that households reporting covariate shocks were more likely to use the forest and other wildlands (positive, significant coefficient), as we had expected in Hypothesis 2. The estimated signs for labor shocks (negative) and shock severity (positive) are also as expected, but insignificant.

(b) *Household demographics*

Under Hypothesis 3, we expected younger households to engage in more forest-coping. Also, we thought female-headed households would turn less to physically demanding forest extraction. We also suspect that households belonging to ethnically dominant groups might have privileged access to forests that are often managed as common-pool resources. Indeed, for all three coefficients we estimate the expected signs, but all were insignificant. We hypothesized that larger households with more labor available would use forests more often.

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The estimated sign is opposite, but also not significantly different from zero. Hence, none of the demographic variables proved to be significant for household decisions.

(c) *Household assets*

Hypothesis 3 maintains that asset poverty goes hand-in-hand with more forest-coping, as people with few assets lack access to other response options.[8] Our results strongly confirm this notion. This is definitely true for human capital (higher education of household heads strongly reduces forest-based responses) and for landholdings (the amount of cropland owned by the household has a strong negative correlation with forest-extractive responses). Physical assets (total per-capita value) yield the expected negative sign, but a positively significant quadratic estimate points to non-linearities: forest-based responses increase again at high asset values. This could tentatively be explained by certain minimal capital requirements for access to higher-value forest products, especially timber.

Finally, and going beyond the factors considered in the literature (Section 2), we also include a measure of social capital (degree of trust in village members), the expectation being that households endowed with low social capital face restricted access to village-level social and economic networks that can provide collectively based safety nets, thus leaving extraction from forests and wildlands as a more likely default option. Our results seem to confirm this expectation: less trusting households are more likely to go to the forest after a shock (coefficient highly significant).

(d) *Forest income size and composition among neighbors*

Although not previously considered in the literature, we believe that in comparing shock responses among multiple locations, the local patterns of previous specialization must matter, in that extractive responses are bound to become more likely:

(a) the higher existing forest extractive incomes in the village (e.g., sufficient commercialization networks being in place to augment production),

(b) the higher (lower) the share of timber in these forest extractive incomes is in the village (opposed expectations here reflecting the debate between NTFP and timber enthusiasts; Section 2), and

(c) the higher is forest income diversity (i.e., with many products being collected, raising the flexibility (especially) subsistence-based responses).

We do not have total village income aggregates for these variables, but the survey sample, which was randomly selected within villages, should be fairly representative in most cases. As mentioned, we exclude the household proper in the aggregation, to avoid endogeneity problems, especially in smaller villages with small samples.

For both (a) and (c), we find the expected signs: higher extractive income and high diversity in its sources favor forest-based responses. For (b), we find a positive estimate: forest specialization on timber gives higher probability of extractive shock responses than do NTFPs (perhaps reflecting the greater ability of timber to generate cash needed). All three variables are strongly significant, indicating the importance of pre-established production patterns.

(e) *Spatial variables*

We expected greater distance from households' home to forest to decrease their ease of access to forest-coping options. The estimated coefficient is positive, but insignificant. We also expected greater distance to the market (measured at the village level) to have a positive correlation with forest extraction. In fact, we find the opposite sign for the market-remoteness correlation, though also insignificant. The two results indicate that household and village location are less important than expected for forest-coping strategies.

(f) *Village infrastructure*

We also look at the potential impact of various village-level, collectively defined contextual variables. For instance, village-level access to formal or informal credit might enable risk sharing and reduce the need for forest-based coping strategies. Presence of a village health center might possibly also reduce forest coping needs by abbreviating healthcare needs. For formal credit and health center access, we find the expected negative sign (for informal credit, an unexpected positive coefficient). However, all estimated coefficients are not significantly different from zero, indicating that the impact of village infrastructure on forest-based coping strategies is limited.

(g) *Village forest-resource base and land access*

First, we would expect a good forest resource base to contribute to a greater likelihood of forest-based safety nets. For forest quality, we use the reported decline in the availability of the most important local forest product as an inverted indicator of the progression in natural degradation. Second, we would expect forest-coping responses to be used more when the land tenure facilitates collective access rights (community and some state lands). We use the share of private lands as an inverse indicator. Both coefficients have an unexpected positive sign, and are insignificant.

Finally, we observe that our inclusive approach of testing many potential explanatory variables has some costs. Some of the variables included have many missing values, so that our total number of shocks in the regression is reduced to 5,157, from 7,962 total shocks (Table 1). Moreover, the missing values filter out most shocks in Latin America, which already had the smallest sample, thus exacerbating sample biases. We thus decided to run some extra regressions to test for the stability of significance, consecutively taking out the three most frequently missing variables: "private land share," "cropland," and "trust." In combination, this brings the shock sample size back to 5,966 (16% higher), corresponding to 3,917 shock-affected households. In the model without the three excluded variables, the squared asset value becomes insignificant (the linear coefficient remains significant), whereas two previously insignificant variables (household size, informal credit) both become weakly significant with positive sign. This reveals that most results are stable, but does nevertheless reveal some sensitivity vis-à-vis variations in the tested sample and in model specification.

To sum up, our multilateral results for the household and village determinants of the likelihood of extractive responses to shocks gave us some clear directions. Household demographics, location, village physical and social infrastructure, as well as forest quality and tenure conditions all contributed notably little to our explanations of household shock responses. Conversely, household asset holding (physical, human, and social) are highly significant, although in the first case in a non-linear way. In the same vein, a previous village specialization on forest production, preferably with a variety of products, but in particular a high timber share, are patterns that are highly conducive to making extraction from forest and wildlands more relevant to households' responses to

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shock, especially covariate ones, than would appear from the low average response share alone.

5. RESPONSES TO SEASONAL FLUCTUATION

The PEN questionnaire did not contain explicit questions about how households perceived and responded to seasonal income shortages, so we do not have data regarding stated gap-filling needs and responses. However, we do have quarterly household income data, recorded meticulously from different sources. If Hypothesis 4, regarding forest-based gap-filling were to hold, we would necessarily need to see a seasonal profile of forest income (the alleged gap filler) that is countercyclical to that of non-forest income (the gap-creating income stream), i.e., a negative correlation between the two. Figure 3 displays case-specific Pearson correlation coefficients, computed between quarterly non-forest income and quarterly forest income for the 35 cases studies, and their confidence intervals.

The results do not provide broad support for the conjecture that forests serve as seasonal gap fillers. We find a negative seasonal correlation between the forest and non-forest income components in only 11 out of 35 cases, and in only four cases are these statistically significant (cases from Bangladesh, Indonesia, Ethiopia, and Vietnam). Furthermore, the magnitude of these exceptional negative coefficients was on average lower than for the corresponding positive ones. 10 of the 24 positive coefficients were significant (cases from Bangladesh, Brazil, Burkina Faso, Congo DR, Ecuador, India, Ghana, Nigeria, Uganda, and Zambia). Basically, forest incomes exhibit a predominantly pro-cyclical seasonal profile, tending to rise and fall with non-forest household incomes, which make them inadequate as gap fillers.

This conclusion does not change substantially if one looks at crop income instead of non-forest income, i.e., as an alternative seasonality comparator with forest income (Figure 4). Only two of 35 cases show a significant negative correlation between seasonal crop and forest incomes, as compared to nine cases with a significant positive correlation. This pattern leads us to reject the notion that forest incomes are most important between crop harvests.

So, how do people alternatively fill seasonal gaps? Looking at the shock responses from previous sections, wage income might emerge as a likely source, given that reallocation of labor to off-farm work also figured prominently as a safety net. Figure 5 shows the corresponding patterns of correlation between quarterly crop income and quarterly wage income. This income profile is more consistent with a gap-filling pattern: of the 35 coefficients, 27 are negative (seven significantly) and only eight are positive (three significantly).

Our overall results do not preclude the possibility that households use forests as a seasonal gap-filler in specific places with preconditions that favoring the use of forests. Conditions in case study areas differed widely, including with the predominant forest products extracted. Future analyses could look in detail at selected cases with positive and negative correlations, respectively. We also attempted a series of disaggregated specifications sample-wide (e.g., excluding the firewood component, focusing on forest subsistence incomes only), but none of these yielded substantially different results. Hence, the aggregate quantitative picture in our sample indicates that wage labor, possibly complemented by other options, is likely to be a more important seasonal gap filler, on average, than are forests.

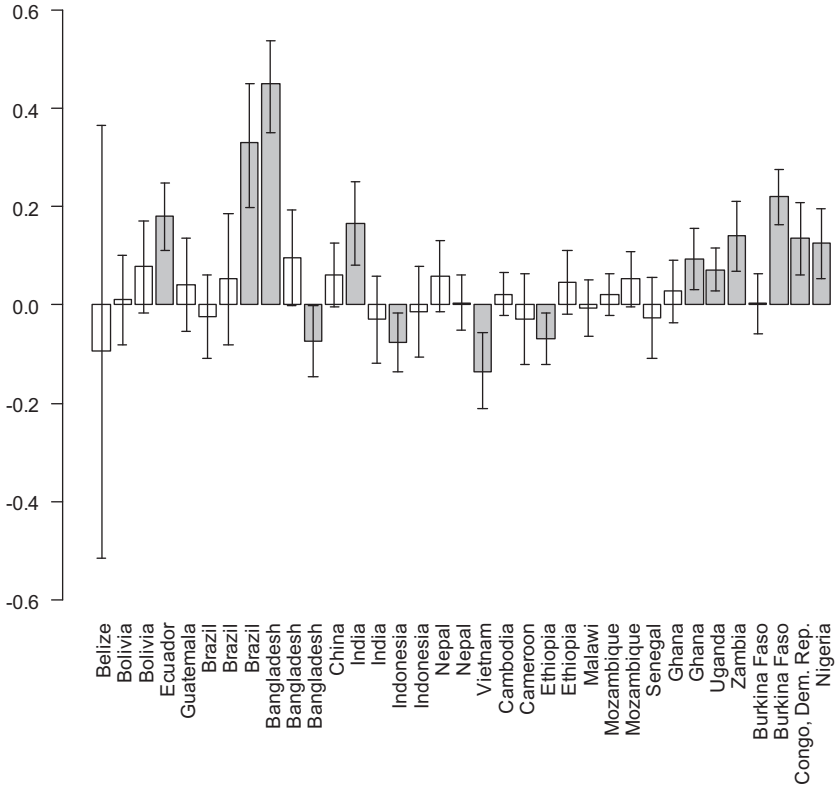

Figure 3. *Seasonal correlation between quarterly forest and non-forest income by PEN study area (multiple study areas in some countries).*

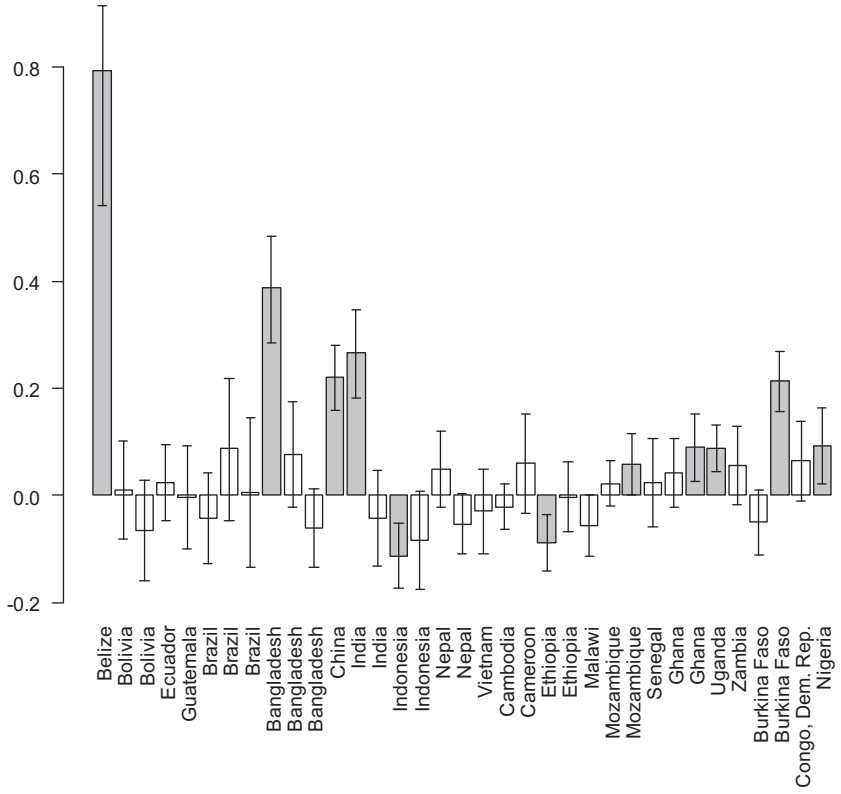

Figure 4. *Seasonal correlation between quarterly forest and crop income by PEN study area (multiple study areas in some countries).*

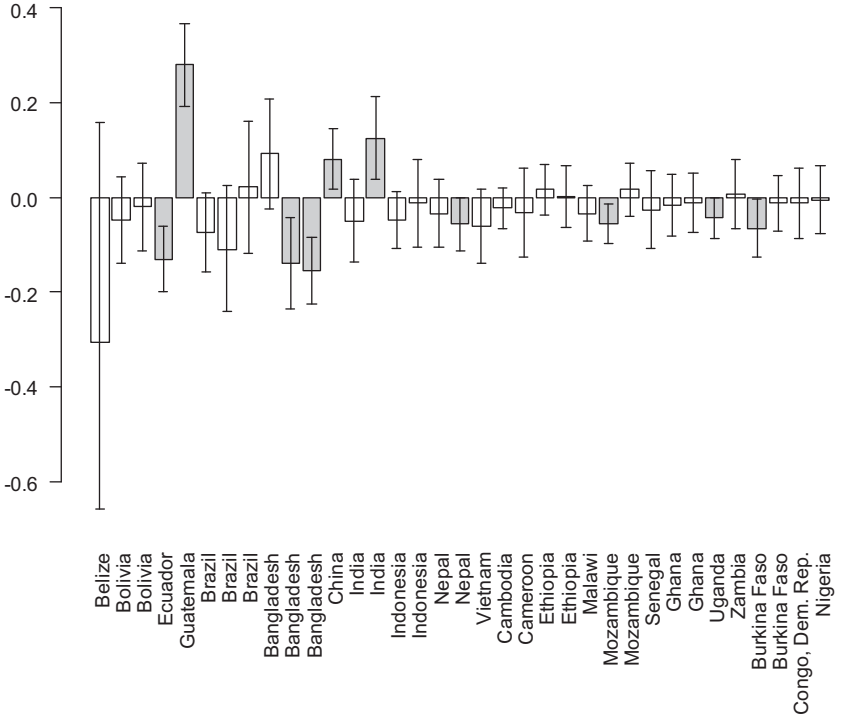

Figure 5. *Seasonal correlation between quarterly wage and crop income by PEN study area (multiple study areas in some countries).*

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6. CONCLUSIONS AND DISCUSSION

(a) *Main findings*

The literature on safety nets, gap-filling, and natural resources draws almost exclusively on individual case studies; comparative work is rare. The current analysis provides a "bigger picture" derived from data across multiple continents, because one might logically expect contextual factors to exercise strong influence over the shock responses utilized by households. Using a multi-country, 8,000+ household survey focused on a broad range of rural livelihoods aspects, we tested four hypotheses:

1. Forests and wildlands are important as safety nets in responses to shocks;
2. Forest-based shock responses differ in relevance across shock types;
3. Household and village characteristics determine which households turn to forests;
4. Forests and wildlands play an important role for seasonal gap-filling.

In testing the first hypothesis, the analysis overturns some conventional wisdom. We find that barely one in ten households reported using an extractivist strategy as the highest ranking response to a shock. Many other options, such as labor reallocation to other sectors, assistance from extra-household sources, asset sales, or reduced consumption all proved more important in the retrospective shock evaluation of respondents.

Second, this pattern differed significantly, as expected in Hypothesis 2, across shock types. Shocks in the PEN sample are largely either covariate crop failures or idiosyncratic illnesses and deaths. For idiosyncratic shocks, people turned to a range of options for seeking outside assistance, with very little additional forest use (6–8%). In the case of covariate shocks this was less feasible; consumption was often reduced, and forest extraction came into play twice as often (14%).

Third, we can describe quite well the particular scenarios where these forest-coping options are preferred by households (Section 4). Not only household, but also village characteristics co-determine these. As expected, forests are more likely to be a preferred coping option for a household when it is hit by a covariate shock, and when that household is poor in various forms of asset holdings—particularly education and land ownership, but also social and physical capital, though the latter only up to a certain point. Note, as we could see from the bivariate correlations (Section 3), that this did not imply that the most income-poor households would turn more to forest extraction in their shock responses.[9] A second, highly significant cluster of explanatory factors relates to pre-established patterns of specializing in forest extraction, especially of timber, but also a sufficient level of forest-income diversification. The latter two factors may at some stage become contradictory (timber specialization *vs.* forest-product diversification), but may still go a long way in complementing each other strategically, including to respond to different types of calamities and the differential needs they trigger (e.g., cash- *vs.* subsistence-based responses). We note that asset holdings and specialization strategies combined can help explaining extractive shock responses; other variable clusters such as demographics, location, infrastructure, and institutional factors played a surprisingly limited role.

Fourth, we do not find much evidence in support of the popular view that forest income serves as a primary seasonal gap filler to make up for intra-annual income shortfalls, e.g., in agricultural off-seasons. Quarterly forest income is in the majority of cases *positively* correlated with both total income and crop income, which excludes it from being a gap-filler. Rather, wage income exhibits a negative correlation with crop income, implying that households between harvests are more likely to seek temporary employment than to exploit forests.

What general picture does this provide regarding the emergency functions of forests? Our findings fit well with the view held in part of the literature that forests and other wildlands are "options of last resort", which people only select as their primary safety net response when shocks are particularly severe and when, due to adverse household and village conditioning factors, they do not have any easier way out.

The livelihoods analysis of PEN data in this volume (Angelsen, Jagger, Babigumira, Belcher, Hogarth, *et al.*, 2013) found that forests contribute more to regular household incomes than is often recognized, and thus to some extent come to function as what has been called "the supermarket of the wild" (Cavendish, 2000: 1980). Why is the corresponding "insurance company of the wild" thus apparently much less in demand? Our results raise implicit but fundamental doubts as to how much value can be extracted from most forests on a short-term basis in response to an emergency. There may be substantial seasonal constraints (marked harvesting seasons for some NTFPs, restricted transport access for timber extraction in wet seasons, etc.). It may also be that high-value forest rents have already widely been extracted (see below). This is particularly important when safety-net functions are nowadays much more closely tied to cash than to subsistence uses—a possibility that seems worthy of future research. Finally, the typically high labor intensity of forest extraction may be an obstacle when shocks directly affect the workforce of households.

(b) *Discussion*

The results of this study challenge conventional wisdom about the role of forests in mitigating shocks and income shortages. Could there be additional reasons why our findings differ from the picture that most existing case studies portray?

First, we should self-critically consider possible limitations in our survey method. The questionnaire asked about multiple livelihood aspects, which is needed to describe the shock context, but does not provide in-depth understanding of crisis events and responses. This limitation could be particularly important with respect to understanding the role of forests as secondary or tertiary shock response options, where responses display some signs of respondent fatigue in a long questionnaire, and where one cannot exclude the possibility that the role of forests was underestimated. There may also be reluctance in admitting to forest responses in those cases where it is entirely illegal to access the forest.[10] Finally, respondents' annual recall of shock responses might sometimes give inaccuracies: if they already extract forest goods daily, doing more of that might be harder to recall than doing something discretely different (e.g., borrowing money from a relative). Cross-checks with *in situ* observations might shed more light on that.[11] Further analysis of these data with respect to *de facto* inter-quarter responses of households to observed income shortfalls may further complement the picture about the shock responses in our sample. Similarly, for our gap-filling analysis the pooling of seasons into uniform three-month quarters could sometimes mask seasonal shortfalls that were either longer or (especially) shorter than that.[12] This problem could only be remedied by constructing case-by-case calendars of customized shortfall periods for each study case.

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Second, various sample considerations apply. As mentioned, the PEN sample did not include any observations of major, catastrophic shocks. Could it be that the observed shocks were not severe enough to produce the circumstances in which forests might matter the most? We do find econometrically that forest use increases marginally with shock severity, but that the relationship is not statistically significant. In other words, we cannot entirely exclude this possibility, but also do not find strong empirical *a priori* indications in our data that would strengthen this suspicion. Conversely, PEN also somewhat oversamples sites in close proximity to rich forests, compared to an average rural developing country setting. Given that forest-product specialization is found to be positively correlated with forest coping in our data, any underlying bias in favor of forest use should actually pull our conclusions in the pro-forest use direction. However, we underscore that many of the case studies in the literature are focused even more than our data on forest-rich, indigenous people settings, so they may be even further away from a "rural developing country norm." The fact that their forest shock responses are more prominent should on these grounds not surprise.

Third, the vast majority of case studies that confirmed forests' safety-net role focused entirely on forests in the first place, without considering the importance of other responses. In other words, if you ask households if they went more into the forest after a shock, they may confirm that—but they may also have done half a dozen of other things that proved more important in coping, but which pass unnoticed. Note also that many of the case studies that populate the literature were primarily interested in the environmental impacts on forests. If 10% of shock responses imply increased forest product extraction, this may be enough to generate environmental stress, even if the livelihood impacts—often not analyzed in depth in these studies—could be much more limited.

Finally, we should not underestimate the possibility that the world has changed in important ways since some of the above-cited case studies were published. Rural labor markets in many parts of the world have become more developed, and thereby opened up new options in times of hardship. Development and emergency aid institutions may have a larger presence, and may provide some safety-net functions when shocks occur. Previously rich forest resources may now already have been stripped for their greatest riches (e.g., highly-valued timber species), so that their ability to supply emergency cash is reduced. And a generally higher reliance on the market economy, on average, may increase households' focus on cash needs.

What does all this mean for our understanding of the role of forests and wildlands in mitigating shocks, and what are the policy implications? Patterns suggest that forest extraction is but one of the many responses used to respond to income shortfalls, especially for the most asset-poor households that live near forests. At the same time, forests also appear to play a relatively small role as seasonal income gap fillers. Yet, as we saw in the first article of this issue (Angelsen *et al.*, 2013), forests and other wildlands contribute more than expected to regular income generation. This finding also seems important for adaptation to climate change, which will likely increase the frequency and severity of economic shocks: forests are perhaps less important than often believed in responding to accelerating shocks, but more so as sources of regular livelihoods contributions.

Rather than presuming that forests always have important safety-net and gap-filling functions, careful case-by-case analysis will probably be needed to understand what kinds of shocks trigger specific local reactions, and how prominently forests figure comparatively in the equation. For instance, it may be the case that cash needs are more important than access to a wide range of subsistence products. Finally, maybe extractive safety-net functions are most important to the most asset-poor strata of the population, in sites where other safety-net functions remain unavailable or underdeveloped, so that forests genuinely become emergency responses of the last resort.

NOTES

1. For additional information on PEN, see Angelsen *et al.* (2013, this issue), and http://www.cifor.cgiar.org/pen.

2. We deliberately excluded areas where no forest at all is present, as well as areas that are completely forest covered, e.g., dominated by indigenous hunter-gatherers. We were thus interested in the wide-ranging middle ground of some type of forest-agriculture mosaic. See Angelsen *et al.* (2013) in this issue for further details about the PEN dataset.

3. Both shock categories and response options were pre-identified in pilot tests of the PEN questionnaire in different countries.

4. Cross-checking household responses regarding shock severity with village-level information and PEN partner assessment in the narratives revealed that the terms "moderate" and "severe" were not interpreted entirely homogeneously across the global sample of households, with probably some cultural cross-country differences also being at work. The limitation in our data here is that we are not trying to quantify the degree of income loss caused by each shock.

5. The PEN questionnaire was not designed so as to enable a watertight distinction between covariate and idiosyncratic shocks, but at least we can make some qualified approximations. Looking at all shocks at the village level (incl. using weights for multiple shocks per household), we observe that the covariate shock types affected 34% of interviewed households (who thus faced the same shock type over the last 12 months), as opposed to 27% for labor shocks and 9.82 less for the other two idiosyncratic shock types. Given that among labor shocks (deaths, illnesses), many will naturally occur in various households also without any common cause, we can say that this pattern is quite consistent with our classification, in that what we label as covariate shocks are indeed occurring more concentrated in the same villages, as compared to idiosyncratic shocks.

6. Generally, the numbers of non-blank responses goes down continuously for the second- and third-ranked responses (Table 1). Additionally, among the valid responses, the default option "did nothing in particular" gains a much higher value. The proportion among the rest of responses remains fairly constant across the three shock types. It thus seems adequate to restrict the analysis to the first-ranked response.

7. Running the model for subgroups of shocks, i.e., only moderate or only severe shocks, does not lead to changes in results, so we opted for the most inclusive response variable so as not to sacrifice any information.

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8. We cannot test here for the impact of households' income poverty, since we only have data for income during the same year were the shock occurred, leading to potential problems of endogeneity in the multivariate analysis.

9. Several factors might help explaining this apparent paradox between the results for income-poverty in Section 3 and asset poverty in Section 4. First, the poverty ranking of households according to asset and income criteria may differ substantially. Second, the relationship is non-linear for physical assets. Third, the endogeneity problems with incomes directly being affected by shocks may be larger than for assets, though asset losses may also be a direct consequence of some shocks. Fourth, the analysis in Section 4 controls for multiple other explanatory factors; the bivariate correlations in Section 3 do not.

10. We do believe though that the illegality problem is more important for the case of our detailed quarterly forest income recording, where the single products and quantities have to be specified (Angelsen *et al.*, 2013). Giving the more abstract response "extracted more from the forest" is much less likely to be seen by households as sensitive.

11. In principle, this approach is similar to the one we adopted in the seasonal gap-filling section.

12. For instance, within the three 3-month recall period, households may rely heavily on forest products for two 2 months—just before the harvest— while in the month they harvest their crops. This could show up as forest and crop income being highly correlated, but conceal a within-quarter shifting dominance of the two respective sources.

REFERENCES

Alderman, H., & Garcia, M. (1993). *Poverty, household food security and nutrition in Rural Pakistan*. Research Report 96. Washington, DC: The International Food Policy Research Institute.

Alderman, H., & Paxson, C. H. (1992). *Do the poor insure? A synthesis of the literature on risk and consumption in developing countries*. Policy Research Working Papers WPS 1008. World Bank, Agriculture and Rural Development Department.

Almeida, M. 1996. Household Extractive Economies. In M.R. Perez, & J. E. M. Arnold (Eds.), *Current issues in non-timber forest products research*, 119-42. Bogor, Indonesia: CIFOR.

Anderson, A. B., May, P. H., & Balick, M. J. (1991). *The subsidy from nature: Palm forests, peasantry, and development on an Amazon frontier*. New York: Columbia University Press.

Angelsen, A., & Wunder, S. (2003). *Exploring the forest-poverty link: Key concepts, issues and research implications*. CIFOR Occasional Paper 40. Bogor: Center for International Forestry Research.

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N., Bauch, S., *et al.* (2013). *Environmental income and rural livelihoods: A global-comparative analysis* (this special issue).

Angelsen, A., Larsen, H. O., Lund, J. F., Smith-Hall, C., & Wunder, S. (2011). *Measuring livelihoods and environmental dependence: Methods for research and fieldwork*. London: Earthscan, p. 263.

Babigumira, Angelsen, R. A., Buis, M., Bauch, S., Sunderland, T., & Wunder, S. (2013). *Forest clearing in rural livelihoods: Household-level global-comparative evidence* (this special issue).

Barham, B. L., Coomes, O. T., & Takasaki, Y. W. (1999). Rain forest livelihoods: Income generation, household wealth and forest use. *Unasylva, 50*, 34–42.

Beegle, K., Dehejia, R. H., & Gatti, R. (2006). Child labor and agricultural shocks. *Journal of Development Economics, 81*, 80–96.

Binswanger, H., & McIntire, J. (1987). Behavioral and material determinants of production relations in land-abundant tropical agriculture. *Economic Development and Cultural Change, 36*(1), 73–99.

Byron, N., & Arnold, M. (1999). What futures for the people of tropical forests?. *World Development, 27*(5), 789–805.

Campbell-Platt, G. (1980). African locust bean (*Parkia* spp.) and the fermented food product dawadawa. *Ecology of Food and Nutrition, 9*(2), 123–132.

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

Chambers, R., & Leach, M. (1989). Trees as savings and security for the rural poor. *World Development, 17*(3), 329–342.

Coate, S., & Ravallion, M. (1993). Reciprocity without commitment: Characterization and performance of informal insurance arrangements. *Journal of Development Economics, 40*(1), 1–24.

de Beer, J. H., & McDermott, M. J. (1996). *The economic value of non-timber forest products in Southeast Asia* (2nd ed.). Amsterdam: IUCN.

Deaton, A. (1997). *The analysis of household surveys: A microeconometric approach to development policy*. Baltimore, MD: Johns Hopkins University Press.

Debela, B. L., Shively, G., Angelsen, A., & Wik, M. (2012). Economic shocks, diversification and forest use in Uganda. *Land Economics, 88*(1), 139–154.

Dercon, S. (1998). Wealth, risk and activity choice: Cattle in Western Tanzania'. *Journal of Development Economics, 55*(1), 1–42.

Dercon, S. (2000). Income risk, coping strategies and safety nets. In *Background paper for the World Development Report 2000/01*. Washington, DC: The World Bank.

Dercon, S. (2005). Risk, insurance and poverty: A review. In S. Dercon (Ed.), *Insurance against poverty*. Oxford: Oxford Univ. Press.

Ellis, F. (1998). Household strategies and rural livelihood diversification. *Journal of Development Studies, 35*(1), 1–38.

Falconer, J. (1990). The major significance of minor forest products – Examples from West Africa. *Appropriate Technology, 17*(3), 13–16.

Falconer, J. (1992). *Non-timber forest products in Southern Ghana: A summary report*. London.

Falconer, J., & Arnold, J. E. M. (1989). *Household food security and forestry: An analysis of socioeeonomic issues*. Rome: FAO.

Fisher, M., Chaudhury, M., & McCuske, B. (2010). Do forests help rural households adapt to climate variability? Evidence from Southern Malawi. *World Development, 38*(9), 1241–1250.

Fisher, M., & Shively, G. (2005). Can income programs reduce tropical forest pressure? Income shocks and forest use in Malawi. *World Development, 33*(7), 1115–1128.

Fisher, M., & Shively, G. (2007). Agricultural subsidies and forest pressure in Malawi's Miombo Woodlands. *Journal of Agricultural and Resource Economics, 32*(2), 349–362.

Foster, A. (1988). *Why things fall apart: A strategic analysis of repeated interaction in rural financial markets*, Mimeo. Department of Economics, University of California at Berkeley, Berkeley, CA.

Gelman, A., & Hill, J. (2007). *Data analysis using regression and multilevell hierarchical models*. Cambridge: Cambridge University Press.

Godoy, R., Jacobson, M., & Wilkie, D. (1998). Strategies of rain-forest dwellers against misfortunes: The Tsimane' Indians of Bolivia. *Ethnology, 37*, 55–69.

Godoy, R., Wilkie, D., Overman, H., Cubas, A., Cubas, G., Demmer, J., *et al.* (2000). Valuation of consumption and sale of forest goods from a Central American Rain Forest. *Nature, 406*, 62–63.

Gunatilake, H. M., Senaratine, D. M. A. H., & Abeygunawardena, P. (1993). Role of nontimber forest products in the economy of peripheral communities of Knuckles National Wilderness Area of Sri Lanka. *Economic Botany, 47*(3), 275–281.

Hecht, S. B., Anderson, A., & May, P. (1988). the subsidy from nature: Shifting cultivation, successional palm forests and rural development. *Human Organization, 47*(1), 25–35.

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Hegde, R., & Bull, G. (2008). Economic shocks and Miombo Woodland resource use: A household level study in Mozambique. In: P. A. Dewees (Ed.), *Managing the Miombo Woodlands of Southern Africa. Technical Annex 4*. Washington, DC: The World Bank.

Hoogeveen, H. (2003). Evidence of informal insurance in rural Zimbabwe. *Journal of African Economies, 11*(2), 249–278.

Kant, S., Nautiyal, J. C., & Berry, R. A. (1996). Forests and economic welfare. *Journal of Economic Studies, 23*(2), 31–43.

Khundi, F., Jagger, P., Shively, G., & Sserunkuuma, D. (2011). Income, poverty and charcoal production in Western Uganda. *Forest Policy and Economics, 13*(3), 199–205.

Liswanti, N., Sheil, D., Basuki, I., Padmanaba, M., & Mulcahy, G. (2011). Falling back on forests: How forest-dwelling people cope with catastrophe in a changing landscape. *International Forestry Review, 13*(4), 442–455.

McSweeney, K. (2004). Forest product sale as natural insurance: The effects of household characteristics and the nature of shock in Eastern Honduras. *Society and Natural Resources, 17*(1), 39–56.

Morduch, J. (1995). Income smoothing and consumption smoothing. *Journal of Economic Perspectives, 9*(3), 103–114.

Neumann, R. P., & Hirsch, E. (2000). *Commercialization of non-timber forest products: Review and analysis of research*. Bogor, Indonesia: Center for International Forestry Research.

Ogle, B. (1996). People's dependency on forests for food security. In M. R. Perez, & J. E. M. Arnold (Eds.), *Current issues in non-timber forest products research*, 219-42. Bogor, Indonesia: CIFOR.

Pattanayak, S. K., & Sills, E. O. (2001). Do tropical forests provide natural insurance? The microeconomics of non-timber forest product collection in the Brazilian Amazon. *Land Economics, 77*(4), 595–612.

Perz, S. G. (2001). Household demographic factors as life cycle determinants of land use in the Amazon. *Population Research and Policy Review, 20*, 159–186.

Reardon, T., Delgado, C., & Matlon, P. (1992). Determinants and effects of income diversification amongst farm households in Burkina Faso. *Journal of Development Studies, 28*(2), 264–296.

Rosenzweig, M. R., & Binswanger, H. P. (1993). Wealth, weather risk, and the composition and profitability of agricultural investments. *The Economic Journal, 103*, 56–78.

Rosenzweig, M. R., & Wolpin, K. I. (1993). Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in India. *Journal of Political Economy, 101*(2), 223–244.

Sahn, D. E., van Frausum, Y., & Shively, G. (1994). Modeling the nutritional and distributional effects of taxing export crops. *Economic Development and Cultural Change, 42*(4), 773–793.

Scoones, I., Melnyk, M., & Pretty, J. N. (1992). *The hidden harvest: Wild foods and agricultural systems. A literature review and annotated bibliography*. London.

Shively, G. E. (1997). Poverty, technology, and wildlife hunting in Palawan. *Environmental Conservation, 24*(1), 57–63.

Sunderlin, W. D. (2004). *Community forestry and poverty alleviation in Cambodia, Lao-PDR, and Vietnam: An agenda for research*. Bangkok, Thailand, September 1–2, 2004. (Online) Available at <http://www.adb.org/Documents/Papers/GMS-Forestry/community-forestry.pdf>.

Sunderlin, W. D., Angelsen, A., & Wunder, S. (2003). Forests and poverty alleviation. *State of the World's Forests*, 61–73.

Takasaki, Y., Barham, B. L., & Coomes, O. T. (2004). Risk coping strategies in tropical forests: Floods, illnesses, and resource extraction. *Environment and Development Economics, 9*(2), 203–224.

Towson, I. M. (1994). *Forest products and household incomes: A review and annotated bibliography* Manuscript. Oxford.

Udry, C. (1990). Credit markets in Northern Nigeria: Credit as insurance in a rural economy. *The World Bank Economic Review, 4*(3), 251–269.

Vedeld, P., Angelsen, A., Sjaastad, E., & Berg, G. K. (2004). *Counting on the environment: Forest incomes and the rural poor*. Environmental economics series No. 98. Washington, DC: The World Bank.

Völker, M., & Waibel, H. (2010). Do rural households extract more forest products in times of crisis? Evidence from the mountainous uplands of Vietnam. *Forest Policy and Economics, 12*, 407–414.

Wickramasinghe, A., Ruiz Perez, M., & Blockhus, J. M. (1996). Non-timber forest product gathering in Ritigala Forest (Sri Lanka): Household strategies and community differentiation. *Human Ecology, 24*(4), 493–519.

Wolpin, K. (1982). A new test of the permanent income hypothesis: The impact of weather on the income and consumption of farm households in India. *International Economic Review, 23*(3), 583–594.

Wood, G. (2003). Staying secure, staying poor: The "Faustian Bargain". *World Development, 31*(3), 455–471.

World Bank (2001). *World development report 2000–2001: Attacking poverty*. Oxford and New York: Oxford University Press.