Economic Change and Restructuring
https://doi.org/10.1007/s10644-022-09400-9

Shocks, household consumption, and livelihood diversification: a comparative evidence from panel data in rural Thailand and Vietnam

Duy Linh Nguyen[1,2] · **Trung Thanh Nguyen**[1] · **Ulrike Grote**[1]

Received: 12 August 2021 / Accepted: 24 March 2022

Abstract
We examine the roles of land and labor diversification in mitigating the effects of covariate and idiosyncratic shocks in the two middle-income countries Thailand and Vietnam. We use an unbalanced panel dataset of rural households obtained from five survey waves during 2007–2016 (9291 households for Thailand and 9255 households for Vietnam). We employ the System-Generalized Method of Moments estimators to control for endogeneity. Our study finds that (i) rural households in both countries are able to maintain per capita consumption in the face of idiosyncratic shocks but not covariate shocks; (ii) labor diversification in Thailand and land diversification in Vietnam are used as *ex-post* coping strategies against covariate shocks but their shock-mitigating roles are insignificant; and (iii) land diversification in Thailand and labor diversification in Vietnam are helpful in improving per capita consumption when households face covariate shocks. Our findings suggest that facilitating access to credit, enhancing farm mechanization, and improving road quality in Thailand as well as promoting the development of local rural nonfarm sectors in Vietnam would benefit rural households in dealing with covariate shocks.

Keywords Diversification · Covariate and idiosyncratic shocks · Household consumption · System-generalized method of moments

✉ Trung Thanh Nguyen
thanh.nguyen@iuw.uni-hannover.de

[1] Institute for Environmental Economics and World Trade, Leibniz University Hannover, Königsworther Platz 1, 30167 Hannover, Germany

[2] Vietnam National University of Agriculture, Hanoi, Vietnam

Published online: 11 April 2022

1 Introduction

Shocks disrupt the flows of household income and consumption, and are responsible for welfare losses in developing countries (Arouri et al. 2015; Porter 2012; Pradhan and Mukherjee 2018). They can be classified into idiosyncratic and covariate shocks (OECD 2009). The former affects a specific individual or household, while the latter affects a group of households, communities, regions or even an entire country. There is consensus that covariate shocks have more significant impacts on household welfare than idiosyncratic shocks (Dercon 2004). Catastrophic disasters such as storms, floods, and droughts can directly erode household resources, drive them into poverty traps, widen inequality, and worsen poverty among the already poor (Bui et al. 2014; Carter et al. 2007; Sawada and Takasaki 2017; Skoufias 2003). However, certain idiosyncratic shocks such as health shocks could be dangerous to households as well. They directly limit the working capacity of main bread earners and reduce permanent income while increasing the expenditure for health recovery (Alam and Mahal 2014). Finding reliable strategies to cope with or to mitigate welfare consequences of shocks in developing countries is therefore a theme which has gained great interest of policy makers and scientific communities (Mitra et al. 2016; Porter 2012).

Livelihood diversification is an important strategy that households in developing countries use for their survival and for improving their living standards (Dercon 2002; Rahut and Micevska Scharf 2012). There is fruitful literature showing that livelihood diversification plays a crucial role in improving food security, reducing poverty, and promoting economic growth in low-income countries (e.g., Birthal et al. 2015; Gautam and Andersen 2016; Rahut et al. 2018; Waha et al. 2018). It is also well evidenced that households widely adopt livelihood diversification as a coping strategy in response to shocks (Gao and Mills 2018; Mohammed et al. 2021). However, the empirical evidence regarding the effectiveness of livelihood diversification in dealing with shocks is rather limited in middle-income countries.

To fill this research gap, this study examines the roles of alternative livelihood diversification strategies undertaken by rural households in response to shocks in Thailand, an upper-middle income country, and Vietnam, a lower-middle income country. These two emerging economies in Southeast Asia are selected because they have been among the top ten countries most affected by extreme weather events during the last two decades (Nguyen et al. 2020). Both countries have a high proportion of rural population with agriculture being the major income source, and their rural households are known to diversify their major productive assets of land and labor in response to shocks (Nguyen et al. 2017). Our research questions include: (i) what are the impacts of idiosyncratic and covariate shocks on rural household consumption and on land or labor diversification? and (ii) how effective are land and labor diversifications in mitigating the impacts of idiosyncratic and covariate shocks on household consumption? Answering these questions provides useful information for policy interventions to support one of the most vulnerable population groups, the rural households, to overcome the adverse impact of these types of shocks.

The rest of the paper is structured as follows. Section 2 reviews the literature. Section 3 describes the theoretical framework and empirical procedure. Section 4 presents the results and discusses the findings. Section 5 concludes.

2 Literature review

In developing countries, livelihood diversification is one of the livelihood strategies that rural households adopt either to make a living or to improve their resilience in coping with and recovering from shocks (Scoones 2009). The elements of household livelihood diversification are generally be categorized by sector (e.g., agriculture or non-agriculture), by function (e.g., wage employment or self-employment), or by location (e.g., on-farm or off-farm) (Alobo Loison 2015). Livelihood diversification can also take place within farm boundaries through allocating farmland to different crops (i.e., on-farm or agricultural diversification), but it can also occur beyond household residence through distributing household labor to other economic sectors (i.e., off-farm or non-farm diversification) (Barrett et al. 2001; Haggblade et al. 2010). Land diversification is often implemented where rural producers have a low level of capital endowment, and where restructuring agricultural production is easier than investing in non-agricultural activities (Hussein and Nelson 1998). Labor diversification arises if a labor market exists, especially with a blooming rural non-farm sector (Barrett et al. 2001).

Regardless of the form it takes, livelihood diversification has two facets that need to be distinguished. First, livelihood diversification is a means of living. In places where labor and agricultural output markets are limited, rural households may diversify their livelihoods in order to survive or to accumulate wealth (Rahut et al. 2018). In the absence of shocks, empirical evidence illustrates that rural households have gained welfare when adopting land or labor diversification. For example, land diversification improves household food security (Waha et al. 2018) and reduces poverty (Birthal et al. 2015; Michler and Josephson 2017), while labor diversification leads to an increase in household income and consumption (Hoang et al. 2014), in asset accumulation (Martin and Lorenzen 2016), and in household well-being (Gautam and Andersen 2016). Second, since risks are associated with the utilization of household's asset portfolio, the diversity of livelihoods is the norm (Barrett et al. 2001). This is especially true in places where well-functioning credit and insurance markets are absent and rural households, including the poor and non-poor, are vulnerable to adverse events (Klasen and Povel 2013). They may adopt livelihood diversification as an *ex-ante* strategy to reduce income risk or diversify *ex-post* to maintain food security and consumption in the aftermath of shocks (Dercon 2002). For instance, labor diversification is adopted by households facing idiosyncratic (agricultural) shocks (Cameron and Worswick 2003) or covariate (weather) shocks (Gao and Mills 2018), while land diversification is an avenue for increasing household resilience toward floods (Shah et al. 2021) and droughts (Auffhammer and Carleton 2018).

Although livelihood diversification is documented among shock mitigating mechanisms, empirical evidence on its effectiveness is limited due to several reasons. First, most previous studies on livelihood diversification in developing countries

are based on cross-sectional data while the level and the pattern of diversification change over time (Alobo Loison 2015). Second, if panel data are available, detailed information on covariate and idiosyncratic shocks is normally missing. Thus, some previous studies focused on specific types of either covariate or idiosyncratic shocks, which are easy to measure and model with available data such as floods or droughts through rainfall or temperature data. Other previous studies use an aggregate measure of shocks (Günther and Harttgen 2009; Nguyen et al. 2015). Last, it is difficult to disentangle the causality as there is likely a two-way causation between livelihood diversification and household welfare (Arslan et al. 2018). This reverse causality may lead to a severe bias in estimating the shock-mitigating roles of livelihood diversification. We take these limitations into account and attempt to address them with this research.

3 Theoretical framework and empirical strategies

3.1 Theoretical framework

To investigate the shock mitigating roles of land and labor diversifications, we first measure the impact of shocks on household consumption. We then estimate the consumption smoothing effects of land and labor diversifications. In the literature, there are several theories on the relationship between shocks and consumption, for example the life-cycle, precautionary savings, and consumption insurance models (see Attanasio and Weber 2010 for a review). Among them, the full consumption insurance model is the only one that distinguishes between covariate and idiosyncratic shocks (Ahn et al. 2017). Thus, we use this model as our theoretical framework. In a community with N households, each of them is assumed to be risk averse and has a diminishing marginal utility function:

$$U(C_{\text{ist}}(\gamma_{\text{ist}})) = e^{\theta\gamma_{\text{ist}}}\frac{1}{\theta}(C_{\text{ist}})^{\theta} \tag{1}$$

and a life time intertemporal utility function:

$$u_i = \sum_{s=1}^{S}\sum_{t=1}^{T}\beta^t\rho_s U(C_{\text{ist}}(\gamma_{\text{ist}})) \tag{2}$$

where C_{ist} is the consumption of household i in state s at time t; γ_{ist} represents the "taste shifters" accounting for household interpersonal and intertemporal variations in needs; θ is the risk preference which is assumed to be the same and constant across households; β^t is the discount factor; and ρ_s is the probability of state s.

Because of the diminishing marginal utility of consumption, the welfare loss from a decrease in household consumption is higher than the welfare gain from the same increase in household consumption. Therefore, households prefer to stabilize their consumption over time. They agree to cooperate and pool their income in order to insure each other against risk. By some process of initial bargaining that takes into account

relative wealth, they decide who gets what share of the total and then maximize the weighted sum of household utilities as

$$\max \sum_{i=1}^{N} w_i \sum_{s=1}^{S} \sum_{t=1}^{T} \beta_i^t \rho_s U(C_{\text{ist}}(\gamma_{\text{ist}})) \tag{3}$$

subject to

$$\sum_{s=1}^{S} C_{\text{ist}}(\gamma_{\text{ist}}) = C_{\text{ast}} \tag{4}$$

where w_i is the weight assigned to household i with $1 > w > 0$. C_{ast} is the total consumption of all households at time t and state s. In the Pareto optimal consumption allocation, the first order condition for maximizing Eq. (3) subject to (4) is

$$w_i \beta^t \rho_s U'(C_{\text{ist}}(\gamma_{\text{ist}})) = \delta_{st} \tag{5}$$

where δ_{st} is the Lagrange multiplier in state s at time t. Given that state s occurs, in order to remove household fixed effects, Eq. (5) at time $t+1$ is divided by itself at time t:

$$\frac{U'(C_{i(t+1)}(\gamma_{i(t+1)}))}{U'(C_{\text{ist}}(\gamma_{\text{ist}}))} \beta_i = \frac{\delta_{t+1}}{\delta_t} \tag{6}$$

The specification of the household utility function in Eq. (1) allows the left-hand side of Eq. (6) to be rewritten as

$$\frac{U'(C_{i(t+1)}(\gamma_{i(t+1)}))}{U'(C_{\text{ist}}(\gamma_{\text{ist}}))} = \beta_i e^{\theta(\gamma_{i(t+1)} - \gamma_{it})} \left(\frac{C_{i(t+1)}}{C_{it}} \right)^{(1-\theta)} \tag{7}$$

Substituting Eq. (7) by (6) and taking the natural logarithm:

$$\ln C_{i(t+1)} - \ln C_{it} = \frac{1}{(1-\theta)} \left[\theta(\gamma_{it+1} - \gamma_{it}) + \ln \frac{\delta_{t+1}}{\delta_t} + \ln \frac{1}{\beta_i} \right] \tag{8}$$

Conditional on the change in taste shifters $\left(\theta_{i(t+1)} - \theta_{it}\right)$ and the discount factor β_i, Eq. (8) indicates that the consumption growth of household i depends only on the change in collective resources or aggregate income, and does not depend on the household income growth or initial household assets. This implies that, under the optimal risk allocation, household consumption is fully insured against idiosyncratic shocks. But it cannot be insured against covariate shocks, as all households in the community are affected (Dercon 2002).

3.2 Econometric strategies

3.2.1 Identifying the impacts of shocks on consumption and livelihood diversification

We employ the dynamic model proposed by Porter (2012) to assess the impact of these two types of shocks on consumption because the level of consumption in the current year may be determined by the level of consumption in the previous year. More specifically, the per capita consumption of household i in village j in year t (C_{ijt}, in ln form) is a function of the per capita consumption in the last year (C_{ijt-1}, in ln form), a vector of household and village characteristics X'_{ijt}, a vector of shocks S'_{ijt}, a household fixed effect u_{ij} and an error term ε_{ijt}.

$$\ln C_{ijt} = \alpha_0 \ln C_{ijt-1} + \alpha_1 X'_{ijt} + \alpha_2 S'_{ijt} + u_{ij} + \varepsilon_{ijt} \tag{9}$$

In Eq. (9), household's diversification strategies are not included, and therefore, α_2 measures the pure impact of shocks on consumption (Gao and Mills 2018).

We also employ a dynamic model to examine the impact of shocks on livelihood diversification because the farm household cannot completely change the portfolio of crops or labor uses in a short time period. This impact is estimated as in Eq. (10)

$$\ln D_{ijt} = \varphi_0 \ln D_{ijt-1} + \varphi_1 X'_{ijt} + \varphi_2 S'_{ijt} + \upsilon_{ij} + \varsigma_{ijt} \tag{10}$$

where D_{ijt} is either the land or labor diversification index (ranging from 0 to 100).

3.2.2 Determining the shock-mitigating effect of livelihood diversification

As indicated in the literature section, livelihood diversification is first a means of living and then an *ex-ante* or *ex-post* coping strategy. To examine the first role as a means of living, we estimate the effect of livelihood diversification on household consumption by adding a vector of diversification strategies D'_{ijt} on the right side of Eq. (9), which yields Eq. (11):

$$\ln C_{ijt} = \gamma_0 \ln C_{ijt-1} + \gamma_1 X'_{ijt} + \gamma_2 D'_{ijt} + \gamma_3 S'_{ijt} + \psi_{ij} + \xi_{ijt} \tag{11}$$

We then add the interaction terms between shocks and diversification strategies to Eq. (11) to investigate their second role as a shock coping strategy.

$$\ln C_{ijt} = \beta_0 \ln C_{ijt-1} + \beta_1 X'_{ijt} + \beta_2 D'_{ijt} + \beta_3 S'_{ijt} + \beta_4 D'_{ijt} * S'_{ijt} + \nu_{ij} + \omega_{ijt} \tag{12}$$

In Eq. (12), β_4 represents the shock-mitigating effect of diversification in terms of consumption.

A challenge in estimating Eqs. (9–12) is the existence of endogeneity, which might be due to unobserved heterogeneity, reverse causality, and dynamic endogeneity. We, therefore, employ the System-General Methods of Moments (S-GMM) estimators developed by Arellano and Bover (1995) and Blundell and Bond (1998)

to address this concern.[1] The advantage of the S-GMM estimators is the ability to control for fixed effects and endogeneity of regressors while bypassing dynamic panel bias via instrumenting the explanatory variables (Roodman 2009a). In addition, the S-GMM is flexible in addressing unbalanced panels with a large number of observations and multiple endogenous variables in limited time periods. According to Roodman (2009b), instruments for differenced equations are taken from values (levels) of regressors lagged at least twice while instruments for level equations are lagged differences of the variable. In Eqs. (9–12), the endogenous variables include lagged values of dependent variables, and various shock coping strategies such as credit access, remittances, savings, and livelihood diversification. The consistency of the S-GMM estimators depends on the validity of the instruments. Two specification tests are therefore used, the Hansen test (Hansen 1982) for over-identifying restrictions and the Arellano-Bond test (Arellano and Bond 1991) for autocorrelation. The results of these tests in Tables 5, 6, and 7 indicate that our models are consistently specified and the instruments are valid. We also check the variance inflation factor (VIF) values for multicollinearity in all empirical models; the VIF values in Appendices 2–4 signal no such a concern.

4 Data

4.1 Data source

The data for this study come from the long-term research project "*Poverty dynamics and sustainable development: A long-term panel project in Thailand and Vietnam (*www.tvsep.de*)"*. This project aims to establish a unique, multipurpose and long-term socio-economic panel in the two emerging economies. Six provinces (Buri Ram, Ubon Ratchathani, and Nakhon Phanom in Thailand, and Ha Tinh, Thua Thie Hue, and Daklak in Vietnam, see Fig. 1) were selected because they represent the target population with low average per capita income, high dependence on agriculture, existence of climate-related risks, and poor infrastructure (Hardeweg et al. 2013). A three-stage procedure for primary data collection based on the guidelines of the United Nations Department of Economic and Social Affairs (United Nations 2005) were applied. First, two sampled districts were selected in each province. Then, two villages per district were chosen with a probability proportional to the size of the population. Third, a random selection of ten households per village was made based on the list of all households in the sampled villages with equal probability. The pre-determined sample included 4400 rural households in 440 villages in these two countries. However, this pre-determined sample was not complete as some households did not participate in the survey waves. Thus, the final sample for our analysis includes 9291 households in Thailand and 9525 households in Vietnam obtained from five survey waves undertaken during 2007–2016.

[1] We assume that unobserved heterogeneity exists but it is fixed over time (time-invariant).

Fig. 1 Study sites in Thailand and Vietnam (source: Nguyen et al. 2020)

Two instruments were used for data collection: the household questionnaire for household heads and the village questionnaire for village officials.[2] The village questionnaire records information at the village level such as the quality of the roads to the village and the distance from the village to the town of the district. The household questionnaire is structured in several sections including socio-demographic data of the household and its members (Sect. 2), shocks and risks (Sect. 3), land, other natural resources, and agricultural production (Sect. 4), off-farm employment (Sect. 5), non-farm self-employment (Sect. 6), lending, borrowing, insurance, and other public transfers (Sect. 7), and household consumption (Sect. 8).

Regarding shock data in Sect. 3, the households were asked to report all shock events that they faced, shock type, time of occurrence, which household member(s)/ other households were affected, and its severity. The severity is categorized as "no impact", "low impact", "medium impact" and "high impact" in terms of damages in assets or losses in income. We consider only the shocks that have a severity of either a medium or a high impact. A shock is categorized as covariate or idiosyncratic based on its dispersion. If the shock affects only the interviewed household or some other households in the village, it is idiosyncratic. If the shock affects many other households in the village, district or provinces, it is covariate.

4.2 Measures of livelihood diversification

4.2.1 Land diversification

In our sample, a farm household produces several crops; we thus use the Simpson Index (Simpson 1949) to measure land diversification. This index allows us to capture not only the number of crops but also the share of land allocated to each crop. We compute the index as follows:

$$L_{ijt} = 1 - \sum_{k=1}^{N} P_{k(ijt)}^2 \tag{13}$$

where L_{ijt} is the Simpson index of land diversification of household i in village j in year t; $P_{k(ijt)}$ is the land share of crop k in total cultivated farm land.[3] L_{ijt} ranges from zero (monoculture) to $1–1/N$ (Minot 2006). The maximum level of $1–1/N$ is achieved when farmland is distributed equally to N crops. The higher the value of L_{ijt} is, the higher the level of land diversification.

[2] The survey instruments are available at https://www.tvsep.de/survey_documents.html

[3] The total cultivated farmland could be different from the total natural farmland, depending on the number of crops being cultivated and the number of crop seasons per year. For example, if a household fully uses one ha of farmland to cultivate two seasons of paddy rice (spring and summer season) and one crop of corn (winter season), the total cultivated farmland is three ha and the land diversification index is $1-((2/3)^2+(1/3)^2)=.33$.

4.2.2 Labor diversification

In rural areas of developing countries, detailed information on working time allocated to each employment within a year of each household member is difficult to obtain. Therefore, labor diversification in our study refers to the diversity of employment categories that rural household laborers take part in. We use five categories to cover household employments, including: (i) own farm production (e.g., crop and livestock production), (ii) natural resource extraction (e.g., fishing, collection of non-timber forest products), (iii) non-farm self-employment (e.g., household business), (iv) temporary wage employment (e.g., casual labor in agriculture and non-agriculture), and (v) permanent wage employment (e.g., government officers, company employees). We exclude migrating members and consider only nucleus members[4] of 15–65 years of age. The Shannon–Wiener diversity index, representing labor diversification, is computed as in Eq. (14) below:

$$H_{ijt} = -\sum_{l=1}^{n} \ln\left(S_{l(ijt)}\right) * S_{l(ijt)} \tag{14}$$

where H_{ijt} is the Shannon–Wiener labor diversification index of household i in village j in year t; $S_{l(ijt)}$ is the share of labor distributed to employment category l in total labor of household i in village j in year t. The higher the value of H_{ijt} is, the higher the level of labor diversification.

For more convenience in interpreting estimated results in the next section, we multiply the diversification indices computed from Eqs. (13) and (14) with 100, so that the land and labor diversification indices now range from 0 to 100.

5 Results and discussion

5.1 Description of rural setting and livelihood

5.1.1 Characteristics of rural households and villages

The descriptive statistics in Table 1 illustrates that the livelihood conditions in Thailand are in general better than those in Vietnam. At the village level, rural households in Vietnam live closer to the district center than in Thailand, but their physical access is worse due to poorer road conditions. At the household level, an average Thai household is wealthier than a Vietnamese one, as it has a 1.4 times higher per capita consumption, a higher number of physical assets such as tractors and motorbikes, and better access to credit and social safety nets. On average, each rural

[4] Nucleus members are household members that have normally lived and eaten meals together for at least six months over the year prior to the survey (Rigg et al. 2011).

Table 1 Main descriptive statistics of the surveyed households and villages (pooled data)

Variable	Thailand			Vietnam			Difference		
	Whole sample	Without shock	With shock	Whole sample	Without shock	With shock	(1) &(4)	(2) & (3)	(5) & (6)
	(1)	(2)	(3)	(4)	(5)	(6)			
Household level									
Total consumption per capita (PPP USD$)	2008.9 (1925.7)	1929.0 (1976.4)	2061.4 (1890)	1424.9 (1167.3)	1624.1 (1318.6)	1356.4 (1102.3)	583.9***	−132.5***	267.6***
Age (years)	57.1 (12.6)	56.6 (12.6)	57.4 (12.5)	50.3 (13)	51.4 (13.1)	50.0 (13)	6.7***	−0.8***	1.4***
Ethnic majority (%)	93.6 (24.4)	93.5 (24.6)	93.7 (24.3)	78.6 (41)	87.7 (32.9)	75.5 (43)	15.1***	−0.2	12.2***
Education (years)	5.0 (3.1)	5.2 (3.3)	4.9 (2.9)	6.7 (4)	7.3 (4.1)	6.5 (3.9)	−1.7***	0.3***	0.7***
Household size	4.1 (1.7)	4.0 (1.7)	4.1 (1.7)	4.3 (1.7)	4.1 (1.7)	4.3 (1.7)	−0.2***	−0.2***	−0.3***
Household labor	2.7 (1.3)	2.6 (1.3)	2.7 (1.3)	2.8 (1.4)	2.7 (1.4)	2.8 (1.4)	−0.1***	−0.1***	−0.2***
Farmland size (ha)	2.4 (3)	2.2 (3.1)	2.6 (2.8)	0.7 (1.5)	0.6 (2)	0.7 (1.2)	1.8***	−0.3***	−0.1***
Tractor	0.6 (0.6)	0.5 (0.6)	0.6 (0.6)	0.3 (0.5)	0.3 (0.5)	0.3 (0.5)	0.2***	−0.1***	−0.1***
Motorbike	1.3 (0.9)	1.3 (0.9)	1.4 (0.9)	1.1 (0.9)	1.2 (1)	1.0 (0.9)	0.3***	−0.1***	0.2***
Savings (%)	83.9 (36.8)	81.9 (38.5)	85.2 (35.6)	36.3 (48.1)	44.9 (49.8)	33.3 (47.1)	47.6***	−3.3***	11.6***
Credits (%)	69.3 (46.1)	65.5 (47.6)	71.8 (45)	48.6 (50)	36.7 (48.2)	52.7 (49.9)	20.7***	−6.4***	−16***
Livestock (TLU)	1.7 (2.7)	1.7 (2.8)	1.7 (2.6)	1.0 (1.7)	0.9 (1.7)	1.1 (1.8)	0.7***	−0.1	−0.2***

Table 1 (continued)

Variable	Thailand			Vietnam			Difference		
	Whole sample	Without shock	With shock	Whole sample	Without shock	With shock	(1) &(4)	(2) & (3)	(5) & (6)
	(1)	(2)	(3)	(4)	(5)	(6)			
Remittances (%)	39.7 (48.9)	37.8 (48.5)	40.9 (49.2)	21.2 (40.9)	23.1 (42.1)	20.5 (40.4)	18.5***	−3.0***	2.5*
Health insurance	0.1 (0.4)	0.1 (0.4)	0.1 (0.4)	0.6 (1.3)	0.6 (1.3)	0.6 (1.2)	−0.5***	0.0	.01***
Public transfer (%)	59.7 (49.1)	52.7 (49.9)	64.3 (47.9)	41.8 (49.3)	33.9 (47.3)	44.6 (49.7)	17.9***	−11.6***	−10.7***
Village level									
Road type (1 = good; 4 = bad)	1.6 (0.8)	1.6 (0.9)	1.6 (0.8)	1.9 (1)	1.8 (1)	1.9 (1)	−0.3***	0.0	0.1***
Distance to town (km)	13.5 (8.4)	13.2 (8.2)	13.6 (8.6)	12.5 (9.9)	11.9 (9.4)	12.7 (10)	1.0***	−0.4***	−0.7***
Number of observations	9291	3686	5605	9525	2430	7057			

*Significant at 10%, **significant at 5%, ***significant at 1%; standard deviations in parentheses

Table 2 Diversification of land and labor in rural area of Thailand and Vietnam (pooled data)

Diversification level	Unit	Thailand			Vietnam			Difference		
		Whole sample	Without shock	With shock	Whole sample	Without shock	With shock	(1) &(4)	(2) & (3)	(5) & (6)
		(1)	(2)	(3)	(4)	(5)	(6)			
Land use										
Cereals	(%)	74.8 (38.9)	69.1 (42.7)	78.4 (35.7)	50 (40.3)	46.4 (42.5)	51.3 (39.4)	24.73***	−9.3***	−4.91***
Vegetables and Melons	(%)	2 (11)	2.3 (12.7)	1.7 (9.7)	2.2 (10)	2.5 (12)	2.1 (9.2)	−0.24	0.6*	0.39
Fruits and Nuts	(%)	1.9 (11.3)	2.3 (12.6)	1.7 (10.4)	4.3 (15.1)	4.9 (17.4)	4.1 (14.2)	−2.37***	0.62**	0.75***
Oilseed crops and Oleaginous fruits	(%)	0.1 (2.2)	0.1 (2.4)	0.1 (2)	4.8 (13.5)	5.1 (14.6)	4.8 (13.1)	−4.75***	−0.03	0.29
Root/tube crops with high starch	(%)	3.8 (14.2)	3.2 (13.4)	4.3 (14.7)	4 (12.4)	3.1 (11.3)	4.4 (12.8)	−0.22	−1.09***	−1.29***
Stimulant, spice and aromatic crops	(%)	0 (1.1)	0 (0.6)	0 (1.3)	17.8 (34.4)	15.4 (33.1)	18.7 (34.7)	−17.8***	−0.03	−3.22***
Sugar crops	(%)	1 (7.6)	0.9 (7.5)	1 (7.6)	0.2 (3.2)	0.2 (2.9)	0.3 (3.3)	0.74***	−0.14	−0.11
Other crops	(%)	1.6 (10.1)	1.8 (10.7)	1.5 (9.6)	6.4 (19.7)	4.9 (18.5)	6.8 (20)	−4.73***	0.23	−1.88***
Land diversification index	0–100	21 (24)	17 (22.8)	23 (24.1)	27 (21)	21 (24)	30 (26)	6***	−6***	−9***
Labor use										
Own agricultural production	(%)	61.8 (32)	57.8 (34.9)	64.5 (29.7)	62.5 (30)	55.5 (33.7)	64.9 (28.2)	−0.63	−6.7***	−9.33***
Natural resource extraction	(%)	1.6 (8.9)	1.5 (8.9)	1.6 (8.8)	2.6 (10.9)	2.5 (11)	2.7 (10.9)	−1.04***	−0.1	−0.23
Nonfarm self-employment	(%)	11.6 (22.5)	13.3 (25.2)	10.5 (20.4)	11.9 (23.4)	17.3 (28.7)	10 (21)	−0.3	2.81***	7.34***

Table 2 (continued)

Diversification level	Unit	Thailand			Vietnam			Difference		
		Whole sample	Without shock	With shock	Whole sample	Without shock	With shock	(1) &(4)	(2) & (3)	(5) & (6)
		(1)	(2)	(3)	(4)	(5)	(6)			
Temporary wage employment	(%)	17.2 (25.3)	18 (27.5)	16.6 (23.7)	11.7 (19.4)	10 (19.3)	12.3 (19.4)	5.48***	1.32***	−2.28***
Permanent wage employment	(%)	7.8 (19.4)	9.4 (22.3)	6.8 (17.2)	11.3 (21.5)	14.7 (25.2)	10.2 (20)	−3.52***	2.67***	4.51***
Labor diversification index	0–100	46 (38)	42.8 (38.4)	47.4 (37.9)	49 (37)	47.7 (38)	49.2 (37)	−3***	−0.05***	−0.02*
Number of observations		9291	3686	5605	9525	2430	7057			

*Significant at 10%, **significant at 5%, ***significant at 1%; standard deviations in parentheses

household in Thailand has 2.4 ha of farmland while this number is only 0.7 ha in Vietnam.

However, on average, a Thai rural household has an older and less educated household head, a smaller household size, and a lower number of laborers. The Thai National Family Planning Program established in the early 1970s has led to a rapid decline in fertility (Podhisita 2017). In addition, rural Thailand has witnessed a more massive out-migration of young and skilled laborers to urban areas (Grandstaff et al. 2008).

5.1.2 Land and labor use

Table 2 summarizes the use of household labor and farmland. In both countries, there is a tendency that rural households facing shocks have a higher share of land for rice production, a higher share of labor working in the farm sector, and higher levels of land and labor diversifications. This suggests that livelihood diversification might be one of their shock coping strategies. Regarding land use, rice production occupies the largest acreage of household farmland in both countries, accounting for 75 percent of the cultivated area in Thailand and 50 percent in Vietnam. This is not surprising because both countries are the world leading rice exporters. Farm households in Thailand have a lower level of land diversification than their counterparts in Vietnam. Only a handful of cash crops are produced such as groundnut, sweet potato, sesame, and vegetables in the lowland (in the dry season), and orchards and industrial crops in the upland (e.g., cassava and sugarcane) in Thailand (Lacombe et al. 2017). Meanwhile, Vietnamese farmers have a more diversified cropping system with more than 30 crops being cultivated. For instance, perennials such as coffee, pepper, cashew nuts, fruit trees, tea, and acacia are mainly grown in the upland whereas annual crops like vegetables, legumes, corn and ground nuts are cultivated in the lowlands. One of the factors that might lead to more land diversification in Vietnam is land fragmentation, which reduces the possibility for farmers to increase the economies of scale (Hoang et al. 2021).

In terms of labor use, Table 2 shows that agriculture is the dominant sector in our study regions, employing more than 60 percent of household laborers in both countries. Given the fact that migrating members are excluded from household labor (see subsection 4.4.2), this share illustrates that households largely rely on agriculture and that the rural non-farm sectors in both countries are not well developed. The shares of non-farm self-employment are similar in both countries, accounting for around 12 percent of total household labor. Vietnamese rural households have higher shares of household members engaged in natural extraction (such as fishing) and permanent wage non-farm employment. Meanwhile, Thai households have more laborers who generate income from temporary off-farm employment.

5.1.3 Shocks

Table 3 summarizes different types of shocks reported by rural households in the study sites. Covariate shocks hit 42 and 44 percent of the surveyed households in

Table 3 Percentage of households experienced with shocks (pooled data)

Type of shock	Thailand	Vietnam	Difference
Covariate shock (Cov_shock)	41.9	44.2	−2.4***
of which:	(49.3)	(49.7)	
Flood	9.3	14.8	−5.5***
	(29)	(35.5)	
Drought	26.3	17.3	9.0***
	(44)	(37.8)	
Storm	1.4	8.2	−6.8***
	(11.8)	(27.5)	
Other climate shocks	1.2	9.6	−8.4***
	(10.7)	(29.4)	
Market shock	15.1	4.5	10.6***
	(35.8)	(20.8)	
Idiosyncratic shock (Idio_shock)	37.7	57.0	−19.3***
of which:	(48.5)	(49.5)	
Demographic shocks	23.4	34.1	−10.8***
	(42.3)	(47.4)	
Agricultural production shocks	8.9	26.1	−17.2***
	(28.5)	(43.9)	
Financial shocks	10.0	9.6	0.4
	(30)	(29.5)	
Other idiosyncratic shocks	4.6	6.8	−2.2***
	(21)	(25.2)	
Number of observations	9291	9525	

*Significant at 10%, **significant at 5%, ***significant at 1%; standard deviations in parentheses

Thailand and Vietnam, respectively. Adverse weather events are the dominant covariate shocks in both countries. Among them, drought is the most popular climatic shock in Thailand while in Vietnam storms and floods are also frequent. Market shocks are also important covariate shocks in Thailand. Around 38 and 57 percent of the surveyed households in Thailand and Vietnam experienced at least one idiosyncratic shock, respectively. Demographic shocks such as illness, injury, or death of household members are the most frequent, accounting for around 60 percent of all idiosyncratic shocks in each country.

5.2 Estimation results and discussion

5.2.1 Impact of shocks on household consumption

Estimated results of Eq. (9) are presented in Table 4. The lagged per capita consumption is statistically significant to the current consumption in both Thailand and Vietnam, and thus supports our dynamic specification. The positive coefficient

Table 4 Impact of shocks on household consumption

Dependent variable (consumption per capita (ln))	Thailand		Vietnam	
Lag consumption per capital (ln)	0.083***	(0.023)	0.081***	(0.027)
Covariate shock	−0.028*	(0.015)	−0.081***	(0.019)
Idiosyncratic shock	0.046***	(0.015)	−0.020	(0.016)
Labor diversification				
Land diversification				
Age	0.003***	(0.001)	−0.001	(0.001)
Ethnic majority	0.168***	(0.033)	0.419***	(0.058)
Education	0.043***	(0.004)	0.018***	(0.002)
Household size	−0.179***	(0.008)	−0.212***	(0.014)
Household labor	0.055***	(0.011)	0.059***	(0.012)
Farmland (ln)	0.026***	(0.006)	0.032***	(0.006)
Tractors	0.072***	(0.016)	0.070***	(0.024)
Motorbikes	0.171***	(0.011)	0.309***	(0.023)
Livestock (TLU)	−0.013***	(0.004)	−0.005	(0.005)
Health insurances	0.103***	(0.031)	0.042***	(0.006)
Public transfer	−0.067***	(0.016)	0.345*	(0.201)
Saving	0.002	(0.130)	0.003	(0.141)
Credit	−0.025	(0.110)	0.219***	(0.063)
Remittances	0.084	(0.102)	−0.546***	(0.137)
Road type	−0.022***	(0.008)	0.049***	(0.013)
Distance to town (ln)	−0.014*	(0.008)	−0.004	(0.006)
2010	−0.015	(0.019)	−0.100*	(0.052)
2013	0.109***	(0.027)	0.318***	(0.082)
2016	0.251***	(0.028)	0.352***	(0.100)
Constant	6.576***	(0.220)	6.165***	(0.233)
Number of observations	7113	7372		
AR (1) test (p-value)[a]	0.000	0.000		
AR (2) test (p-value)[b]	0.966	0.824		
Hansen test (p-value)[c]	0.109	0.144		

*Significant at 10%, ** significant at 5%, ***significant at 1%, robust standard errors in parentheses

[a, b]Arellano-Bond test for autocorrelation: *H0* no autocorrelation

[c]Hansen test: *H0* the overidentification restrictions are valid (instruments are valid)

of the lagged consumption indicates that the impact of shocks is not persistent in these countries. In other words, shocks in the previous years do not negatively affect household consumption in the current year. Regarding the impact of current shocks, covariate shocks reduce per capita consumption by three percent in Thailand and eight percent in Vietnam. Meanwhile, idiosyncratic shocks increase per capita consumption significantly in Thailand by 4.6 percent but this effect is not statistically significant in Vietnam.

The positive association between idiosyncratic shocks and per capita consumption in Thailand can be explained by two main factors: first, the dominance of health shocks and second, the availability of coping strategies for health shocks in this country. As presented in Table 3, health shocks such as illness, injury, or death of household members account for more than 63 percent of all idiosyncratic shocks in Thailand. These shocks often make households in developing countries increase their consumption, for example for more nutritious food, so that affected members are able to recover (Alam and Mahal 2014). In addition, health insurance is more popular in Thailand, which helps rural households to reduce out-of-pocket health spending. As a result, the positive association between idiosyncratic shocks and per capita consumption is possible. Our results in this table are also consistent with the full consumption insurance model that the coping strategies adopted by rural households in these countries are sufficient to insure consumption from idiosyncratic shocks. However, they cannot absorb the negative effect of covariate shocks. Therefore, finding more effective instruments to deal with covariate shocks in rural areas of middle-income countries is still important.

5.2.2 Impact of shocks on livelihood diversification

Estimated results of Eq. (10) are presented in Table 5. They show that an idiosyncratic shock does not statistically significantly impact on any of the two diversification strategies in both countries. Possibly, livelihood diversification is not an *ex-post* coping strategy for this type of shock. The availability of other instruments such as health insurance (Damrongplasit and Melnick 2015; Hoang et al. 2018), formal and informal credit (Barslund and Tarp 2008; Kislat 2015), and remittances (Amare and Hohfeld 2016; Curran et al. 2016) might be alternatives to maintain consumption. However, the effect of a covariate shock on livelihood diversification is distinct. A covariate shock increases the labor diversification index by four percentage points, but has no significant effect on the land diversification index in Thailand. Meanwhile, in Vietnam, it decreases the labor diversification index by five percentage points and increases the land diversification index by seven percentage points. Thus, covariate shocks are drivers of livelihood diversification in the study sites of both countries. In Thailand, it pushes household labor out of their own agricultural production by making the rain-fed farming in economic terms less attractive. For instance, Thai farmers have little chances to switch their crops when a shortage of rainfall occurs (Lacombe et al. 2017). As a result, they can only undertake local off-farm activities with a low return due to their low level of education and a high share of agricultural laborers (see Tables 1 and 2).

In Vietnam, rural households with less economic advantages have also to diversify *ex-post* but with different mechanisms. Earnings from local non-farm activities, especially among economically disadvantaged groups are rather limited and might rely on casual employments from moving around in the agricultural sector (Brünjes and Revilla Diez 2016). When climatic shocks strike, such casual off-farm opportunities decline, and thus lead to a negative effect on household labor diversification.

Table 5 Impact of shocks on livelihood diversification

Dependent variable (land and labor diversification index)	Thailand		Vietnam	
	Labor diversification	Land diversification	Labor diversification	Land diversification
	(1)	(2)	(3)	(4)
Lag labor diversification	0.132*** (0.026)		0.118*** (0.024)	
Lag land diversification		0.268*** (0.031)		0.383 (0.374)
Covariate shocks	3.795*** (1.231)	0.627 (1.263)	−5.069*** (1.957)	5.661** (2.572)
Idiosyncratic shocks	0.237 (1.111)	−0.505 (1.030)	−0.977 (1.194)	−0.588 (1.166)
Age	−0.131* (0.071)	0.078 (0.086)	−0.072 (0.179)	0.026 (0.054)
Ethnic majority	4.414 (2.751)	−4.438 (3.746)	−38.912 (24.003)	−0.742 (3.924)
Education	0.183 (0.264)	−0.318 (0.278)	0.258 (0.583)	0.532 (0.460)
Household size	0.492 (0.539)	−0.022 (0.402)	0.257 (1.037)	−0.700 (0.704)
Household labor	6.530*** (0.811)	−0.633 (0.688)	2.072** (1.012)	0.019 (0.640)
Farmland (ln)	1.605*** (0.461)	3.207*** (0.660)	−1.504 (1.480)	3.945** (1.959)
Tractors	−4.298*** (1.118)	3.409*** (1.030)	−7.690*** (1.950)	5.025* (2.668)
Motorbikes	1.992** (0.815)	−1.366 (0.897)	6.531*** (2.011)	1.355 (1.869)
Livestock (TLU)	−0.484* (0.264)	0.140 (0.253)	5.627** (2.816)	−3.575 (3.268)
Health insurances	2.046 (2.320)	−2.438 (1.898)	3.554*** (1.224)	−0.432 (0.479)
Public transfer	−1.324 (1.256)	0.858 (1.041)	−5.547 (3.490)	5.142** (2.321)
Saving	5.784 (17.101)	15.520 (18.878)	8.752 (11.181)	−29.547 (28.306)
Credit	−2.874 (10.396)	26.828** (12.625)	9.881** (4.748)	13.192 (8.243)
Remittances	−12.815 (8.828)	−7.103 (7.958)	−25.162** (11.313)	4.683 (12.175)
Road type	−1.410** (0.631)	−4.133*** (1.349)	−5.326*** (2.042)	−1.547* (0.818)
Distance to town (ln)	−0.132 (0.579)	−14.264** (5.620)	−1.291*** (0.433)	−0.101 (0.442)
2010	0.222 (1.718)	−0.085 (1.793)	−10.368** (4.770)	3.449 (9.347)
2013	−6.331** (2.581)	5.572* (2.902)	7.173 (5.620)	14.673* (8.544)
2016	−1.287 (2.649)	0.854 (3.681)	−6.316 (7.347)	13.269 (13.546)

Table 5 (continued)

Dependent variable (land and labor diversification index)	Thailand		Vietnam	
	Labor diversification	Land diversification	Labor diversification	Land diversification
	(1)	(2)	(3)	(4)
Constant	27.534* (15.368)	31.939 (28.602)	87.121*** (19.432)	7.578 (13.586)
Number of observations	7113	7113	7372	7372
AR (1) test (p-value)[a]	0.000	0.000	0.000	0.000
AR (2) test (p-value)[b]	0.383	0.901	0.105	0.344
Hansen test (p-value)[c]	0.101	0.247	0.293	0.587

*Significant at 10%, **significant at 5%, ***significant at 1%, robust standard errors in parentheses

[a, b]Arellano-Bond test for autocorrelation: *H0* no autocorrelation

[c]Hansen test: *H0* the overidentification restrictions are valid (instruments are valid)

Increasing the number of crops is therefore a choice in response to weather shocks (Nguyen et al. 2017).

Going beyond shocks, there are other factors that determine livelihood diversification. Households with a larger farmland area and more agricultural productive assets such as tractors are able to grow more crops. Similarly, households with more labor and transportation vehicles such as motorbikes are able to increase their participation in other sectors. In addition, in both countries, households in villages with poorer road access, have lower levels of land and labor diversifications. Similarly, households in the villages locating far from the town center have a lower level of land diversification in Thailand and a lower of labor diversification in Vietnam. Probably, poor road conditions prevent rural household members from accessing local crop markets and off-farm opportunities. Therefore, as suggested by Mottaleb and Rahut (2019), improvement of roads is a necessary precondition for livelihood diversification in rural areas.

5.2.3 Impact of livelihood diversification on consumption

The estimated results of Eq. (11) are presented in Table 6. Regarding the roles of labor and land diversification as a means of living, we find that only in Thailand land diversification has a negative and significant impact on per capita consumption. The effects of land diversification in Vietnam and of labor diversification in both countries are insignificant. Overall, this result reveals that livelihood diversification is not an income enhancing strategy in these two middle-income countries. This is different in low-income countries where livelihood diversification contributes to increasing income (e.g., McCord et al. 2015; Michler and Josephson 2017). It is rather an instrument adopted by rural households to reduce income risks (by

Table 6 Impact of livelihood diversification on household consumption

Dependent variable (consumption per capita (ln))	Thailand	Vietnam
Lag consumption per capita (ln)	0.086***	0.079***
	(0.024)	(0.029)
Covariate shock	−0.027*	−0.091***
	(0.015)	(0.029)
Idiosyncratic shock	0.046***	−0.017
	(0.015)	(0.017)
Labor diversification	0.001	−0.001
	(0.001)	(0.002)
Land diversification	−0.003**	0.002
	(0.001)	(0.003)
Age	0.003***	0.001
	(0.001)	(0.002)
Ethnic majority	0.144***	0.419***
	(0.034)	(0.072)
Education	0.044***	0.016***
	(0.004)	(0.003)
Household size	−0.181***	−0.208***
	(0.008)	(0.014)
Household labor	0.059***	0.061***
	(0.013)	(0.015)
Farmland (ln)	0.034***	0.026**
	(0.008)	(0.011)
Tractors	0.085***	0.046*
	(0.018)	(0.026)
Motorbikes	0.171***	0.303***
	(0.011)	(0.025)
Livestock (TLU)	−0.013***	−0.008
	(0.004)	(0.010)
Health insurances	0.104***	0.043***
	(0.031)	(0.008)
Public transfer	−0.062***	0.250
	(0.016)	(0.182)
Saving	−0.018	0.082
	(0.118)	(0.129)
Credit	0.041	0.198***
	(0.089)	(0.068)
Remittances	0.111	−0.597***
	(0.096)	(0.156)
Road type	−0.025***	0.041***
	(0.008)	(0.014)
Distance to town (ln)	−0.017**	−0.004
	(0.008)	(0.007)
2010	−0.006	−0.133***
	(0.019)	(0.050)
2013	0.129***	0.281***
	(0.026)	(0.086)
2016	0.263***	0.293***
	(0.027)	(0.094)

Table 6 (continued)

Dependent variable (consumption per capita (ln))	Thailand	Vietnam
Constant	6.565*** (0.221)	6.218*** (0.294)
Number of observations	7113	7372
AR (1) test (*p*-value)[a]	0.000	0.000
AR (2) test (*p*-value)[b]	0.966	0.820
Hansen test (*p*-value)[c]	0.109	0.322

*Significant at 10%, **significant at 5%, ***significant at 1%, robust standard errors in parentheses

[a, b]Arellano–Bond test for autocorrelation: *H0* no autocorrelation

[c]Hansen test: *H0* the overidentification restrictions are valid (instruments are valid)

diversifying *ex-ante*) and to maintain food security (by diversifying *ex-post*). Regarding land diversification, this view is supported by previous studies, for example Kasem and Thapa (2011) who report that crop diversification in Thailand brings higher income than mono-rice cultivation but it significantly requires more labor. In addition, households diversifying crops have a smaller farm size and a lower share of off-farm income than those practicing monoculture. In terms of labor diversification, our result supports Reardon (1997) who stresses the importance of rural nonfarm labor markets in developing countries. It is obvious that entry barriers to local high earning nonfarm activities and high income crops have constrained the roles of land and labor diversification in enhancing household well-beings.

The estimated results of Eq. (12) reported in Table 7 demonstrate the contradictory roles of land and labor diversification as shock coping strategies in these two countries. In Thailand, the interactions between land diversification and shocks (both idiosyncratic and covariate) are significant and positive to household consumption while the interactions between labor diversification and shocks are insignificant. In Vietnam, the interactions between land diversification and shocks are not statistically significant but those between labor diversification and shocks are positive and significant to household consumption.

In general, our results reveal that livelihood diversification, when used as a coping strategy, is effective in helping rural households in middle-income countries to partly mitigate the impact of shocks, except for idiosyncratic shocks in Thailand. The positive interaction between land diversification and idiosyncratic shocks illustrates that the increase in per capita consumption due to shocks is higher than the decrease in per capita consumption due to land diversification. This is consistent with the estimated results in Tables 4 and 5. In particular, our findings from Tables 5 and 7 show that diversifying *ex-ante* (e.g., land diversification in Thailand, and labor diversification in Vietnam) is more helpful than diversifying *ex-post* (e.g., labor diversification in Thailand, and land diversification in Vietnam).

There might be the possibility that the pattern of livelihood diversification is inherited over time, and thus having some impact on current consumption. We,

Table 7 Role of livelihood diversification in mitigating the impact of shocks on consumption

Dependent variable (consumption per capita (ln))	Land diversification		Labor diversification	
	Thailand	Vietnam	Thailand	Vietnam
	(1)	(2)	(3)	(4)
Lag consumption per capita (ln)	0.089***	0.085***	0.097***	0.076***
	(0.023)	(0.027)	(0.027)	(0.029)
Covariate shock	−0.212***	−0.179***	−0.156*	−0.292***
	(0.041)	(0.067)	(0.094)	(0.105)
Idiosyncratic shock	−0.036	−0.139	0.449	−0.273**
	(0.031)	(0.101)	(0.305)	(0.138)
Labor diversification	−0.000	−0.001	0.002	−0.007*
	(0.001)	(0.002)	(0.003)	(0.004)
Land diversification	−0.008***	−0.008	−0.002	0.002
	(0.002)	(0.005)	(0.002)	(0.003)
Cov_shock * labor diversification			0.003	0.004**
			(0.002)	(0.002)
Idio_shock * labor diversification			−0.009	0.005*
			(0.007)	(0.003)
Cov_shock * land diversification	0.007***	0.004		
	(0.002)	(0.003)		
Idio_shock * land diversification	0.003***	0.005		
	(0.001)	(0.004)		
Age	0.003***	0.001	−0.001	−0.001
	(0.001)	(0.002)	(0.003)	(0.001)
Ethnic	0.139***	0.372***	0.230***	0.425***
	(0.035)	(0.064)	(0.058)	(0.069)
Education	0.041***	0.017***	0.039***	0.016***
	(0.004)	(0.002)	(0.005)	(0.003)
Household size	−0.180***	−0.208***	−0.196***	−0.204***
	(0.008)	(0.014)	(0.018)	(0.014)
Household labor	0.054***	0.058***	0.080***	0.068***
	(0.013)	(0.015)	(0.026)	(0.013)
Farmland (ln)	0.047***	0.052***	0.044***	0.033***
	(0.009)	(0.011)	(0.012)	(0.012)
Tractors	0.084***	0.058**	0.075***	0.023
	(0.018)	(0.027)	(0.021)	(0.027)
Motorbikes	0.175***	0.292***	0.155***	0.310***
	(0.011)	(0.024)	(0.015)	(0.023)
Livestock (TLU)	−0.012***	0.008	−0.015***	−0.006
	(0.004)	(0.009)	(0.004)	(0.010)
Health insurances	0.105***	0035***	0.118***	0.044***
	(0.030)	(0.0.07)	(0.035)	(0.007)
Public transfer	−0.066***	0.278	0.217	0.199
	(0.016)	(0.208)	(0.235)	(0.187)
Saving	−0.004	0.116	0.061	0.064
	(0.119)	(0.140)	(0.173)	(0.126)
Credit	−0.025	0.250**	0.039	0.201***
	(0.091)	(0.108)	(0.147)	(0.067)

Table 7 (continued)

Dependent variable (consumption per capita (ln))	Land diversification		Labor diversification	
	Thailand	Vietnam	Thailand	Vietnam
	(1)	(2)	(3)	(4)
Remittances	0.028	−0.582***	0.028	−0.631***
	(0.097)	(0.148)	(0.096)	(0.146)
Road type	−0.024***	0.037**	−0.121	0.034**
	(0.009)	(0.016)	(0.097)	(0.014)
Distance to town (ln)	−0.015*	−0.007	−0.181**	−0.007
	(0.008)	(0.006)	(0.078)	(0.007)
2010	−0.012	−0.146***	−0.079	−0.141***
	(0.019)	(0.051)	(0.075)	(0.050)
2013	0.144***	0.301***	0.095	0.298***
	(0.027)	(0.102)	(0.075)	(0.081)
2016	0.260***	0.289***	0.135	0.300***
	(0.027)	(0.099)	(0.110)	(0.092)
Constant	6.801***	6.473***	6.975***	6.630***
	(0.238)	(0.360)	(0.408)	(0.369)
Number of observations	7113	7372	7113	7372
AR (1) test (*p*-value)a	0.000	0.000	0.000	0.000
AR (2) test (*p*-value)b	0.958	0.761	0.212	0.980
Hansen test (*p*-value)c	0.481	0.144	0.561	0.437

*Significant at 10%, **significant at 5%, ***significant at 1%, robust standard errors in parentheses

[a, b]Arellano-Bond test for autocorrelation: *H0* no autocorrelation

[c]Hansen test: *H0* the overidentification restrictions are valid (instruments are valid)

therefore, estimate another specification of Eq. (12) in which we use the lagged value of the land and labor diversification indices. The estimated results of this specification (in Appendix 5) also show that the interactions between shocks and lags of land diversification in Thailand and labor diversification in Vietnam are positive. Meanwhile, the interactions between shocks and lags of labor diversification in Thailand and land diversification in Vietnam are not statistically significant.

6 Conclusions

Livelihood diversification is an important strategy to improve household welfare and to cope with shocks in low-income countries. However, the role of livelihood diversification is little known in middle-income countries. This study examines and compares the effects of land and labor diversification strategies of rural households who are exposed to covariate and idiosyncratic shocks in these two emerging economies, Thailand—an upper middle-income country, and Vietnam—a lower middle-income country. We use an unbalanced panel dataset of rural households and villages from five survey waves undertaken during

2007–2016. We employ the System-Generalized Method of Moments estimators to control for potential endogeneity. Our analysis results in several important findings.

First, we find that covariate shocks are negatively associated with household consumption in both countries, but idiosyncratic shocks are positively associated with household consumption in Thailand. Covariate shocks are found to be positively associated with labor diversification in Thailand, but negatively with labor diversification in Vietnam. Meanwhile, there is no evidence on the relationship between idiosyncratic shocks and labor and land diversification in both countries. Second, labor and land diversifications are found not to be able to improve household consumption in Thailand and Vietnam. Instead, the role of labor and land diversification as a shock coping strategy is more pronounced. Third, however, this does not mean that these diversifications are effective in mitigating the negative effects of shocks on household consumption. Although rural households in both countries are able to insure their consumption against idiosyncratic shocks, they are not able to do so against covariate shocks. In response to covariate shocks, only land diversification in Thailand and labor diversification in Vietnam are effective in maintaining household consumption.

As these two countries are among the ones most affected by extreme weather events worldwide, and rural households belong to the most vulnerable groups, more effective instruments should be developed to support rural households. Our findings suggest that promoting land diversification in Thailand and labor diversification in Vietnam would benefit rural households in dealing with covariate shocks. This can be done through facilitating access to credit, enhancing farm mechanization, and improving road quality in Thailand as well as promoting the development of local rural nonfarm sectors in Vietnam.

Even though our study provides important insights, it still has a number of limitations. First, it covers only six provinces in two middle-income countries. Second, the panel are only for a ten year period. Thus, extending the spatial and temporal coverage would allow for a more robust generalization. From a methodological point of view, despite the S-GMM estimators are able for account for endogeneity concerns, they in fact ignore the cross-sectional dependence. These issues should be addressed in future studies.

Appendix 1: Name and definition of the independent variables in the regression models

Variable	Definition
Household level	
age	Age of household (HH) head in years
education	Education level of HH head in years
ethnic majority	Dummy if HH head is ethnic majority (1 = yes)
household size	Number of HH nucleus members who stays in the HH for at least 180 days

Variable	Definition
household labor	Number of HH nucleus labors, aging from 15–65 years old
farmland size	Total area of agricultural land of the household in ha
tractor	Number of tractors of household
motorbike	Number of motorbikes of household
savings	Dummy if HH has savings (1 = yes)
credit	Dummy if HH has an access to credit in the last 02 years (1 = yes)
livestock	Number of livestock owns by HH (in tropical livestock unit)
remittance	Dummy if HH receives remittances from family members (1 = yes)
health insurance	Number of voluntary health insurance owned by household
public transfer	Dummy if HH was monetary assisted from public sector (1 = yes)
Village characteristics	
road type	1=two-lane road; 2=single lane road; 3=all seasons dirt road; 4=dirt road, seasonally not viable
distance to town	Distance from village to the district town in km
Shocks	
Covariate shock	Dummy if HH experienced with covariate shocks in the last two years (1 = yes)
Idiosyncratic shock	Dummy if HH experienced with idiosyncratic shocks in the last two years (1 = yes)

Appendix 2: Variance inflation factor values as a multicollinearity check for the models presented in Tables 4, 5, 6

	Equation 10		Equation 11				Equation 12	
	Thailand	Vietnam	Thailand	Thailand	Vietnam	Vietnam	Thailand	Vietnam
Lag consumption							1.32	1.8
Lag labor diversification index				1.06		1.08		
Lag land diversification index			1.25		1.21			
Age	1.39	1.2	1.4	1.41	1.19	1.21	1.41	1.2
Ethnic	1.02	1.43	1.02	1.02	1.47	1.44	1.02	1.51
Education	1.18	1.25	1.18	1.18	1.26	1.26	1.24	1.29
Household size	2.42	2.19	2.45	2.45	2.23	2.23	2.67	2.44
Household labor	2.52	2.2	2.55	2.57	2.24	2.25	2.6	2.26
Farmland size (ln)	1.35	1.38	1.41	1.37	1.41	1.37	1.36	1.38
Tractor	1.26	1.16	1.28	1.26	1.17	1.18	1.26	1.17
Motorbike	1.22	1.48	1.21	1.21	1.47	1.47	1.25	1.69
Livestock (TLU)	1.19	1.19	1.19	1.19	1.25	1.19	1.19	1.21
Health insurance	1.03	1.2	1.01	1.01	1.24	1.24	1.01	1.25
Public transfer	1.33	1.13	1.26	1.26	1.19	1.18	1.27	1.19
Covariate shock	1.13	1.11	1.14	1.14	1.14	1.13	1.14	1.13

	Equation 10		Equation 11				Equation 12	
	Thailand	Vietnam	Thailand	Thailand	Vietnam	Vietnam	Thailand	Vietnam
Idiosyncratic shock	1.03	1.03	1.04	1.04	1.03	1.03	1.04	1.03
Road type	1.12	1.19	1.13	1.13	1.2	1.2	1.13	1.21
Distance to town (ln)	1.06	1.06	1.07	1.07	1.04	1.04	1.07	1.04
2010	1.34	1.29	1.68	1.57	1.64	1.63	1.59	1.64
2013	1.38	1.38	1.81	1.65	1.72	1.72	1.66	1.71
2016	1.54	1.62	1.91	1.78	2.01	2.02	1.82	2.05
Mean VIF	1.36	1.36	1.42	1.39	1.43	1.41	1.42	1.48

Appendix 3: Variance inflation factor values as a multicollinearity check for the model in Table 7

	Thailand	Vietnam	Thailand	Vietnam
Lag consumption	1.32	1.82	1.32	1.82
Covariate shock*labor diversification			3.57	3.72
Idiosyncratic shock* labor diversification			3.28	4.33
Covariate shock*land diversification	3.56	3.81		
Idiosyncratic shock* land diversification	2.92	3.88		
Labor diversification index	1.14	1.15	2.5	3.28
Land diversification index	2.83	3.66	1.22	1.28
Age	1.42	1.23	1.42	1.23
Ethnic	1.03	1.53	1.03	1.53
Education	1.24	1.3	1.24	1.3
Household size	2.67	2.46	2.67	2.46
Household labor	2.68	2.28	2.68	2.28
Farmland size (ln)	1.54	1.46	1.5	1.45
Tractor	1.28	1.19	1.28	1.19
Motorbike	1.26	1.7	1.26	1.7
Livestock (TLU)	1.2	1.27	1.2	1.27
Health insurance	1.01	1.25	1.01	1.25
Public transfer	1.27	1.2	1.27	1.2
Covariate shock	2.39	2.55	2.76	3.1
Idiosyncratic shock	2.1	2.21	2.54	2.9
Road type	1.14	1.22	1.14	1.21
Distance to town (ln)	1.07	1.05	1.08	1.05
2010	1.59	1.64	1.59	1.64
2013	1.69	1.72	1.67	1.72
2016	1.82	2.06	1.82	2.06
Mean VIF	1.75	1.9	1.78	1.96

Appendix 4: Variance inflation factor values as a multicollinearity check for the model in Appendix 5

	Thailand	Vietnam	Thailand	Vietnam
Lag consumption	1.32	1.81	1.32	1.81
Covariate shock* lag labor diversification			3.52	3.46
Idiosyncratic shock* lag labor diversification			3.35	4.13
Covariate shock* lag land diversification	2.89	3.52		
Idiosyncratic shock* lag land diversification	2.42	3.8		
Lag labor diversification index	1.07	1.08	2.44	3.17
Lag land diversification index	2.68	3.52	1.25	1.21
Age	1.42	1.22	1.42	1.22
Ethnic	1.03	1.54	1.03	1.54
Education	1.24	1.3	1.24	1.3
Household size	2.67	2.45	2.67	2.45
Household labor	2.62	2.27	2.62	2.27
Farmland size (ln)	1.44	1.43	1.43	1.42
Tractor	1.28	1.18	1.28	1.18
Motorbike	1.25	1.7	1.26	1.7
Livestock (TLU)	1.19	1.27	1.19	1.27
Health insurance	1.01	1.25	1.01	1.25
Public transfer	1.27	1.19	1.27	1.19
Covariate shock	1.96	2.42	2.82	2.89
Idiosyncratic shock	1.76	2.15	2.61	2.73
Road type	1.14	1.21	1.14	1.21
Distance to town (ln)	1.07	1.05	1.07	1.05
2010	1.7	1.66	1.7	1.66
2013	1.83	1.72	1.82	1.72
2016	1.96	2.08	1.96	2.08
Mean VIF	1.66	1.86	1.8	1.91

Appendix 5: Role of lagged livelihood diversification in mitigating the impact of shocks

Dependent variable (consumption per capita (ln))	Land diversification		Labor diversification	
	Thailand	Vietnam	Thailand	Vietnam
	(1)	(2)	(3)	(4)
Lag consumption per capita (ln)	0.082*** (0.023)	0.088*** (0.028)	0.085*** (0.024)	0.084*** (0.026)
Covariate shock	-0.052*** (0.018)	−0.101*** (0.028)	−0.025 (0.022)	−0.079*** (0.024)
Idiosyncratic shock	0.046** (0.018)	−0.015 (0.025)	0.044** (0.021)	−0.053** (0.023)
Lag labor diversification	0.0006*** (0.0002)	0.0001 (0.0002)	0.0004 (0.0003)	−0.0003 (0.0003)
Lag land diversification	0.0002 (0.0004)	−0.0014*** (0.0005)	0.0007** (0.0003)	−0.0014*** (0.0003)
Cov_shock * Lag labor diversification			0.0002 (0.0003)	0.0001 (0.0003)
Idio_shock * Lag labor diversification			0.0002 (0.0004)	0.0007* (0.0003)
Cov_shock *Lag land diversification	0.0011** (0.0005)	0.0005 (0.0005)		
Idio_shock * Lag land diversification	0.0000 (0.0005)	−0.0004 (0.0006)		
Age	0.003*** (0.001)	−0.001 (0.002)	0.003*** (0.001)	−0.0001 (0.001)
Ethnic	0.168*** (0.033)	0.431*** (0.064)	0.191*** (0.036)	0.408*** (0.057)
Education	0.043*** (0.004)	0.018*** (0.002)	0.045*** (0.004)	0.018*** (0.002)
Household size	−0.179*** (0.008)	−0.217*** (0.015)	−0.184*** (0.009)	−0.213*** (0.013)
Household labor	0.053*** (0.011)	0.063*** (0.014)	0.054*** (0.011)	0.059*** (0.012)
Farmland (ln)	0.024*** (0.006)	0.038*** (0.007)	0.032*** (0.006)	0.036*** (0.007)
Tractors	0.071*** (0.016)	0.082*** (0.026)	0.077*** (0.016)	0.073*** (0.024)
Motorbikes	0.169*** (0.011)	0.307*** (0.027)	0.176*** (0.011)	0.306*** (0.023)
Livestock (TLU)	−0.013*** (0.004)	−0.003 (0.006)	-0.011*** (0.004)	−0.002 (0.005)
Health insurances	0.103*** (0.031)	0.041*** (0.007)	0.127*** (0.032)	0.041*** (0.006)
Public transfer	−0.066*** (0.016)	0.485** (0.235)	−0.060*** (0.017)	0.363* (0.201)

Dependent variable (consumption per capita (ln))	Land diversification		Labor diversification	
	Thailand	Vietnam	Thailand	Vietnam
	(1)	(2)	(3)	(4)
Saving	0.002	0.027	−0.325*	−0.014
	(0.130)	(0.195)	(0.186)	(0.141)
Credit	−0.023	0.284**	−0.023	0.217***
	(0.109)	(0.124)	(0.118)	(0.062)
Remittances	0.101	−0.537***	0.049	−0.524***
	(0.104)	(0.148)	(0.082)	(0.133)
Road type	−0.021***	0.054***	−0.022***	0.050***
	(0.008)	(0.015)	(0.009)	(0.013)
Distance to town (ln)	−0.014*	−0.006	−0.013	−0.005
	(0.008)	(0.006)	(0.009)	(0.006)
2010	−0.028	−0.079	−0.022	−0.085
	(0.021)	(0.061)	(0.021)	(0.052)
2013	0.096***	0.380***	0.088***	0.328***
	(0.029)	(0.118)	(0.029)	(0.081)
2016	0.238***	0.389***	0.226***	0.369***
	(0.029)	(0.118)	(0.030)	(0.101)
Constant	6.551***	6.039***	6.789***	6.192***
	(0.222)	(0.278)	(0.234)	(0.234)
Number of observations	7113	7372	7113	7372
AR (1) test (p-value)[a]	0.00	0.00	0.00	0.00
AR (2) test (p-value)[b]	0.976	0.807	0.838	0.798
Hansen test (p-value)c	0.130	0.240	0.180	0.177

*Significant at 10%, **significant at 5%, ***significant at 1%, robust standard errors in parentheses

[a, b]Arellano-Bond test for autocorrelation: *H0* no autocorrelation

[c]Hansen test: *H0* the overidentification restrictions are valid (instruments are valid)

Acknowledgements We would like to thank the respondents from the surveyed provinces for their kind support and cooperation. We acknowledge the financial support of the German Research Foundation (DFG—FOR 756/2) for the TVSEP project and appreciate the efforts of our colleagues at the Leibniz University Hannover for data collection and cleaning. We also thank the participants of the 6th Economics of Natural Resources and the Environment Conference organized by the University of Thessaly (11-12.06.2021) and four anonymous reviewers for their comments to improve our study.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability The data used in this study are available at the following website: www.tvsep.de

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

References

Ahn SC, Kim HY, Kang TH (2017) Life-cycle consumption, precautionary saving, and risk sharing: an integrated analysis using household panel data. The BE J Macroecon. https://doi.org/10.1515/bejm-2016-0082

Alam K, Mahal A (2014) Economic impacts of health shocks on households in low and middle income countries: a review of the literature. Global Health 10:21. https://doi.org/10.1186/1744-8603-10-21

Alobo Loison S (2015) Rural livelihood diversification in Sub-Saharan Africa: a literature review. J Dev Stud 51:1125–1138. https://doi.org/10.1080/00220388.2015.1046445

Amare M, Hohfeld L (2016) Poverty transition in Rural Vietnam: the role of migration and remittances. J Dev Stud 52:1463–1478. https://doi.org/10.1080/00220388.2016.1139696

Arellano M, Bond S (1991) Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev Econ Stud 58:277. https://doi.org/10.2307/2297968

Arellano M, Bover O (1995) Another look at the instrumental variable estimation of error-components models. J Econom 68:29–51. https://doi.org/10.1016/0304-4076(94)01642-D

Arouri M, Nguyen C, Youssef AB (2015) Natural disasters, household welfare, and resilience: evidence from rural Vietnam. World Dev 70:59–77. https://doi.org/10.1016/j.worlddev.2014.12.017

Arslan A, Cavatassi R, Alfani F, Mccarthy N, Lipper L, Kokwe M (2018) Diversification under climate variability as part of a CSA strategy in rural Zambia. J Dev Stud 54:457–480. https://doi.org/10.1080/00220388.2017.1293813

Attanasio OP, Weber G (2010) Consumption and saving: models of intertemporal allocation and their implications for public policy. J Econ Lit 48:693–751. https://doi.org/10.1257/jel.48.3.693

Auffhammer M, Carleton TA (2018) Regional crop diversity and weather shocks in India. Asian Dev Rev 35:113–130. https://doi.org/10.1162/adev_a_00116

Barrett C, Reardon T, Webb P (2001) Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. Food Pol 26:315–331. https://doi.org/10.1016/S0306-9192(01)00014-8

Barslund M, Tarp F (2008) Formal and informal rural credit in four provinces of Vietnam. J Dev Stud 44:485–503. https://doi.org/10.1080/00220380801980798

Birthal PS, Roy D, Negi DS (2015) Assessing the impact of crop diversification on farm poverty in India. World Dev 72:70–92. https://doi.org/10.1016/j.worlddev.2015.02.015

Blundell R, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data models. J Econom 87:115–143. https://doi.org/10.1016/S0304-4076(98)00009-8

Brünjes J, Revilla Diez J (2016) Obtaining non-farm wage employment in rural Vietnam. Asia Pac Viewp 57:263–279. https://doi.org/10.1111/apv.12116

Bui AT, Dungey M, Nguyen CV, Pham TP (2014) The impact of natural disasters on household income, expenditure, poverty and inequality: evidence from Vietnam. Appl Econ 46:1751–1766. https://doi.org/10.1080/00036846.2014.884706

Cameron LA, Worswick C (2003) The labor market as a smoothing device: labor supply responses to crop loss. Rev Dev Econ 7:327–341. https://doi.org/10.1111/1467-9361.00194

Carter MR, Little PD, Mogues T, Negatu W (2007) Poverty traps and natural disasters in Ethiopia and Honduras. World Dev 35:835–856. https://doi.org/10.1016/j.worlddev.2006.09.010

Curran SR, Meijer-Irons J, Garip F (2016) Economic shock and migration: differential economics effects, migrant responses, and migrant cumulative causation in Thailand. Sociol Dev (oakl) 2:119–157. https://doi.org/10.1525/sod.2016.2.2.119

Damrongplasit K, Melnick G (2015) Funding, coverage, and access under thailand's universal health insurance program: an update after ten years. Appl Health Econ Health Policy 13:157–166. https://doi.org/10.1007/s40258-014-0148-z

Dercon S (2002) Income risk, coping strategies, and safety nets. The World Bank Res Observ 17:141–166. https://doi.org/10.1093/wbro/17.2.141
Dercon S (2004) Growth and shocks: evidence from rural Ethiopia. J Dev Econ 74:309–329. https://doi.org/10.1016/j.jdeveco.2004.01.001
Gao J, Mills BF (2018) Weather shocks, coping strategies, and consumption dynamics in rural Ethiopia. World Dev 101:268–283. https://doi.org/10.1016/j.worlddev.2017.09.002
Gautam Y, Andersen P (2016) Rural livelihood diversification and household well-being: Insights from Humla. Nepal J Rural Stud 44:239–249. https://doi.org/10.1016/j.jrurstud.2016.02.001
Günther I, Harttgen K (2009) Estimating households vulnerability to idiosyncratic and covariate shocks: a novel method applied in Madagascar. World Dev 37:1222–1234. https://doi.org/10.1016/j.worlddev.2008.11.006
Grandstaff TB, Grandstaff S, Limpinuntana V, Suphanchaimat N (2008) Rainfed revolution in Northeast Thailand. Southeast Asian Stud 46(3):289–376
Haggblade S, Hazell P, Reardon T (2010) The rural non-farm economy: prospects for growth and poverty reduction. World Dev 38:1429–1441. https://doi.org/10.1016/j.worlddev.2009.06.008
Hansen LP (1982) Large sample properties of generalized method of moments estimators. Econometrica 50:1029. https://doi.org/10.2307/1912775
Hardeweg B, Klasen S, Waibel H (2013) Establishing a database for vulnerability assessment. In: Klasen S, Waibel H (eds) Vulnerability to poverty: theory, measurement and determinants, with case studies from Thailand and Vietnam, vol 101. Palgrave Macmillan. Basingstoke, England, New York, pp 50–79
Hoang TX, Pham CS, Ulubaşoğlu MA (2014) Non-farm activity, household expenditure, and poverty reduction in rural Vietnam: 2002–2008. World Dev 64:554–568. https://doi.org/10.1016/j.worlddev.2014.06.027
Hoang VN, Nguyen TT, Wilson C, Ho QT, Khanal U (2021) Scale and scope economies of small household rice farming in Vietnam. J Integr Agric 20:3339–3351. https://doi.org/10.1016/S2095-3119(21)63612-2
Hoang CK, Hill P, Nguyen HT (2018) Universal health insurance coverage in Vietnam: a stakeholder analysis from policy proposal (1989) to Implementation (2014). J Public Health Manag Pract 24 Suppl 2 Supplement, Public Health in Vietnam: S52–S59. https://doi.org/10.1097/PHH.0000000000000729
Hussein K, Nelson J (1998) Sustainable livelihoods and livelihood diversification. IDS Working Paper 69. Institute of Development Studies, Sussex. https://www.ids.ac.uk/files/Wp69.pdf
Kasem S, Thapa GB (2011) Crop diversification in Thailand: status, determinants, and effects on income and use of inputs. Land Use Pol 28:618–628. https://doi.org/10.1016/j.landusepol.2010.12.001
Kislat C (2015) Why are informal loans still a big deal? Evidence from North-east Thailand. J Dev Stud 51:569–585. https://doi.org/10.1080/00220388.2014.983907
Klasen S, Povel F (2013) Defining and measuring vulnerability: state of the art and new proposals. In: Klasen S, Waibel H (eds) Vulnerability to poverty: theory, measurement and determinants, with case studies from Thailand and Vietnam, vol 58. Palgrave Macmillan. Basingstoke, England, New York, pp 17–49
Lacombe G, Polthanee A, Trébuil G (2017) Long-term change in rainfall distribution in Northeast Thailand: Will cropping systems be able to adapt? Cahiers Agricul 26:25001. https://doi.org/10.1051/cagri/2017006
Martin SM, Lorenzen K (2016) Livelihood diversification in rural Laos. World Dev 83:231–243. https://doi.org/10.1016/j.worlddev.2016.01.018
McCord PF, Cox M, Schmitt-Harsh M, Evans T (2015) Crop diversification as a smallholder livelihood strategy within semi-arid agricultural systems near Mount Kenya. Land Use Policy 42:738–750. https://doi.org/10.1016/j.landusepol.2014.10.012
Michler JD, Josephson AL (2017) To specialize or diversify: agricultural diversity and poverty dynamics in Ethiopia. World Dev 89:214–226. https://doi.org/10.1016/j.worlddev.2016.08.011
Minot N (2006) Income diversification and poverty in the northern uplands of Vietnam. Research report, 145. International Food Policy Research Institute, Washington, D.C
Mitra S, Palmer M, Mont D, Groce N (2016) Can households cope with health shocks in Vietnam? Health Econ 25:888–907. https://doi.org/10.1002/hec.3196
Mohammed K, Batung E, Kansanga M, Nyantakyi-Frimpong H, Luginaah I (2021) Livelihood diversification strategies and resilience to climate change in semi-arid northern Ghana. Climatic Change 164(3–4):53. https://doi.org/10.1007/s10584-021-03034-y

Mottaleb KA, Rahut DB (2019) Impacts of improved infrastructure on labor allocation and livelihoods: the case of the Jamuna Multipurpose Bridge, Bangladesh. Eur J Dev Res 31:750–778. https://doi.org/10.1057/s41287-018-0186-8

Nguyen TT, Do TL, Bühler D, Hartje R, Grote U (2015) Rural livelihoods and environmental resource dependence in Cambodia. Ecol Econ 120:282–295. https://doi.org/10.1016/j.ecolecon.2015.11.001

Nguyen TT, Nguyen LD, Lippe RS, Grote U (2017) Determinants of Farmers' land use decision-making: comparative evidence from Thailand and Vietnam. World Dev 89:199–213. https://doi.org/10.1016/j.worlddev.2016.08.010

Nguyen TT, Nguyen T-T, Le V-H, Managi S, Grote U (2020) Reported weather shocks and rural household welfare: Evidence from panel data in Northeast Thailand and Central Vietnam. Weather Clim Extrem 30:100286. https://doi.org/10.1016/j.wace.2020.100286

OECD (2009) Managing Risk in Agriculture, OECD

Podhisita C (2017) Household dynamics, the capitalist economy, and agricultural change in rural Thailand. Southeast Asian Stud 6:247–273

Porter C (2012) Shocks, consumption and income diversification in Rural Ethiopia. J Dev Stud 48:1209–1222. https://doi.org/10.1080/00220388.2011.646990

Pradhan KC, Mukherjee S (2018) Covariate and idiosyncratic shocks and coping strategies for poor and non-poor rural households in India. J Quant Econ 16:101–127. https://doi.org/10.1007/s40953-017-0073-8

Rahut DB, Micevska Scharf M (2012) Livelihood diversification strategies in the Himalayas*. Aust J Agric Resour Econ 56:558–582. https://doi.org/10.1111/j.1467-8489.2012.00596.x

Rahut DB, Mottaleb KA, Ali A (2018) Rural livelihood diversification strategies and household welfare in Bhutan. Eur J Dev Res 30:718–748. https://doi.org/10.1057/s41287-017-0120-5

Reardon T (1997) Using evidence of household income diversification to inform study of the rural nonfarm labor market in Africa. World Dev 25:735–747. https://doi.org/10.1016/S0305-750X(96)00137-4

Roodman D (2009a) A note on the theme of too many instruments. Oxford Bull Econ Stat 71:135–158. https://doi.org/10.1111/j.1468-0084.2008.00542.x

Roodman D (2009b) How to do xtabond2: an introduction to difference and system GMM in Stata. Stata J 9:86–136

Sawada Y, Takasaki Y (2017) Natural disaster, poverty, and development: an introduction. World Dev 94:2–15. https://doi.org/10.1016/j.worlddev.2016.12.035

Scoones I (2009) Livelihoods perspectives and rural development. The J Peasant Stud 36:171–196. https://doi.org/10.1080/03066150902820503

Shah AA, Gong Z, Khan NA, Khan I, Ali M, Naqvi SAA (2021) Livelihood diversification in managing catastrophic risks: evidence from flood-disaster regions of Khyber Pakhtunkhwa Province of Pakistan. Environ Sci Pollut Res Int 28:40844–40857. https://doi.org/10.1007/s11356-021-13598-y

Simpson EH (1949) Measurement of diversity. Nature 163:688. https://doi.org/10.1038/163688a0

Skoufias E (2003) Economic crises and natural disasters: coping strategies and policy implications. World Dev 31:1087–1102. https://doi.org/10.1016/S0305-750X(03)00069-X

United Nations (2005) Designing household survey samples: practical guidelines. Economic & social affairs, vol 98. United Nations, New York, NY

Waha K, van Wijk MT, Fritz S, See L, Thornton PK, Wichern J, Herrero M (2018) Agricultural diversification as an important strategy for achieving food security in Africa. Glob Chang Biol 24:3390–3400. https://doi.org/10.1111/gcb.14158