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Health shocks and natural resource extraction: A Cambodian case study

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ABSTRACT

Health shocks are common and have serious consequences for the rural poor in developing countries. In this study, we examine the impact of health shocks of household members on the household's vulnerability to poverty. We also analyze the role of natural resource extraction in dealing with health shocks to smooth household consumption. We use a panel dataset of 550 households in 30 rural villages in Cambodia collected from two survey waves in 2013 and 2014. Our findings reveal that there is a significant association between health shocks and vulnerability to poverty and that the extraction of natural resources is important in consumption smoothing when rural households are faced with health shocks. We suggest that while maintaining natural resource stocks, there is a need to reduce pressures on such resources by developing irrigation systems and non-farm employment sectors.

1. Introduction

Poverty and natural resource degradation remain central development challenges for many developing countries (Aisa et al., 2019). According to the World Bank (WB, 2018), despite recent gains in poverty reduction, the number of people who are living in poverty remains unacceptably high - at 736 million in 2015 - most of whom live in rural areas of developing countries. This raises concerns about achieving the millennial goal of ending poverty by 2030. In the developing world, rural households often struggle with a relatively low and volatile income which in most cases is derived from agriculture and dependent on many factors that are largely beyond their control (Ho et al., 2017). Moreover, this income is often insufficient to support their livelihoods. In these cases, natural resource extraction provides an important source of income and a means of livelihoods for rural households, especially for the rural poor (Chambers and Leach, 1989). It is evident that the poor depends more on such resources (Kabubo-Mariara, 2013; Nguyen et al., 2018a), as they are not capable of accessing other livelihood alternatives. However, these valuable natural resources have been constantly degraded in many rural areas of developing countries (Angelsen et al., 2014), making the poor even more vulnerable to poverty.

At the same time, rural households in the developing world are exposed to a variety of income shocks that can trigger substantial income and consumption fluctuations (Heltberg and Lund, 2009; Thanh and Duong, 2017). This is due to the low shock coping capacity of households and absent or ineffective institutional arrangements to cope with shocks (Dercon, 2004; Nguyen et al., 2020). In particular, health shocks - whether an event of death or disease of a household member - are common and can be one of the main reasons for rural households falling into poverty (Khun and Manderson, 2008). Moreover, households facing health shocks may find themselves permanently impoverished due to the loss of income associated with illness and the cost of treatment (Atake, 2018). Annually, about 100 million people fall into poverty because of health care costs (WB, 2014). Consequently, extraction of natural resources may be intensified when households face health shocks, intensifying the threat to natural resource degradation (Chambers, 1981; Damon et al., 2015). In this context, examining the impact of health shocks on poverty of rural households and the implications for natural resource management are of particular research interest.

Cambodia is a good example for such an examination. It is a poor economy with a low gross domestic product (GDP) per capita, a high poverty incidence and a high level of dependence on natural resources (WB, 2015). The country is home to about 16 million people, of which 79% live in rural areas. The GDP per capita was about 1270 US$ in 2016 (WB, 2017). The proportion of the population under the national poverty line was estimated to be only 14% in 2015 (Asian Development

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Bank (ADB), 2017), but a recent report of the United Nations Development Program (UNDP) indicates that 35% of Cambodians are still living in multidimensional poverty (United Nations Development Program (UNDP, 2018). Cambodia is rich in water and forest resources which are extracted, not only for home consumption, but also for sale (Nguyen et al., 2015). However, these resources have significantly decreased over time (Nhem et al., 2017), further impairing rural livelihoods (Sharma et al., 2016). The national forest cover has declined from 73% in 1990 to 54% in 2015 (World Bank (WB, 2015). The rural health care system is extremely poor (Grundy et al., 2009) and health insurance is nonexistent for most of the rural population (Matsuoka et al., 2010). According to Kenjiro (2005), health shocks not only occur more frequently, but also cause more serious economic damage to rural households than crop failure in Cambodia. Therefore, a deep insight into the empirical relationships between health shocks, rural poverty and natural resource extraction takes on an added significance in the context of rural development and resource conservation in this country.

Against this background, our research aimed to answer two related questions. First, to what extent are health shocks of household members the cause of rural households falling into poverty? Second, what is the role of natural resource extraction in helping these households to cope with health shocks? Answers to these questions have important implications in regard to rural households' vulnerability to poverty and to the importance of maintaining or sustaining natural resources. The answers will also shed some light on policy formulation of future development and resource conservation efforts. Despite the global reliance of millions of people on natural resources for their livelihoods while confronting high levels of illness, little is known about how human health problems affect resource extraction. This is partly due to the lack of data on rural households that cover both health issues and natural resource extraction of household members. We therefore believe our study is a pioneering one in examining this relationship in a developing country context.

The remainder of the article is organised as follows. Section 2 presents the theoretical background for the study and reviews the related literature. Section 3 describes the study design, including the study area, data collection, and data analysis. Section 4 presents and discusses the results. Section 5 concludes.

2. Conceptual framework and literature review

In developing countries, a rural household is considered a basic decision making unit with regard to its production and consumption (Ellis, 2000). Based on its available capital or assets and the socio-economic conditions of the surrounding environment, the household often pursues a wide range of different income generating activities. In this regard, the sustainable livelihoods framework (Ashley and Carney, 1999) is a useful tool to guide our analysis as it takes into account three livelihood components, namely livelihood assets, livelihood strategies, and livelihood outcomes. The livelihood assets include natural capital (e.g. land), physical capital (e.g. tractors), human capital (e.g. labour), financial capital (non-farm earnings) and social capital (e.g. social networking). The livelihood strategies include a portfolio of income generating activities such as farming, natural resource extraction, non-farm self-employment or off-farm wage employment (Nguyen et al., 2017; Do et al., 2019). The livelihood outcomes represent the welfare status of the household in terms of income and consumption that can indicate the poverty status of the household. In other words, the livelihood assets establish the platform for the household to choose its livelihood strategies containing a portfolio of livelihood activities. The undertaking of these activities leads to certain livelihood outcomes as illustrated in Fig. 1.

One of the advantages of using this framework in our study is that it enables us to incorporate health shocks of household members into the linkages between natural resources (as a livelihood asset), their extraction (as a livelihood activity) and poverty (as a livelihood outcome). In the literature, health shocks are defined as a sudden or unexpected deterioration in the state of an individual's health, caused by an illness or injury (Leive and Xu, 2008; Novignon et al., 2012). Health shocks are often unpredictable, have significant effects on welfare and pose a considerable challenge to those individuals and households facing health shocks (Wagstaff, 2007). Even though health shocks are common in both developed and developing countries, the impacts of health shocks are more severe in developing countries because the quality of treatment is lower and the cost of treatment is relatively higher (compared to income), given nonexistent or ineffective health insurance in developing countries (Liu, 2016). This disparity is also present in regard to the poor and the non-poor within a country. Health shocks have both short term and long term effects. In the short term, health shocks of household labourers can directly reduce their income generating capacity leading to income losses. Moreover, health shocks of both household labourers and non-labourers induce considerable treatment costs. This can force the household to cut back expenditure on important consumption items such as nutritious food or education (Genoni, 2012) or to use harmful coping strategies such as selling productive assets (e.g. distress sales of farm land) and using child labour (Ferreira and Schady, 2009; Bandara et al., 2015). The combined effects not only reduce household welfare in the short term, but also undermine the welfare in the long term.

In many rural areas of the developing world, farming and extraction of natural resources are the major livelihood activities (Sjaastad et al., 2005; Nguyen et al., 2018b), as other livelihood alternatives such as non-farm self-employment or off-farm wage employment are either limited or unavailable, especially to the poor (Cavendish, 2000; Vedeld et al., 2007). The products of and income from natural resource extraction not only help to sustain the livelihood of rural households during periods of income shortages (Babigumira et al., 2014), but also act as a safety net against shocks (Wunder et al., 2014; Parvathi and Nguyen, 2018). Research has shown that the effect of health shocks on natural resource extraction seems to be ambiguous. One the one hand, if household labourers become too sick to maintain or earn income from other sources than natural resource extraction, they may also be less able or unable to be involved in natural resource extraction which is labour-intensive. This leads to less extraction due to a significant loss of mobility. As a consequence, access to natural resources can do little to enable their consumption smoothing. One the other hand, health shocks of household labourers can affect discount rates when making tradeoffs over time as shorter life expectancies might alter planning horizons and undermine incentives to conserve. In addition, increased medical costs of both household labourers and non-labourers may also force rural households to extract more (Damon et al., 2015). As reported by Damon et al. (2015), since morbidity and mortality decrease income, households are likely to turn to less sustainable activities. As a consequence, health shocks of household members can lead to a higher level of resource extraction, especially in the case of the common property or *de facto* open access resources (Nguyen et al., 2010).

While these theoretical considerations can be found in the literature, the empirical evidence on the causal linkage between health shocks and natural resource extraction is limited (Damon et al., 2015), and evidence of the linkage with livelihood outcomes is (surprisingly) mixed (Islam and Maitra, 2012; Dalton and LaFave, 2017). Some studies examined the effects of climate shocks on poverty (see Angelsen and Dokken, 2018), but little is known about the effects of health shocks on poverty and on natural resource extraction. Some studies (e.g. Kochar, 1995; Skoufias and Quisumbing, 2005) find that health shocks are fairly well insured. Others, however, (e.g. Asfaw and Braun, 2004; Beegle et al., 2006; Cochrane, 1991; Dercon and Krishnan, 2000; Gertler and Gruber, 2002; Lindelow and Wagstaff, 2007), find that health shocks have a negative and statistically significant effect on consumption and/or income. Obviously, the impacts of health shocks depend on the household's capacity to insure against such shocks, which in turn is related to the health status of household members and

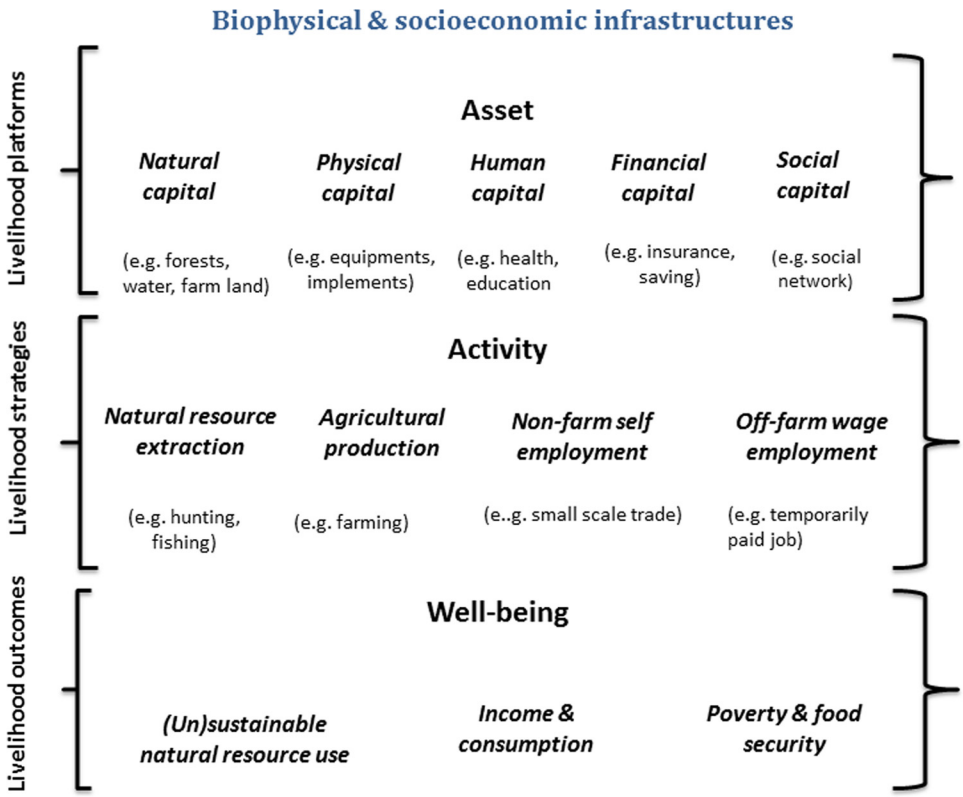

Fig. 1. Conceptual framework for the analysis of livelihoods.
(Source: Ashley and Carney, 1999).

their other livelihood assets.

Our study therefore contributes to the literature in several important aspects. First, this is one of the first studies examining not only the causal relationship between health shocks and poverty, but also the role of natural resources in consumption smoothing of rural households. Second, instead of determining poverty with an absolute threshold value as commonly defined in the literature, we use relative poverty and classify rural households into poor, transient, and non-poor groups. In this way, we are able to provide greater insights into the vulnerability to poverty. Third, our classification of household groups takes into account not only (short term) income but also the (long term) poverty dynamics as we include various types of household assets in poverty measurement. Last, panel data are considered the gold standard of intertemporal behaviour analysis. However, collecting panel data is costly and time consuming, especially panel data of rural households in poor countries. Our study uses a two-year panel dataset of rural households.

3. Data and methods

3.1. Study site and data collection

We collected data for our study in the Stung Treng province of Cambodia (Fig. 2). This province is located in the northeastern part of the country, about 500 km from the capital Phnom Penh. The province has five districts with 129 villages in which around 95,000 inhabitants belong to 17,900 households live (Bühler et al., 2015; Sharma et al., 2016). According to the National Institute of Statistics (National Institute of Statistics (NIS, 2013), this province has a high incidence of poverty with the rural population highly dependent on farming (Ebers et al., 2017) and on extraction of forests and water resources for their livelihood (Nguyen et al., 2018b).

The data collection procedure based on the guidelines of the United Nations Department of Economic and Social Affairs (United Nations (UN, 2005) includes two steps. First, we selected 30 of the 129 villages based on village size measured as the number of households in the village. Second, twenty households of each village were randomly selected. Two survey instruments, namely a household questionnaire and a village questionnaire were employed. The household questionnaire was filled in by the household head or her/his spouse. In cases where the respondents were illiterate, the enumerators helped them to fill in the questionnaires and the recorded data was then verified by the respondents.

The household questionnaire contains different sections on education and employment status of household members, income generating activities and household expenditures (see Nguyen et al., 2018b for more detail on data collection). A separate section of the questionnaire is on the health status of each household member in which information on illness, disease, injury or death, cost and time for treatment and the income loss due to each health shock event are recorded. In addition, respondents were requested to report other shock events such as crop pests, livestock diseases, droughts and floods in terms of time of occurrence and income loss. The reference period is one year (the past 12 months). For each shock event, the respondent was requested to evaluate if the shock was of low, medium or high intensity. Low severity means that there is no or negligible income loss and/or treatment cost. This includes, for example, a fever or a headache. Medium and high severity means there are non-negligible income loss and treatment cost. To avoid the subjective assessment of the respondent, this evaluation was first checked with the information on income loss and cost of treatment. Then we excluded the reported shock events that were of low severity.

A further subsection of the questionnaire is on the extraction of natural resources (e.g. fishing, hunting and collecting non-timber forest products, and logging). These income-generating activities were recorded along with information on extracted products, distances from home to the extracting grounds and to markets, intensity of extraction, cost of extraction and the quantity and revenue of total outputs. All

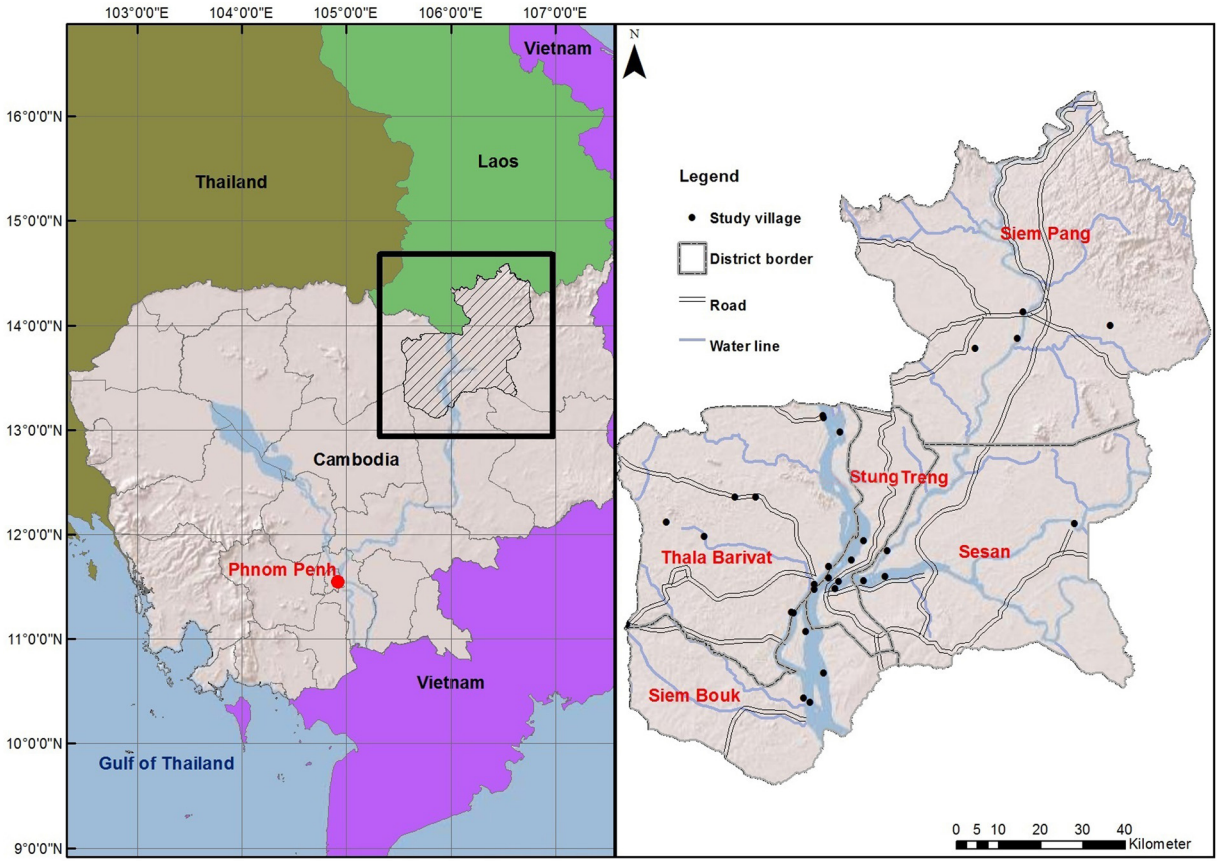

Fig. 2. Map of Cambodia (left) and of the Stung Treng province (right). (Source: Nguyen et al., 2015).

monetary values are converted to 2013 purchasing power parity (PPP $). The village questionnaire captures village-related data, i.e. on road conditions and the number of enterprises in the village, and was filled in by the village head or a village committee member.

The data collection was undertaken by 15 Cambodian enumerators (nine from the Cambodian Development Research Institute (CDRI) in Phnom Penh and six from Stung Treng), German supervisors, Cambodian supervisors and data typists. All enumerators had previous experience in conducting household surveys. Each enumerator conducted face to face interviews at the households' home. Each interview took, on average, three hours. The completed questionnaires were first cross-checked by other enumerators and then checked by the team leaders at the end of each day for consistency and plausibility, and if the required data were missing or not plausible, another visit to the interviewed household was conducted. Two survey waves were implemented from late April until late May in 2013 and in 2014, producing a final sample for our analysis of 1100 observations (550 households were surveyed in each of the two years).

3.2. Methodology

Our methodology included the following steps. First, we classified our surveyed households into different categories based on their poverty status, namely the poor, the transient, and the non-poor. This was done based on both observed and predicted household incomes. Second, we identified the factors, including labour and non-labour health shocks, that affected the probability that a household from either the transient group or the non-poor group falls into the poor group. Third, we examined whether natural resource extraction contributed to consumption smoothing when the household faced health shocks.

3.2.1. Categorizing household poverty groups

The identification of household poverty groups in rural areas of developing countries has an important rationale. It allows us to identify the target groups for possible interventions. In the literature, both income and consumption data are normally used to measure poverty. According to Haughton and Khandker (2009), income reflects household welfare in the short term, whereas consumption reflects household welfare in the long term. However, as income is more sensitive to income shocks than consumption (Cameron and Worswick, 2001), we used income data to identify poverty groups. We calculated household income from our data – which is termed the observed income. The observed income of each household in each year includes incomes from farming, non-farm self-employment, off-farm wage employment, monetary transfers from relatives or household migrant members and extraction of natural resources. The income from extraction of natural resources is termed environmental income following Sjaastad et al. (2005). It is the difference between the revenue of extracted products at local market prices and the costs of extraction.

However, a disadvantage of using income data for poverty measurement is that large inter-annual income variations imply that cross-sectional income data only provide a static picture of the poverty status and thus fail to take into account the dynamics of poverty (Hulme and Shepherd, 2003; Dokken and Angelsen, 2015). We overcame this shortcoming by using households' asset holdings to estimate a "normal" annual income. Predicted income should therefore be able to eliminate the effects of inter-annual income fluctuations and thus show a better picture of the poverty and vulnerability status (Angelsen and Dokken, 2018). This "normal" annual income was estimated as follows:

$$Y_{ijt} = \alpha_0 + X'_{ijt}\alpha_1 + S'_{ijt}\alpha_2 + OS'_{ijt}\alpha_3 + V'_{jt}\alpha_4 + D'_t\alpha_5 + \varepsilon_{ijt} \quad (1)$$

where Y_{ijt} is the predicted income per capita of household i in village j in

year t. X' is a vector comprising human, social, natural, physical, and financial assets of the household. S' is the vector representing health shocks and other shocks. OS' is the vector representing other shocks. V' is a vector representing village j where household i is living. D' is a vector of time dummies, and ε is the error term.

We then used per capita predicted income and per capita observed income to classify all surveyed households into three specific groups, namely poor, transient, and non-poor. As indicated in the literature, there are several approaches to measuring poverty and there is no "best" poverty indicator. Angelsen and Dokken (2018) use a classification which assumes that if a household has both predicted per capita income and observed per capita income below an absolute poverty line, the household is poor. We instead used relative poverty, which refers to the general income level of the community. That means those experiencing relative poverty are poorer than the average person. Thus, in our classification, the poor group includes the households for which both per capita observed income and predicted income are smaller than the averages of per capita observed income and per capita predicted income of the sample. These households are structurally poor. The (structurally) non-poor group includes households for which the two per capita income values are higher than their respective per capita average income values. The rest of the sample belongs to the transient group, which includes the households that have either per capita observed income smaller than the average of per capita observed income or per capita predicted income smaller than the average of per capita predicted income.

3.2.2. Identifying the impact of health shock on poverty

The second step of our analysis was to examine the impact of heath shocks on poverty. As we would like to examine the factors affecting the probability that a household will be in the poor group, and given our two-year panel data, we employed the multinomial logistic regression with a random effects model using the maximum likelihood method instead of the fixed effects model as the latter would drop many observations. In addition, we also performed a pooled multinomial logistic regression model and an ordered logistic regression model to check for the robustness of our estimates. However, we focused our analysis on the results of the multinomial logistic model with random effects. The model was formulated as follows:

$$P_{ijg} = \beta_0 + X'_{ijg}\beta_1 + S'_{ijg}\beta_2 + OS'_{ijg}\beta_3 + V'_{jg}\beta_4 + D'_t\beta_5 + e_{ijg} \quad (2)$$

where P_{ijg} denotes the probability of household i in village j being part of group $g \in \{1,3\}$ instead of the base group (e.g. group one). g is equal to either 1, 2 or 3 for the poor, transient, and non-poor, respectively. X', S', V', OS' and D' are defined as in Eq. (1), and e is the error term.

3.2.3. Examining the role of natural resource extraction on consumption smoothing

The last step in our analysis was to find out whether environmental income is effective in helping rural households to cope with health shocks. We used the fixed-effects model with interaction between the environmental income variable and health shock variables to measure the impact of environmental income on household daily consumption per capita when a household faces a health shock. The model was formulated as follows:

$$C_{ijt} = \gamma_0 + I.\ S'_{ijt}\gamma_1 + X'_{ijt}\gamma_2 + S'_{ijt}\gamma_3 + OS'_{ijt}\gamma_4 + V'_{jt}\gamma_5 + \sigma_{ij} + \mu_{ijt} \quad (3)$$

where C_{ijt} denotes the daily consumption per capita of the household i at the village j at time t (in natural logarithm form). $I.\ S'_{ijt}$ is the interaction between environmental income variable and health shock variables. X', S', V', OS' are defined as in Eq. (1); σ is household specific effect and μ is the error term.

For health shocks of household members, we used two dummies representing the situation where household labourers or household non-labourers have a health shock during the last 12 months. This dichotomous way of representing health shocks has certain limitations as it does not tell us anything about the frequency, intensity and impact of heath shocks. Indeed, health shocks faced by rural households in Cambodia recorded in our data were very different in terms of type, timing, intensity and impact. Moreover, as our recall period is 12 months long this can lead to possible measurement errors. Therefore, the use of dummy variables for health shocks helped us to reduce heterogeneity and to avoid measurement errors. Technically, it also allowed us to interpret the interaction between health shock and environmental income. Health shocks are classified into two types, health shocks of household labourers (from 16 to 65 year olds) and health shocks of household non-labourers (dependents younger than 16 or older than 65 years old). These are described as labour and non-labour health shocks, respectively. This classification is important since health shocks of labourers can have a rapid effect on household income in the short term. In addition to health shocks, we also used a dummy variable to represent the situation where a household has other types of shocks such as crop pests, livestock diseases, droughts and floods.

The variables representing household's assets include human capital, natural capital, social capital, physical capital and financial capital. Human capital is represented by age, gender and education level of the household head as well as household size and household labor. Natural capital is represented by farmland size - as it is typically representative of wealth, status and political power in rural areas of developing countries - irrigated land share and the average distance from home to the main extracting grounds of natural resources. Social capital is represented by the number of mobile phones currently used by household members as it reflects the contacts and networks the household has. Financial capital is represented by a dummy variable which denotes whether a household has non-farm self-employment or off-farm wage employment. Physical capital includes the number of tropical livestock units (TLUs), the number of tractors and the number of motorbikes (the main transportation means in the province). At the village level, we used two variables. The first is a dummy indicating if the village is physically accessible during the whole year, and the second is the distance from the village to the nearest town. This variable represents the accessibility to markets and financial institutions.

In summary, we run three regressions which are used to estimate: (i) per capita household income and thus for identifying household groups based on observed and predicted income (Eq. (1)), (ii) the impact of health shocks on the probability that a household is poor (Eq. (2)), and (iii) whether extraction of natural resource is effective in consumption smoothing when faced with health shocks (Eq. (3)). The dependent and independent variables of these models are summarized in Appendix 1. As the number of independent variables is high, the variance inflation factor (VIF) test was used to detect potential multicollinearity. The result of the test in Appendix 2 rejected the null hypothesis of the problem. In addition, we performed the Hausman tests for choosing fixed-effects or random-effects models for Eq. (3). The results of the tests were in Annex 3.

4. Results and discussion

4.1. Livelihoods of household groups

The results for predicted income are presented in Table 1 (Eq. (1)) with most of the results in line with our expectations. The effect of health shocks of household labourers is significant and negative while that of non-labourers is insignificant but still negative. This finding is consistent with the common notion that, in poor regions of developing countries, heath shocks of household members lead to income losses of rural households. A higher education level of the household head is associated with a higher per capita income. This is reasonable since higher education is usually associated with the possibility of engaging in higher skilled jobs. This in turn enables households to generate income from more secure sources. Regarding household size, it is reasonable that the bigger the household size, the lower the per capita

Table 1
Determinants of household income per capita.

Variable	Coef.	RSE
age	2.454	1.680
gender	−87.714*	45.493
education	17.397***	4.924
hh_size	−111.197***	13.178
hh_labor	17.745	22.278
n_mobile	51.097***	17.645
farm_size (ln)	9.846	16.186
share_irrigated	0.362	0.744
envidist (ln)	54.292**	23.266
tractor	68.778	48.957
motorbikes	124.986***	24.459
trolivu	40.135***	5.620
d_non_farm	234.295***	31.572
labor_health_sh	−67.234*	32.931
non_labor_health_sh	−21.640	34.041
other_shock	−69.883**	36.156
roadtype	125.359*	66.051
dis_town (ln)	4.141	19.549
year (2014)	70.740*	38.464
constant	−141484.9*	77,432.140
No. of observations	1100	
F(19, 29)	25.35	
Prob. > F	0.0000	
R-squared	0.2751	
Root MSE	531.16	

RSE are robust standard errors clustered at household level.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

income is. Thus, as is indicated, household size has a negative effect on per capita income. The number of mobile phones used by household members has a positive effect, indicating the importance of social networks and contacts in generating income. Similarly, we find that the numbers of motorbikes and TLUs and non-farm employment are associated with higher levels of per capita income, which are also reasonable. In addition, we also find that the greater the distance to the extracting grounds of natural resources, the higher the per capita income. This is because extracting grounds are always located in remote areas. Nguyen et al. (2015) using the same data set show that a greater distance to an extracting ground is associated with a lower level of per capita income but a higher level of per capita environmental income. This is in line with the common notion that the poor depend more on the extraction of such resources. It also indicates that valuable natural resources are becoming scarcer and people have to go further to look for them. Better road conditions to the village is associated with a higher level of per capita income. The growth in per capita income over time is indicated by a significant and positive effect of the time dummy variable.

The results of household classification are presented in Table 2. The poor group accounts for about 15% of the observations while the non-poor group accounts for around 35%. These figures are plausible since the poverty rate in Cambodia was estimated to account for 14% of the population in 2015 (ADB, 2017). The poor and the non-poor account for about a half of the observations. The other half belongs to the transient group. Obviously, it is not only the poor who need to be considered, but also the transient who can either be vulnerable to poverty or be able to move to the non-poor group.

Table 2
Household group classification.

No.	Household group	Number (share) of observations
1.	Poor	157 (14.27%)
2.	Transient	545 (49.55%)
3.	Non-poor	398 (36.18%)
	Total	1100 **(100%)**

Table 3
Descriptive statistics of the variables representing livelihood assets of rural households by group.

Variable	Pooled sample (n = 1100)	Poor (n = 157) (1)	Transient (n = 545) (2)	Non-poor (n = 398) (3)
age[b]	45.03	42.02[2]*	44.19[3]***	47.37[1]***
	(13.86)	(14.40)	(14.22)	(12.78)
gender[c]	88.00	87.90[2]	87.71[3]	88.44[1]
	(32.51)	(32.72)	(32.87)	(32.01)
education[b]	3.44	2.48[2]**	3.22[3]***	4.12[1]***
	(3.27)	(2.89)	(3.19)	(3.39)
hh_size[b]	5.48	5.28[2]	5.18[3]***	5.96[1]***
	(1.99)	(1.85)	(1.95)	(2.00)
hh_labor[b]	3.28	2.87[2]	3.03[3]***	3.78[1]***
	(1.58)	(1.44)	(1.43)	(1.70)
n_mobile[b]	1.36	0.84[2]**	1.10[3]***	1.92[1]***
	(1.37)	(0.98)	(1.04)	(1.68)
farm_size[b]	2.79	2.07[2]*	2.49[3]***	3.48[1]***
	(3.54)	(1.65)	(2.40)	(4.99)
share_irrigated[b]	5.11	3.29[2]	5.28[3]	5.58[1]
	(21.18)	(17.03)	(21.39)	(22.34)
envidist[b]	3.01	2.41[2]	2.75[3]***	3.61[1]**
	(4.77)	(2.88)	(4.06)	(6.04)
tractor[a]	0.26	0.15[2]*	0.21[3]***	0.37[1]***
	(0.45)	(0.35)	(0.41)	(0.50)
motorbikes[a]	0.80	0.43[2]***	0.69[3]***	1.09[1]***
	(0.75)	(0.57)	(0.65)	(0.83)
trolivu[b]	2.14	0.86[2]***	1.59[3]***	3.39[1]***
	(3.46)	(1.28)	(2.21)	(4.82)
d_non_farm[c]	66.45	46.50[2]**	62.20[3]***	80.15[1]***
	(47.24)	(50.04)	(48.53)	(39.94)
labor_health_sh[c]	39.73	54.78[2]**	35.41[3]	39.70[1]**
	(48.96)	(49.93)	(47.87)	(48.99)
non_labor_health_sh[c]	29.64	35.67[2]	29.17[3]	27.89[1]*
	(45.69)	(48.06)	(45.50)	(44.90)
other_shock[c]	56.09	70.06[2]***	54.86[3]	52.26[1]***
	(49.65)	(45.94)	(49.81)	(50.01)
roadtype[c]	9.91	7.01[2]	8.99[3]*	12.31[1]*
	(29.89)	(25.61)	(28.63)	(32.90)
dis_town[b]	24.38	28.57[2]**	24.64[3]*	22.37[1]***
	(26.57)	(27.41)	(26.52)	(26.17)

[1, 2, 3] compare with group (1), (2), (3), respectively.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%; standard deviation in parentheses.
[a] T test.
[b] Nonparametric two-sample test: Mann–Whitney U test.
[c] Chi-square test.

Table 3 presents the descriptive statistics of the variables representing livelihood assets for the whole sample and for each household group. The average age of the household head in our sample is 45 years although the poor have a lower average age. 88% of the sampled households are headed by males. There is no significant difference among the three groups with regard to the gender of the household head. The education level of household heads is very low - at about 3 years of schooling - and there are significant differences in the education levels of household heads among the groups. It is not surprising that the poor have the lowest education level while the non-poor have the highest. With regard to household size, it is surprising that the non-poor have the largest household size, and that there is no significant difference between the poor and the transient in this regard. The non-poor have a higher number of labourers. They also have a higher number of mobile phones and a larger farm size. On average, each household in our sample has about 2.8 ha of land but the irrigated land share is very low - only about 5%. It is also evident that the poor and transient live closer to the extracting grounds of natural resources while the non-poor live in villages that are closer to a town. The numbers of

Table 4
Household income and income sources.

Income source	Poor		Transient		Non-poor		Pooled sample	
	PPP$	%	PPP$	%	PPP$	%	PPP$	%
Crop	1,044 (974)	43	1,110 (1068)	38	1,937 (2041)	24	1,400 (1539)	30
Livestock	93 (911)	4	181 (895)	6	1,280 (2229)	16	566 (1612)	12
Natural resource	490 (872)	20	524 (1372)	18	1,135 (2462)	14	741 (1822)	16
Off-farm wage	670 (1125)	28	785 (1279)	27	1808 (2459)	22	1139 (1852)	24
Self-employment	14 (129)	1	189 (951)	6	1,770 (3028)	22	736 (2091)	16
Transfer	110 (275)	5	130 (492)	4	218 (976)	3	159 (690)	3
Total	2,421 (1244)	**100**	2,920 (2026)	**100**	8,149 (3631)	**100**	4,741 (3692)	**100**

Standard deviations in parentheses.

Table 5
Health shock severity and income losses.

	Pooled sample		Poor (1)		Transient (2)		Non-poor (3)	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Health shock								
High severity[b]	175	16 (37)	63[2]***	40 (49)	58[3]	11 (31)	54[1]***	14 (34)
Medium severity[b]	291	26 (44)	94[2]***	60 (49)	111[3]	20 (40)	86[1]***	22 (41)
Income loss (PPP$)[a]	118 (232)		94[2] (232)		106[3]* (313)		160[1]* (355)	

[1, 2, 3] compare with group (1), (2), (3), respectively.
* Significant at 10%.
*** Significant at 1%; standard deviations in parentheses'.
[a] T test.
[b] Chi-square test.

tractors, motorbikes and TLUs are also significantly different between the groups as expected. About 80% of the non-poor have some sort of non-farm employment while this figure for the poor and transient is significantly lower. It is commonly found in the literature that development of non-farm sectors contributes significantly to rural development. Non-farm employment, such as self-employment or wage-employment in rural areas, is important to improve livelihoods and welfare of rural households (Owusu et al., 2011). Of household members, 40% and 30% of labourers and non-labourers respectively in our sample report having health shocks. Poor households have the highest share of labourers with health shocks while non-poor households have the lowest share of non-labourers with health shocks.

These differences in livelihood assets lead to variations in livelihood outcomes, which are represented by the level of income and income sources as reported in Table 4. The non-poor have the highest income, followed by the transient and then the poor. However, the difference in household income between the non-poor and the poor is much larger than that between the transient and the poor. In regard to income sources for the whole sample, crop and livestock contribute about 42%, while non-farm employment (including off-farm wage and self-employment) contributes 40%. The income composition varies between the groups. The poor depend most on farming, but the non-poor depend most on non-farm employment. Within the agricultural sector, the poor depend more on crop income.

Extraction of natural resources is shown to be important, contributing about 16% to the annual household income of our sample. This income source is more important to the poor (22%), then to the transient (18%), and to the non-poor (14%). However, the absolute environmental income of the non-poor is highest, indicating that the non-poor are more likely to destroy resources more because they are able to undertake the activities with high returns, such as logging. In addition, there is evidence in the literature that the non-poor frequently employ the poor to extract natural resources and that the non-poor often buy natural resources collected by the poor (see Narain et al., 2008). When such indirect considerations are taken into account, the destruction of natural resources attributable to the non-poor is likely to be greater. Our findings are in line with Cavendish (2000); Kamanga et al. (2009), and Wunder et al. (2014) who report that the poor are relatively more dependent on natural resources in order to fulfill basic needs than wealthier households, who are nevertheless the main resource extractors.

4.2. Heath shock and poverty

Table 5 presents more information on heath shocks of household members. The poor report a higher number of health shocks and have a greater share of households having health shocks. With regard to income loss due to heath shocks, the non-poor report a higher absolute number. However, if compared to household income, the income loss of the poor is relatively much higher.

Table 6 presents the estimated results for the factors affecting poverty (Eq. (2)) and yields several important findings. The likelihood of being poor is significantly correlated with the heath shocks of household labourers. This is because they lead to significant income losses as indicated in Table 1. Our findings are consistent with previous studies carried out in developing countries. For example, Atake (2018) finds that health shocks are positively associated with poverty in Sub-Saharan Africa. Heltberg and Lund (2009) report that health shocks suffered by household members result in food insecurity, child and bonded labour and informal debts. Novignon et al. (2012) also report that health shocks increase the vulnerability to poverty of households in Ghana. In addition, having other types of shocks is also significantly and negatively correlated with the probability of being transient or non-poor. Crop pests, livestock diseases, droughts and floods have been reported as influencing rural households in developing countries in general and in Cambodia in particular (Nguyen et al., 2020). The main reason is that rural households are not equipped with effective coping

Table 6
Impact of health shocks on poverty (the poor as the base group).

Variable	Multinomial random-effects logit		Pooled multinomial logit		Order logit
	Transient	Non_poor	Transient	Non_poor	All group
age	0.012	0.017*	0.012	0.018**	0.010**
	(0.008)	(0.009)	(0.008)	(0.008)	(0.005)
gender	−0.034	−0.206	−0.037	−0.207	−0.152
	(0.322)	(0.359)	(0.298)	(0.326)	(0.197)
education	0.030	0.078*	0.030	0.078*	0.048**
	(0.037)	(0.040)	(0.037)	(0.041)	(0.022)
hh_size	−0.217***	−0.182**	−0.219***	−0.185*	−0.071
	(0.075)	(0.086)	(0.074)	(0.096)	(0.056)
hh_labor	0.135	0.215*	0.135	0.214*	0.134*
	(0.109)	(0.121)	(0.091)	(0.112)	(0.072)
n_mobile	−0.067	0.146	−0.069	0.145	0.168**
	(0.128)	(0.135)	(0.133)	(0.137)	(0.068)
farm_size (ln)	0.132	0.148	0.133*	0.149	0.077
	(0.087)	(0.097)	(0.077)	(0.098)	(0.061)
share_irrigated	0.010*	0.011*	0.010	0.011*	0.004
	(0.006)	(0.006)	(0.006)	(0.006)	(0.003)
envidist (ln)	0.126	0.323***	0.128	0.324***	0.187***
	(0.083)	(0.097)	(0.089)	(0.123)	(0.062)
tractor	0.282	0.641**	0.286	0.643***	0.378**
	(0.291)	(0.312)	(0.225)	(0.233)	(0.152)
motorbikes	0.776***	1.031***	0.785***	1.039***	0.460***
	(0.208)	(0.227)	(0.221)	(0.217)	(0.112)
trolivu	0.353***	0.504***	0.356***	0.507***	0.209***
	(0.083)	(0.086)	(0.079)	(0.083)	(0.036)
d_non_farm	0.997***	1.912***	1.007***	1.921***	1.053***
	(0.236)	(0.279)	(0.266)	(0.298)	(0.166)
labor_health_sh	−1.069***	−1.065***	−1.076***	−1.073***	−0.464***
	(0.210)	(0.236)	(0.227)	(0.257)	(0.149)
non_labor_health_sh	−0.266	−0.287	−0.269	−0.290	−0.109
	(0.219)	(0.249)	(0.194)	(0.249)	(0.156)
other_shock	−0.678***	−0.857***	−0.682***	−0.860***	−0.442***
	(0.222)	(0.247)	(0.236)	(0.265)	(0.134)
roadtype	0.179	0.560	0.178	0.559**	0.345**
	(0.384)	(0.411)	(0.309)	(0.273)	(0.156)
dis_town (ln)	−0.107	−0.076	−0.108	−0.076	−0.030
	(0.085)	(0.093)	(0.079)	(0.094)	(0.049)
year (2014)	0.392*	0.158	0.394**	0.162	0.025
	(0.212)	(0.238)	(0.166)	(0.233)	(0.143)
constant	1.024*	−1.658**	1.029	−1.649**	
	(0.622)	(0.719)	(0.678)	(0.682)	
No. of observations	1100		1100		1100
Log likelihood	−897.48		−897.48		−922.64
Wald $chi^2(19)$					340.30
Prob. > chi^2					0.000
Pseudo R^2			0.179		0.156

* Significant at 10%.
** Significant at 5%.
*** Significant at 1%; robust standard errors in parentheses are clustered at the household level for pooled multinomial logit and order logit.

mechanisms (Ozawa et al., 2016), while at the same time, institutional arrangements to support them - such as credit and insurance markets and heath care systems - are either non-existent or ineffective. This finding indicates the need for further support for rural households so that they are more able to cope with heath shocks.

Another important factor that has a significant and negative effect on the likelihood of being poor is non-farm employment. *ceteris paribus*, non-farm employment increases the probabilities of being in the transient or in the non-poor group. As reported by Reardon et al. (1998), the setting up of non-farm employment of rural household members requires relatively little capital and provides an important source of income. By relaxing capital constraints, non-farm employment can enhance productive capacity, thereby contributing to higher income (Ruben and Berg, 2001; Taylor et al., 2003; Babatunde and Qaim, 2010). There is also evidence that the importance of nonfarm employment has been increasing over the last few decades (de Janvry and Sadoulet, 2001), especially in emerging Asian economies (Démurger et al., 2010). This indicates the potential to reduce poverty through the development of rural non-farm sectors is relevant not only to Cambodia. Similarly, increasing irrigated land share is positively correlated with the probability to be transient or non-poor. This demonstrates the importance of local irrigation systems for farming in reducing poverty given it can help to increase farm productivity and efficiency.

Other factors that have significant effects on the likelihood of a household moving out of the poor group include age and education level of the household head, household size, household labour, number of mobile phones, distance to the extracting ground of natural resources and numbers of tractors, motorbikes and livestock. Households with older heads seem to be better off and thus are less likely to be poor. Households with educated heads are also more likely to be in the non-poor group. However, a large household size increases the likelihood of being poor. Other livelihood assets such as tractors, motorbikes and livestock increase the probability of being transient or non-poor.

Table 7
Extraction of natural resources.

Product	No. and share of observations	Mean distance (km)	Output value (PPP$)	For sales (PPP$)	For consumption (PPP$)
Game	216 (2.3%)	6.19	1,146.50	773.62	372.88
Other animals	150 (13.64%)	3.18	257.58	113.32	144.26
Vegetables and fruits	621 (56.45%)	2.71	700.76	593.63	107.13
Wood	629 (57.18%)	3.55	703.82	570.55	133.27

4.3. Natural resource extraction and consumption smoothing when confronting health shocks

Many different types of water and forest products are shown to be collected in our study area, including fish, honey, red ants' eggs, birds, wild pigs, mushrooms, herbs, bamboo shoots, other vegetables and fruits and wood. We group them into the following categories: (i) game, (ii) other animal, (iii) vegetables and fruits, and (iv) wood. Table 7 presents more details on the number and share of households participating in the extraction, the distance to the extracting ground, the revenue of the extraction and the shares of the revenue derived from sales and from home consumption.

Table 7 shows that the majority of our sample extract vegetables, fruits and wood products from the environment. This is probably due to the fact that these products are more available and closer to their home. The average distance to the extracting ground of these products is about 3 km. The home consumption value is lower than the sales value, demonstrating that natural resources are a source of cash income for rural households. The number of households hunting game is lowest and the distance to its extracting ground is highest, indicating the scarcity of game, but at the same time, the higher revenue derived from it. As reported by Nguyen et al. (2015), extraction of water and forest resources in Cambodia is mainly undertaken in *de facto* open access areas with very little (if any) restrictions. This does not mean that there are no regulations (Kanchanaroek et al., 2013), but rather that the enforcement of regulations is ineffective (Travers et al., 2011). Clements et al. (2010) also report that the institutions dealing with natural resources in Cambodia are essentially ineffective.

Table 8 presents the results of estimating the role of natural resource extraction in consumption smoothing with fixed effects (Eq. (3)). The dependent variable is household consumption per capita (in natural logarithmic form). In the first specification we include both labour and non-labour health shocks. In the second specification we include only labour health shocks while in the last specification we include only non-labour health shocks. Our main variable of interest is the interaction between environmental income and health shocks of household members. As seen in Table 8, the two interaction terms (between environmental income and labour shocks, and between environmental income and non-labour shocks) are positive and significant, indicating that extraction of forest and water resources is helpful to rural households in smoothing their consumption when they have health shocks.

This finding verifies our hypothesis that, given limited other livelihood alternatives, rural households in poor developing countries tend to intensify the extraction of forest and water resources to deal with health shocks and this seems to be effective in consumption smoothing. On the one hand, this confirms the importance of maintaining the resources. On the other hand, it indicates an environment - development nexus. Thus, natural resources are currently used as insurance against income heath shocks by rural households.

5. Conclusions

In this study we investigated the causal linkage between health shocks and poverty and the implications for natural resource extraction in Cambodia using two-year panel data of 550 rural households collected in Stung Treng province in 2013 and 2014. We first used livelihood assets to classify sampled households into poor, transient, and non-poor groups. We then employed multinomial logit models with random-effects to estimate the effect of health shocks of household members on the likelihood of being poor, and fixed effects models with interaction between environmental income and heath shocks to examine the effectiveness of natural resource extraction in consumption smoothing.

Our analysis yields several important findings. First, health shocks lead to a decrease in household per capita income and are therefore an important factor affecting the likelihood of rural households falling into poverty. Second, extraction of natural resources is not only a livelihood activity but also a health-shock coping strategy of rural households. The extraction contributes a significant share of annual household income. The poor depend more on resource extraction for their livelihoods but the non-poor actually extract the most resources. Such extraction is found to be effective in smoothing household consumption in the short term. Third, non-farm employment and irrigated land share contribute to significantly reducing the likelihood of being poor.

These findings lead to several policy implications. First, rural households should be supported in coping with health shocks in order to avoid welfare losses. Therefore, establishment and development of rural health care systems, including health insurance should be seen as of utmost importance. Second, providing rural residents with greater non-farm employment opportunities should be given high priority. This can be done, for example, through encouragement of rural industrialization. Third, other programs to support a higher return for farming activities should also be pursued. This includes programs for irrigation development. Finally, maintaining a sustainable stock of natural resources is of critical importance. Policies should not only concentrate on enforcing regulations designed to reduce over-extraction of natural resources but also allow the poor to have access to resources when needed.

Even though our study has provided important insights, there are a number of limitations that should be addressed in future studies. Our study is based on only one province with two-year data. Such a short panel imposes limits on the analysis of intertemporal behaviour in a dynamic manner. Extending the spatial and temporal coverage will allow a more robust generalization of the research findings. In addition, our study has not considered non-pecuniary benefits of natural resources. By accounting for these benefits a better estimate of the level of dependence of rural households on natural resources can be achieved.

Declaration of Competing Interest

The authors declare no conflict of interest.

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Table 8
Role of environmental income on consumption smoothing.

Variable	With both labour and non-labor health shock		With only labour health shock		With only non-labor health shock	
	Coef.	RSE	Coef.	RSE	Coef.	RSE
interaction (environmental income*labor shock)	0.140**	(0.060)	0.172***	(0.056)		
interaction (environmental income*non-labor shock)	0.099	(0.082)			0.157*	(0.078)
age	−0.006	(0.004)	−0.005	(0.004)	−0.006	(0.004)
gender	−0.182*	(0.089)	−0.167	(0.101)	−0.215**	(0.090)
education	−0.010	(0.038)	−0.009	(0.039)	−0.008	(0.038)
hh_size	−0.061	(0.062)	−0.058	(0.064)	−0.059	(0.062)
hh_labor	0.049	(0.048)	0.051	(0.049)	0.046	(0.049)
n_mobile	0.019	(0.018)	0.018	(0.019)	0.021	(0.017)
farm_size (ln)	0.010	(0.017)	0.009	(0.017)	0.011	(0.018)
share_irrigated	0.001*	(0.001)	0.001*	(0.001)	0.001*	(0.001)
envidist (ln)	0.018	(0.012)	0.019	(0.012)	0.019	(0.011)
tractor	0.067	(0.058)	0.067	(0.058)	0.074	(0.063)
motorbikes	0.181***	(0.033)	0.178***	(0.032)	0.184***	(0.032)
trolivu	0.021**	(0.008)	0.021**	(0.008)	0.021**	(0.008)
d_non_farm	−0.107*	(0.060)	−0.104*	(0.060)	−0.097	(0.060)
labor_health_sh	−0.078	(0.057)	−0.100*	(0.053)		
non_labor_health_sh	−0.065	(0.067)			−0.095	(0.060)
roadtype	−0.021	(0.038)	−0.023	(0.038)	−0.027	(0.039)
other_shock	−0.011	(0.026)	−0.017	(0.028)	−0.011	(0.027)
dis_town (ln)	−0.033**	(0.015)	−0.035**	(0.014)	−0.030**	(0.013)
constant	1.367***	(0.300)	1.293***	(0.330)	1.394***	(0.304)
No. of observations	1100		1100		1100	
F value	17.39		9.61		14.79	
Prob. > F	0.000		0.000		0.000	
R^2: within	0.102		0.099		0.093	
between	0.182		0.183		0.198	
overall	0.154		0.155		0.165	

* Significant at 10%.
** Significant at 5%.
*** Significant at 1%; RSE robust standard errors clustered at the household level.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ecolecon.2019.106517.

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