
# Shocks, Agricultural Productivity and Natural Resource Extraction in Rural Southeast Asia

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## Abstract

Natural resources are depleting at an alarming rate, causing severe threats to the sustainable development in many developing countries. Given an ambiguous relationship between shocks, agricultural productivity, and natural resource extraction, we use a dataset of about 4200 rural households surveyed in four Southeast Asian countries (Cambodia, Laos, Thailand, and Vietnam) to investigate the impact of shocks and agricultural productivity on natural resource extraction by rural households. Our results show that weather shocks and market shocks force households to extract more natural resources. An increased agricultural productivity, however, discourages natural resource extraction. In addition, our results show that low education and low access to electricity are positively associated with natural resource extraction. We suggest that measures enhancing agricultural productivity should be prioritized, and more assistance and support to farmers for mitigating the severe effects of weather shocks and market shocks should be provided. Furthermore, accelerating farm mechanization, land defragmentation, rural electrification, supporting the development of communication systems and local markets, and promoting rural education should be encouraged.

***Key words:*** *shocks; agricultural productivity; natural resource extraction; Southeast Asia.*

## 1. Introduction

Natural resource extraction is one of the major livelihood strategies of rural households in Southeast Asian countries (Nguyen et al., 2015; Völker and Waibel, 2010). It provides a wide range of products such as food, medicine, fuel, and construction materials for fulfilling households' subsistence needs and generating cash income. However, natural resource degradation is happening at an alarming rate in this region (Feng et al., 2021; Leung et al., 2020; Sodhi et al., 2010). From 1990 to 2010, the total forest area of Southeast Asia had experienced a drop of around 30 million ha (Stibig et al., 2014). It is expected that this region could lose three-quarters of its original forests and more than 40% of its biodiversity by the end of the 21st century (Sodhi et al., 2004). These losses will also cause long-lasting consequences for the future provision of natural resources and ecosystem services as many of these degraded ecosystems will not be able to recover (Lampert, 2019). Therefore, identifying the factors affecting households' decision to extract natural resources is essential to provide useful information for policymakers and practitioners to design effective programs for environmental conservation.

Another major livelihood strategy of rural households in developing countries is agricultural production. It is the main source of employment and income for at least 30% of the population in low- and middle-income countries (World Bank, 2020). Of this percentage, small-scale farmers make up the majority, approximately 80% of the farming population (Lowder et al., 2016). Their conventional farming methods often rely on using cows as draught power, indigenous seeds, simple equipment, and are highly dependent on weather conditions (Boonsrirat, 2014; Nguyen et al., 2020). Therefore, their productivity is relatively moderate and might not be able to ensure adequate food and sufficient income for farmers (Nguyen et al., 2018a). Consequently, other income-generating activities such as natural resource extraction are also needed (Walelign, 2017).

The relationship between agricultural production and natural resource extraction has been investigated by a few studies, but their results are mixed. On the one hand, some studies show that improving agricultural efficiency could discourage households from extracting natural resources as it will make farming activities more profitable, therefore, increasing the opportunity cost of extraction activities (Illukpitiya and Yanagida, 2010). In addition, raising agricultural productivity makes farmers wealthier, allowing them to substitute market goods for forest goods. On the other hand, it is argued that raising incomes from and returns on agricultural activities motivate farmers to convert forests to farmland (Faris, 1999; Phelps et al., 2013). In addition, an increase in returns on agricultural production could make rural households wealthier, enabling them to access modern technologies to accelerate extraction activities (Bierkamp et al., 2021). It is noted that due to many drivers (natural but also socio-economic factors) and their interactions, it is difficult to provide robust predictions.

Natural resources are argued to play an important role as safety nets to shocks[1] for rural farmers in developing countries (Angelsen et al., 2014). In these countries, farmers are often prone to several types of shocks such as floods, droughts, or market instability, and as formal insurance mechanisms are often limited, shocks might cause severe impacts on their welfare, pushing them into food insecurity and poverty. Under these circumstances, farmers might enhance natural resource extraction for foods and compensate for income losses due to shocks. A few studies have investigated the impact of shocks on natural resource extraction, but the results vary across study sites and types of shocks. For example, Völker and Waibel (2010) show that

[1] Shocks are events that cause damages to households' well-being (Haider and Kumar, 2019) and include weather shocks (e.g. floods, drought, and storms), health shocks (e.g. illness or death), and market shocks (e.g. increase in input price or decrease in output price).

weather shocks and health shocks significantly motivate rural Vietnamese households to extract more natural resources. Wunder et al. (2014) show that covariate shocks significantly push households to extract more natural resources, whereas the impact of idiosyncratic health shocks is insignificant. McSweeney (2004) finds that households in Honduras tend to sell forest products in response to illness and crop shortfalls, but they are more likely to use loans to cope with weather shocks. Moreover, previous studies separately investigate either the impact of shocks on agricultural productivity (Isoto et al., 2017, Amare et al., 2018) or the impact of shocks on natural resource extraction (Takasaki et al., 2004, Völker and Waibel, 2010). None of the empirical studies have taken into account the effect of shocks on agricultural productivity and natural resource extraction simultaneously.

Against this background, our study aims to study the interrelationship between shocks, agricultural productivity, and natural resource extraction by using a large dataset collected from more than 4200 rural households in Southeast Asia (Cambodia, Laos, Thailand, and Vietnam). These Southeast Asian countries are chosen as (i) they are rich in natural resources but among the major hotspots of natural resource degradation, (ii) they have a large share of the population working in the agricultural sector and relying on natural resource extraction, (iii) households in these countries are highly vulnerable to shocks. Our empirical analysis includes two main steps. First, we used ordinary least squares (OLS) models to study the impact of shocks (weather shocks, market shocks, and health shocks) on natural resource extraction. Second, we employed heteroscedasticity-based instruments models to study the impact of agricultural productivity on natural resource extraction. Estimations were conducted for the whole sample as well as for each country. In addition, we also undertook other economic models and specifications to check the robustness of our estimations.

The rest of the paper is structured as follows. Section 2 introduces the study design, including study sites, data sources, and methodologies. Section 3 presents the results. Section 4 discusses the findings and concludes with policy implications.

## 2. Study Design

### *2.1 Study site and data sources*

Our analysis was conducted in rural areas in four Southeast Asian countries, including Cambodia, Laos, Thailand, and Vietnam. This region is endowed with diverse natural resources, but it is also a major hotspot of deforestation and natural degradation (Estoque et al., 2019; Sodhi et al., 2010, Song et al., 2018, Feng et al., 2021). With regard to the economic characteristics of the four surveyed countries, Thailand is the most developed one and is categorized as an upper-middle income country, while Vietnam is a lower-middle income country, and Laos and Cambodia are in the group of the least developed countries (United Nations, 2015). In addition, these countries are commonly characterized by a majority of people living in rural areas and by high dependence on agriculture and natural resources (Birthal et al., 2019; Do & Park, 2019; Zhai & Zhuang, 2009). The shares of the workforce in the agricultural sector in Cambodia, Laos, Thailand, and Vietnam are approximately 40%, 70%, 30%, and 40%, respectively (Birthal et al., 2019). Furthermore, Southeast Asia is among the most vulnerable regions to climate risks with Vietnam, Thailand, Cambodia, and Laos being ranked at $9^{th}$, $13^{th}$, $19^{th}$, and $89^{th}$ position, respectively (Eckstein et al., 2019). It is estimated that due to climate change, extreme weather events will occur more frequently and more severely in this region, causing a potential drop in rice yield by up to 50% by 2100 compared to 1990 levels (Prakash, 2018). This poses severe threats and challenges to ensure food security for an increasing population of around 800 million by 2050 (an increase of about 20% from 2019) (Birthal et al., 2019; Vollset et al., 2020).


**Figure 1. Map of studied sites in Cambodia, Laos, Thailand, and Vietnam**

Our data was collected in 2013 in eight provinces in these four countries: Stung Treng in Cambodia; Savannakhet in Laos; and Dak Lak, Ha Tinh and Thua Thien Hue in Vietnam; Buriram, Nakhon Phanom and Ubon Ratchathani in Thailand (see Figure 1). These provinces were selected because of (i) a high incidence of poverty, (ii) high reliance on agriculture, and

(iii) rich and diverse natural resources. In Thailand and Vietnam, the survey was conducted under the project "Impact of shocks on the vulnerability to poverty: Consequences for development of emerging Southeast Asian Economies (FOR 756)" funded by the German Research Foundation (DFG)[2]. This project aims to generate a deeper understanding of vulnerability to poverty in rural areas of rapidly emerging economies. Following the guidelines of the United Nations Department of Economic and Social Affairs (United Nations, 2005), the random sampling was undertaken based on a three-stage procedure (sub-district, villages and then households; see Povel (2015) and Nguyen et al. (2017) for detailed information of the survey). In the first stage, sub-districts (communes) were sampled with a probability corresponding to the number of households living in these sub-districts, taking into account the population density to ensure that both densely and less densely populated communes are adequately covered (Povel, 2015). Then, sampled villages within the chosen sub-districts were selected with a probability proportional to the size of the population. At the third stage, ten households in each sampled village were randomly chosen. For a generalization of our findings in the Lower Mekong Basin region, similar surveys were conducted in Laos and Cambodia. The surveys were carried out in collaboration with local institutions (Development Resource Institute in Cambodia; University of Champasak in Laos; University of Ubon Ratchathani in Thailand). All enumerators were carefully selected and intensively trained before the surveys took place. Each enumerator conducted face-to-face interviews of around two hours at households' homes. Collected data from each interview was checked in multiple steps (by another enumerator, team leaders, and data typists). In case of missing or implausible data, questionnaires were sent back to the responsible enumerators for correction, either by phone or by another visit to the household.

[2] https://www.tvsep.de/overview-tvsep.html

All information used in our study was collected from the survey with two instruments, namely household questionnaires (for household heads) and village questionnaires (for village heads). The village questionnaire captures villages' information on population, infrastructure, geography, and socioeconomic conditions. The household questionnaire includes about 1000 variables classified into different sections (i.e. demographics, agricultural production, natural resource extraction, non-farm employment, consumption, remittances and financial transfers). The information on natural resource extraction encompasses a wide range of activities such as fishing, hunting, collecting, and logging, types of extracted products, extraction places, extraction costs (e.g. fuel, tools, and materials), and total outputs (quantity and value). As our study mainly focuses on the impact of agricultural productivity on natural resources extraction, we excluded households not engaged in farming activities. Therefore, the final sample includes 4,213 households (507 from Laos, 503 from Cambodia, 1,578 from Thailand, and 1,625 from Vietnam).

### *2.2 Methodology*

#### *2.2.1 Impact of shocks on agricultural productivity*

The first step of our empirical analysis was to estimate the impact of shocks and other household and village characteristics on agricultural productivity. This productivity is represented by two indicators: crop yield (total crop output value per hectare) and crop income per hectare. Crop yield has a positive value for all farmers and was therefore transformed into the logarithmic form in order to reduce potential outliers in value. Meanwhile, as some surveyed households report negative farm income, we did not transform this indicator into the logarithmic form. We applied an OLS regression to estimate agricultural productivity as follows:

$$A_{iv} = \alpha + \beta S_{iv} + \delta H_{iv} + \vartheta V_v + \epsilon_{iv} \quad (1)$$

where $A_{iv}$ denotes either the natural logarithm of crop yield or crop income per hectare of household $i$ in village $v$. $S_{iv}$ represents shocks that household $i$ faced in the last three years. $H_{iv}$ is the vector representing household characteristics. $V_v$ is the vector capturing the village characteristics and $\epsilon$ is the error term. $\alpha$ is the constant. $\beta$, $\delta$, and $\vartheta$ are parameters showing impacts of shocks, household characteristics and village characteristics on agricultural productivity. It is expected that households suffering from shocks ($S$) have $100\% * (e^{-\beta} - 1)$ lower crop yield (A, in ln form) than those without shocks ($S$). All monetary variables are measured in 2005 Purchasing Power Parity dollar (2005 PPP$[3]).

Shocks are categorized into three main groups, namely weather shocks (e.g. floods, drought, and storms), health shocks (e.g. illness or death), and market shocks (e.g. increase in input price or decrease in output price). To prevent reporting and measurement errors, we dropped the shock events that are reported to have no impact and cause no losses. Household characteristics include age of household head, household size, number of male labors (age from 16-60), share of literate members, land area, irrigated land area, share of rice-planted area, share of fruit-planted area, number of land plots, tractor value (in ln form), number of mobile phones and total asset value per capita (in ln form). Village characteristics are represented by the distance to the nearest market, share of households with access to electricity, a dummy of whether the village is located in mountain areas, and province dummies. The detailed definition and dimension of these dependent and independent variables are described in Appendix A1. In addition, we applied the variance inflation test (VIF) to detect potential perfect multicollinearity, and the results of the test reject the null hypothesis (see Appendix A2).

[3] 2005 PPP$ is a unit of currency that has the same power to purchase a comparable amount of goods and services in the domestic market of the converted country as an U.S. dollar would buy in the United States in 2005. To convert monetary variables measured in local currencies to 2005 PPP$, we divided their values by purchasing power parity conversion factor (World Bank, 2008) and by consumer price index ratio of the converted countries between 2013 and 2005.

*2.2.2 Impact of agricultural productivity on natural resource extraction*

In the second step, we identify the effects of agricultural productivity on natural resource extraction by estimating the following model:

$$E_{iv} = \gamma + \rho A_{iv} + \varphi S_{iv} + \tau H_{iv} + \theta V_v + \varepsilon_{iv} \quad (2)$$

where $E_{iv}$ is the total output value of extracted products (in ln form) of household $i$ in village v. $A_{iv}$, $S_{iv}$, $H_{iv}$, and $V_v$ are defined as in Equation 1. $\gamma$ is the constant. $\rho$, $\varphi$, $\tau$ and $\theta$ are parameters showing impacts of agricultural productivity, shocks, household characteristics and village characteristics on the total output value of extracted products. It is expected that an increase in crop yield (A, in ln form) by 1% would lead to $\rho$% increase in the extraction output (E, in ln form). Households suffering from shocks ($S$) have $100\% * (e^{-\varphi} - 1)$ higher extraction output (E, in ln form) than those without shocks ($S$).

As crop yield is a dependent variable in Equation (1), it is endogenous in estimating natural resource extraction as in Equation (2). We addressed this issue by employing the heteroscedastic-based instruments method proposed by Lewbel (2012). This method allows us to generate internal instrumental variables (IVs). These IVs for $A_i$ in estimating natural resource extraction in Equation (2) are constructed as: $[z_i' - E(z_i')]\hat{\xi}_i$ . With $\xi$ and *z* are the residuals and exogenous variables in Equation 1, respectively. IVs are uncorrelated with $\varepsilon_i$ in Equation (2) as it is assumed that $Cov(z_i', \varepsilon_i) = Cov(z_i', \xi_i) = Cov(z_i', \varepsilon_i \xi_i) = 0$. Meanwhile, due to the existence of heteroscedasticity ($Cov(z_i', \xi_i^2) \neq 0$), IVs are correlated with $A_i$ through $\xi_i$. In addition, as Lewbel (2012) suggests, we used an additional external instrument to improve efficiency of this approach by employing the average crop yield per household in the village. To ensure the validity of our estimation, a number of post-estimation tests for underidentification, overidentification and weak instruments were conducted; the results of these tests confirmed the validity of our model (see Tables 3 and 4). In addition, we also checked the VIF values to detect potential perfect multicollinearity and the results do not show that problem (see Appendix A3). Moreover, as robustness checks, we also examined the impact of crop income per hectare on natural resource extraction and these results are highly consistent with the estimation results of equation 2.

Another concern is that since we employed both household and village variables, they might not be independent. Thus, we performed two additional models: the first one with only household variables, and the second one is a mixed-effects model. The results of these models, as shown in Appendices (A8-A15), are consistent with those from our original model.

## 3. Results

### *3.1 Data description*

Table 1 illustrates household and village characteristics by countries. With respect to demographic characteristics, households in Cambodia and Laos have larger household sizes, younger household heads, and lower literacy rates than in Thailand and Vietnam. On average, more than 80% of the sampled rural population in Thailand and Vietnam can read and write, whereas these figures in Cambodia and Laos are less than 60%. In addition, sampled households in Thailand appear to be better off with a total asset value per capita of more than 2,000 PPP$. The total asset value per capita of households in Vietnam is only around 900 PPP$, but this is still higher than that of households in Cambodia and Laos.

**Table 1. Household and village characteristics**

| | Whole Sample | Cambodia | Laos | Thailand | Vietnam |
|---|---|---|---|---|---|
| **Household characteristics** | | | | | |
| age of head | 53.63 | 44.8 | 48.89 | 58.76 | 52.87 |
| (years) | (13.68) | (13.97) | (13.36) | (12.2) | (12.94) |
| share of literate members | 78.36 | 51.71 | 58.47 | 87.48 | 83.96 |
| (%) | (26.91) | (30.41) | (31.66) | (18.77) | (21.96) |
| Household size | 4.42 | 5.25 | 5.99 | 4.02 | 4.07 |
| (numbers) | (1.97) | (1.93) | (2.46) | (1.67) | (1.74) |
| male members | 2.17 | 2.68 | 3.01 | 1.93 | 1.98 |
| (%) | (1.3) | (1.39) | (1.63) | (1.13) | (1.14) |
| total assets per capita | 1411 | 503 | 759 | 2460 | 876 |
| (2005 PPP$) | (3431) | (787) | (1234) | (5114) | (1649) |
| tractor_value | 1112 | 853 | 1531 | 1966 | 233 |
| (2005 PPP$) | (4086) | (1679) | (1622) | (6376) | (753) |
| mobile phones | 1.86 | 1.17 | 1.26 | 2.12 | 2 |
| (numbers) | (1.43) | (1.2) | (1.27) | (1.41) | (1.45) |
| land area | 1.87 | 3.04 | 2.24 | 2.29 | 0.99 |
| (ha) | (2.12) | (3.02) | (1.89) | (2.21) | (1.24) |
| irrigated land area | 0.3 | 0.26 | 0.07 | 0.14 | 0.53 |
| (ha) | (0.78) | (0.96) | (0.51) | (0.68) | (0.81) |
| no. of land plots | 3.61 | 2.69 | 2.2 | 3.35 | 4.57 |
| (numbers) | (1.95) | (0.85) | (0.48) | (1.6) | (2.29) |
| share of rice-planted | 62.19 | 47.36 | 55.79 | 83.75 | 47.84 |
| area (%) | (41.39) | (44.96) | (44.65) | (30.27) | (39.62) |
| crop income per ha | 2375 | 1763 | 927 | 1911 | 3467 |
| (2005 PPP$) | (3935) | (3316) | (1661) | (3468) | (4695) |
| crop yields | 3301 | 1882 | 1132 | 2957 | 4751 |
| (2005 PPP$) | (4389) | (3447) | (1719) | (3529) | (5381) |
| extracting natural | 55.49 | 81.91 | 84.22 | 48.54 | 45.11 |
| resources (%) | (49.7) | (38.53) | (36.49) | (49.99) | (49.78) |
| extraction income | 387.79 | 1876 | 664.91 | 85.28 | 134.38 |
| (2005 PPP$) | (1542) | (3853) | (1015.85) | (263.93) | (571.08) |
| **Village characteristics** | | | | | |
| share of households having electricity | 84.67 | 20.43 | 64.46 | 98.52 | 97.42 |
| (%) | (33.08) | (32.71) | (42.61) | (7.73) | (11.38) |
| distance to market | 9.51 | 26.96 | 14.63 | 8.88 | 3.12 |
| (km) | (14.03) | (25.54) | (16.49) | (7.77) | (4.69) |
| Share of villages in mountain regions | 25.4 | 22.47 | 5.72 | 8.87 | 48.49 |
| (%) | (43.53) | (41.78) | (23.25) | (28.44) | (49.99) |
| **No. of households** | **4213** | **503** | **507** | **1578** | **1625** |

*Standard deviations in parentheses, ha: hectare, 2005 PPP$: 2005 purchasing power parity.*

With regard to land and farm characteristics, households in Vietnam have the smallest land area, but the highest number of land plots. This is due to the agrarian land allocation undertaken at the beginning of the reform process known as Doi Moi in Vietnam (Huy et al., 2019). However, irrigation systems are more accessible in Vietnam than in other countries. In particular, the irrigated land area is around 0.5 ha in Vietnam, accounting for around 50% of total land area that a household owns, whereas the figure in the other countries is less than 20%. This is in line with Birthal et al. (2019) who show that irrigation is limited to less than 20% of the cropland in most Southeast Asian countries, whereas in Vietnam more than 40% of the cropland is irrigated. This might explain why the total value of crop output per hectare is the highest in Vietnam. The average value of the crop yield in Vietnam is more than 4,700 PPP$ per hectare, whereas these figures in Thailand, Cambodia, and Laos are approximately 3,000 PPP$, 1,800 PPP$ and 1,000 PPP$, respectively. The higher yield in Vietnam could be explained by a large share of land used for commercially industrial crops such as pepper, tomato, and coffee as well as the intensive use of fertilizers and other agro-chemicals. For natural resource extraction, households in Laos and Cambodia are more involved in extraction activities. More specifically, more than 80% of the surveyed households in Laos and Cambodia participate in extraction activities, whereas these figures in Thailand and Vietnam are less than 50%. With regard to village characteristics, infrastructure in rural villages in Vietnam appears more developed than in Laos and Cambodia. Almost all farmers in Vietnam and Thailand have access to the national electricity grids. Meanwhile, the share of farmers having access to electricity in Laos and Cambodia are 60% and 20%, respectively. The average distance to the nearest market in Vietnam is less than 5 km, whereas it is more than 25 km in Cambodia.

**Table 2. Descriptive statistics of extraction activities of rural households**

| | Whole sample | Cambodia | Laos | Thailand | Vietnam |
|---|---|---|---|---|---|
| **Extracting places** | | | | | |
| water (e.g. rivers, lakes) | 31.79 | 35.59 | 34.01 | 40.4 | 10.21 |
| (%) | (46.57) | (47.9) | (47.39) | (49.09) | (30.3) |
| forest and other lands | 68.21 | 64.41 | 66 | 59.59 | 89.79 |
| (%) | (89.86) | (69.19) | (83.34) | (85.2) | (97.12) |
| distance to extracting places | 3.03 | 3.23 | 1.72 | 3.47 | 3.92 |
| (km) | (6.98) | (6.91) | (3.26) | (5.82) | (11.17) |
| **Type of extracted products** | | | | | |
| animal products | 38.42 | 44 | 47.77 | 42.42 | 12.42 |
| (%) | (48.65) | (49.67) | (49.97) | (49.44) | (33) |
| wood products | 24.88 | 24.78 | 2.19 | 11.2 | 79.34 |
| (%) | (43.23) | (43.2) | (14.65) | (31.55) | (40.51) |
| other products (e.g. mushroom, vegetables | 36.71 | 31.22 | 50.04 | 46.38 | 8.24 |
| (%) | (48.21) | (46.37) | (50.02) | (49.89) | (27.52) |
| **Type of activities** | | | | | |
| Fishing | 31.08 | 36.79 | 33.74 | 38.24 | 9.1 |
| (%) | (46.29) | (48.25) | (47.3) | (48.61) | (28.78) |
| Hunting | 7.44 | 7.53 | 14.37 | 3.81 | 3.57 |
| (%) | (26.24) | (26.41) | (35.1) | (19.15) | (18.56) |
| Collecting | 48.8 | 45.63 | 47.94 | 51.38 | 49.32 |
| (%) | (49.99) | (49.84) | (49.98) | (50) | (50.03) |
| Logging | 12.66 | 10.04 | 3.94 | 6.5 | 38.01 |
| (%) | (33.26) | (30.07) | (19.47) | (24.66) | (48.57) |
| **Output value and uses** | | | | | |
| Total extraction value | 385.77 | 1030.27 | 295.45 | 98.99 | 258.7 |
| (2005 PPP$) | (1457.2) | (2864.13) | (559.58) | (242.46) | (769.03) |
| Value for sales | 215.25 | 667.79 | 147.89 | 23.12 | 119.13 |
| (2005 PPP$) | (1321.3) | (2651.6) | (510.14) | (139.13) | (669.14) |
| Value for consumption | 170.33 | 363.73 | 148.75 | 75.86 | 139.56 |
| (2005 PPP$) | (356.78) | (624.55) | (215.78) | (176.87) | (215.01) |
| **No. of activities** | **4209** | **916** | **1141** | **1339** | **813** |

*Standard deviations in parentheses, ha: hectare, 2005 PPP$: 2005 purchasing power parity.*

Table 2 provides detailed information of extraction activities, including extraction locations (e.g. forest, rivers), types of products extracted (e.g. animal, wood), types of extraction activities (e.g. fishing, logging), output value and the use of extracted products (e.g. for consumption or for cash income). Generally, forests are the most common extraction place in all surveyed countries with more than 60% of all extraction activities being undertaken. The distance to extraction places is farthest in Vietnam (approximately 4 km), and shortest in Laos (about 2 km). Meanwhile, the average distance to extraction places in Cambodia and Thailand is around 3 km. For types of extraction activities, the most common activity in Vietnam is logging, whereas the second most common one is collecting non-timber forest products. By comparison, collecting is the most common activity in Cambodia, Laos, and Thailand, whereas fishing is the second. For the value and the use of extracted products, the average output value of extraction activities is highest in Cambodia, with slightly more than 1,000 PPP$ and mainly for sale. The average output value of extracted products is lowest in Thailand amounting to around 100 PPP$ and mainly for home consumption. The average value of extracted products in Laos and Vietnam is nearly 300 PPP$ with around half of these values for consumption and the other half for sale.

With regard to shocks, Figure 2 presents the shares of affected households and the average damages and losses of shock per affected household. The line charts show that weather shocks are the most common, affecting more than 30% of the households in all surveyed countries. Meanwhile, the share of population affected by health shocks is more than 20%. Market shocks are less common, affecting less than 10% of the households in all surveyed countries. Comparing the prevalence and severity of shocks between countries, weather shocks and health shocks are more common in Cambodia, whereas market shocks affect a larger share of households in Vietnam and Thailand. Weather shocks affect around 60% of the households in Cambodia, and 40% to 50% of the households in the other countries. The share of the households affected by health shocks in Cambodia is around 55%, whereas this figure in the other countries is between 30% and 40%. Market shocks affect around 10% of all households in Vietnam and Thailand, whereas less than 5% of the households in Cambodia and Laos are affected by market shocks. With respect to the damages and losses due to shocks, the bar charts show that weather shocks are the most severe shocks to households in Thailand and Vietnam with an average damage of around 1,100 PPP$ and 900 PPP$, respectively. In Cambodia, the most severe ones are market shocks, causing an average damage of around 800 PPP$, whereas an average damage of health shocks and weather shocks in this country amounts to around

600$. In contrast, health and weather shocks are more severe than market shocks in Laos, causing an average damage of around 700 PPP$, whereas the average damage of market shocks in this country is around 500$.

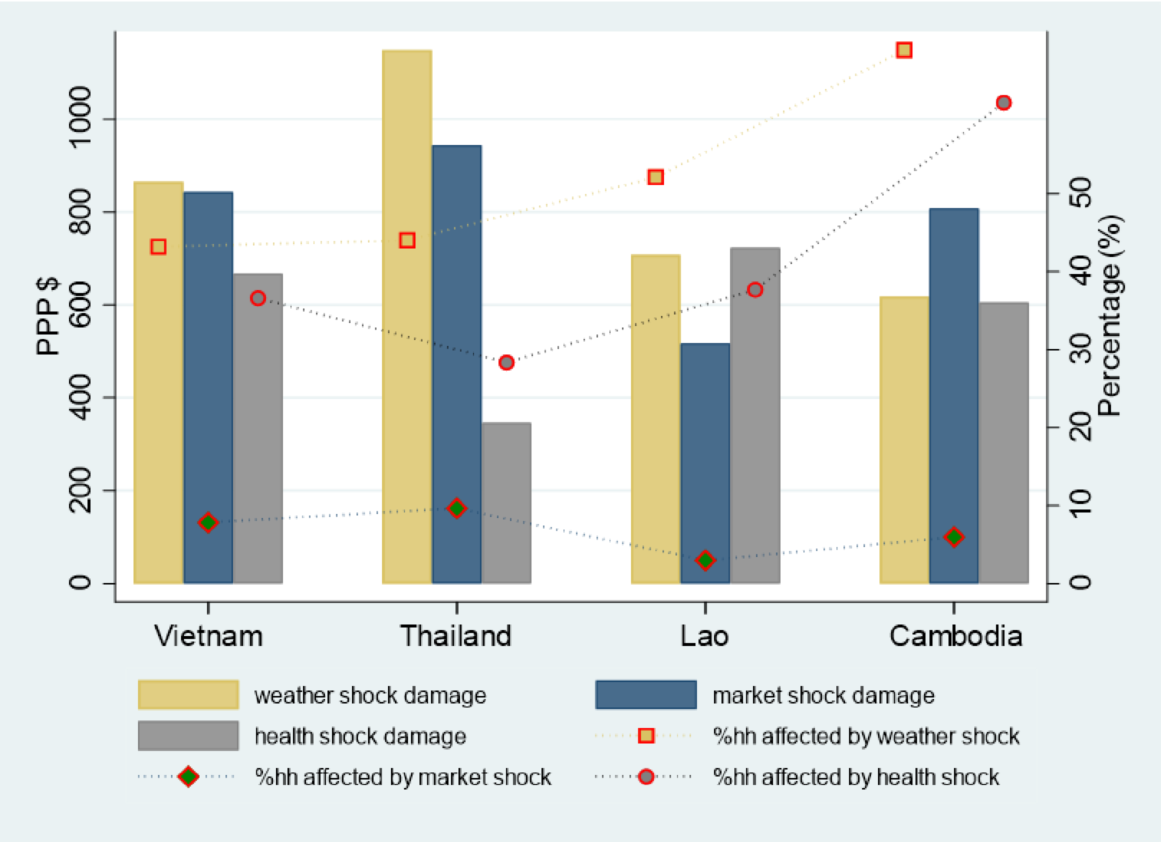


**Figure 2. Percentage of affected households and average damages of shocks**

*3.2 Impact of shocks on agricultural productivity*

Table 3 shows the estimation of the effects of shocks. Column 1 shows the impact on crop yield (in ln form) while column 3 shows the impact on crop income. Models' summary statistics and diagnostics parameters are presented in the lower section of Table 1 with the p-value of the Wald chi$^2$ being statistically significant at the 1% level.

**Table 3. Impact of shocks on agricultural productivity**

| | OLS models | | | |
|---|---|---|---|---|
| | Crop yields (in ln) | | Crop income per ha | |
| weather shock | -0.139*** | (0.026) | -590.786*** | (120.622) |
| health shock | -0.011 | (0.027) | -183.990 | (120.646) |
| market shock | 0.064 | (0.048) | 115.401 | (259.143) |
| age head | 0.002** | (0.001) | 1.327 | (4.563) |
| share of literate members | 0.212*** | (0.060) | 482.253* | (273.153) |
| household size | 0.008 | (0.010) | -39.362 | (49.583) |
| male members | -0.011 | (0.015) | 70.560 | (58.470) |
| total asset value per capita (ln) | 0.044*** | (0.012) | 71.714 | (52.861) |
| tractor value (ln) | 0.017*** | (0.004) | 5.408 | (19.146) |
| mobile phone | 0.031*** | (0.010) | 117.339** | (47.562) |
| land area | -0.136*** | (0.014) | -364.068*** | (55.455) |
| land area squared | 0.004*** | (0.001) | 10.783*** | (2.888) |
| irrigated land area | 0.084*** | (0.021) | 284.282*** | (88.247) |
| no of land plots | -0.003 | (0.007) | -145.184*** | (36.265) |
| share of rice-planted land | -0.335*** | (0.041) | -2277.902*** | (240.816) |
| (village) distance to market | -0.001 | (0.001) | -4.494 | (3.785) |
| (village) electricity | 0.199*** | (0.069) | 595.916** | (267.158) |
| (village) mountain | -0.148*** | (0.033) | -288.552* | (165.598) |
| Constant | 7.406*** | (0.139) | 4086.740*** | (679.304) |
| province dummies | | yes | | yes |
| No of observations | | 4213 | | 4213 |
| $R^2$ | | 0.350 | | 0.133 |
| Adjusted $R^2$ | | 0.346 | | 0.128 |
| P-value | | 0.000 | | 0.000 |

*Robust standard errors in parentheses; *** p<0.01, **p<0.05, * p<0.1*

Our findings show that weather shocks significantly reduce crop yield and crop income per ha. Crop yield of households with weather shocks are 15% lower than those without weather shocks. In Table 4, we also disentangle the impact of shocks by countries. The incidence of weather shocks is negatively associated with crop yield and crop income per ha in all countries, although this impact is not statistically significant in Laos. Weather shocks are shown to decrease crop yield of households in Cambodia, Thailand, and Vietnam on average by 16%, 18% and 7%, respectively.

With regard to other household and village characteristics (see Table 3 for the whole sample and Appendices 4 and 5 for each country), land area is negatively and significantly correlated with crop yield, whereas the impact of the square of land area is positively significant for all samples. This indicates the non-linear effect of land area on land productivity. Education is also shown to positively affect agricultural productivity in all countries, although the impact in Laos is insignificant. Our findings also show that the impact of irrigated land area on crop yield and crop income is positive and significant for the whole sample and Vietnam. Meanwhile, the number of land plots, an indicator of land fragmentation, is negatively associated with crop income per hectare for the whole sample, Vietnam, and Cambodia. Mobile phones and tractors are shown to positively affect crop yield or crop income per hectare for the whole sample, Vietnam, and Laos. With regard to village characteristics, electricity access is found to have positive impacts on agricultural productivity in Cambodia and Laos. In addition, our results show that distance to markets is negatively associated with agricultural productivity for the whole sample and Vietnam. Moreover, Vietnamese and Thai households living in mountain regions are shown to have a lower crop yield than the others.

**Table 4. Impact of shocks on agricultural productivity by countries**

| | OLS models | | | |
|---|---|---|---|---|
| ***Panel A: Impact of shocks on crop yields (ln)*** | | | | |
| | **Cambodia** | **Laos** | **Thailand** | **Vietnam** |
| weather shock | -0.149* | -0.059 | -0.166*** | -0.072* |
| | (0.088) | (0.070) | (0.038) | (0.041) |
| health shock | 0.022 | 0.107 | -0.025 | -0.009 |
| | (0.080) | (0.075) | (0.045) | (0.041) |
| market shock | 0.218 | 0.071 | -0.013 | 0.114 |
| | (0.185) | (0.220) | (0.070) | (0.075) |
| control variables | yes | yes | yes | yes |
| No of observations | 503 | 507 | 1578 | 1625 |
| $R^2$ | 0.161 | 0.166 | 0.113 | 0.239 |
| Adjusted $R^2$ | 0.130 | 0.135 | 0.102 | 0.229 |
| P-value | 0.000 | 0.000 | 0.000 | 0.000 |
| ***Panel B: Impact of shocks on crop income per hectare*** | | | | |
| | **Cambodia** | **Laos** | **Thailand** | **Vietnam** |
| weather shock | -1013.991*** | -113.881 | -631.415*** | -372.531* |
| | (328.189) | (107.430) | (200.875) | (218.288) |
| health shock | 267.985 | -40.951 | -182.516 | -191.524 |
| | (329.819) | (166.958) | (185.599) | (228.183) |
| market shock | 1118.417 | 170.295 | -98.264 | 134.122 |
| | (1374.893) | (438.462) | (297.768) | (469.259) |
| control variables | yes | yes | yes | yes |
| No of observations | 503 | 507 | 1578 | 1625 |
| $R^2$ | 0.201 | 0.088 | 0.104 | 0.109 |
| Adjusted $R^2$ | 0.171 | 0.055 | 0.093 | 0.098 |
| P-value | 0.000 | 0.000 | 0.000 | 0.000 |

*Robust standard errors in parentheses; *** p<0.01, **p<0.05, * p<0.1*

### *3.3 Impact of agricultural productivity on natural resource extraction*

Table 5 presents the estimation of the total extraction output value. Column 1 shows the impact of crop yield on the total extraction output value, whereas the impact on crop income is in column 2. The models' summary statistics and diagnostics parameters, presented in the lower section of the table, show that all tests for overidentification, underidentification and weak instruments meet statistical requirements, confirming the validity and relevance of our models.

**Table 5. Impact of agricultural productivity on natural resource extraction**

| | Heteroscedasticity-Based Instruments | | | |
|---|---|---|---|---|
| | Extraction output value (ln) | | Extraction output value (ln) | |
| crop yields (ln) | -0.25653*** | (0.07449) | | - |
| crop income per hectare | - | | -0.00003*** | (0.00001) |
| weather shock | 0.38943*** | (0.07679) | 0.41787*** | (0.07573) |
| health shock | -0.15839** | (0.07535) | -0.16402** | (0.07524) |
| market shock | 0.31056** | (0.13926) | 0.27288** | (0.13897) |
| age head | -0.01587*** | (0.00283) | -0.01589*** | (0.00282) |
| share of literate | -0.64603*** | (0.16341) | -0.70862*** | (0.16217) |
| household size | 0.04128 | (0.03092) | 0.03986 | (0.03083) |
| male members | 0.10776** | (0.04442) | 0.10704** | (0.04437) |
| total asset value per capita (ln) | -0.18136*** | (0.03323) | -0.18869*** | (0.03308) |
| tractor value (ln) | 0.07428*** | (0.01274) | 0.06914*** | (0.01267) |
| mobile phone | -0.07876*** | (0.02962) | -0.08198*** | (0.02951) |
| land area | -0.03404 | (0.03805) | -0.01666 | (0.03625) |
| land area squared | -0.00146 | (0.00156) | -0.00159 | (0.00147) |
| irrigated land | -0.00095 | (0.05287) | -0.01349 | (0.05213) |
| no of land plots | 0.00978 | (0.02175) | 0.00577 | (0.02171) |
| share of rice-planted land | -0.35265*** | (0.10783) | -0.33359*** | (0.10662) |
| (village) distance to market | 0.00603** | (0.00269) | 0.00573** | (0.00269) |
| (village) electricity | -0.45172** | (0.19471) | -0.47690** | (0.19481) |
| (village) mountain | 0.33590*** | (0.09249) | 0.36725*** | (0.09140) |
| constant | 6.86579*** | (0.66850) | 5.08192*** | (0.36624) |
| province dummies | yes | | yes | |
| No of observations | | 4213 | | 4213 |
| $R^2$ | | 0.355 | | 0.357 |
| Adjusted $R^2$ | | 0.351 | | 0.353 |
| P-value | | 0.000 | | 0.000 |
| Underidentification | | 0.000 | | 0.000 |
| Overidentification | | 0.859 | | 0.126 |
| Weak identification | | 65.296 | | 136.987 |

*$^{***}$ p<0.01, $^{**}$ p<0.05, $^{*}$ p<0.1; robust standard errors in parentheses; the underidentification test is an LM test based on Kleibergen and Paap (2006) rk LM statistics with the null hypothesis that the model is underidentified. The overidentification test is based on the Hansen J test with the null hypothesis of all instruments being valid. For weak identification, Kleibergen-Paap rk Wald F statistics is reported.*

Our results show that both crop income per hectare and crop yield are significantly and negatively associated with total extraction output. This indicates that enhancing agricultural productivity will discourage farmers from natural resource extraction. A 10% increase in crop yield would lead to a decrease in the extraction output of 2.6%. Regarding the impact of shocks on natural resource extraction, weather shocks and market shocks are significantly and negatively associated with the extraction output. Suffering from weather shocks and market shocks will increase the extraction output value by 32% and 27%, respectively. Meanwhile, suffering from health shocks reduces the extraction output by 17%.

Table 6 presents the estimations of total extraction output by country. Panel A shows the impact of crop yield on the total extraction output, whereas the impact of crop income is in panel B. The estimations for Cambodia, Laos, Vietnam, and Thailand are in columns 1, 2, 3, and 4, respectively. Our results show that enhancing crop yield or crop income per ha could significantly reduce the value of extraction output in all countries. Increasing crop yield by 10% would lead to a decrease in the extraction output of households in Cambodia, Laos, Thailand, and Vietnam by 3.5%, 0.7%, 2.3%, and 1%, respectively. With respect to shocks, our results show that the incidence of weather shocks is positively associated with the value of extraction output in all surveyed countries, although the impact of weather shocks in Thailand is statistically insignificant. Weather shocks are shown to increase the extraction output of households in Cambodia, Laos, and Vietnam by 55%, 31%, and 32%, respectively. Market shocks are shown to increase the extraction output of households in Thailand by 49%. Health shocks are shown to reduce the extraction output of households in Laos and Thailand by 58% and 23%, respectively.

**Table 6. Impact of agricultural productivity on natural resource extraction by countries**

| | Heteroscedasticity-Based Instruments | | | |
|---|---|---|---|---|
| | Extraction output value (ln) | | | |
| | **Cambodia** | **Laos** | **Thailand** | **Vietnam** |
| **Panel A: The impact of crop yields** | | | | |
| crop yields (ln) | -0.34740** | -0.07444 | -0.22996** | -0.10572 |
| | (0.17619) | (0.18632) | (0.11720) | (0.11202) |
| weather shock | 0.79583*** | 0.36835* | 0.10855 | 0.38424*** |
| | (0.28879) | (0.19940) | (0.12128) | (0.11288) |
| health shock | -0.17573 | -0.45904** | -0.21421* | -0.09543 |
| | (0.24274) | (0.19053) | (0.12321) | (0.11188) |
| market shock | 0.11113 | -0.48134 | 0.67574*** | 0.24537 |
| | (0.43845) | (0.64059) | (0.19575) | (0.21721) |
| control variables | yes | yes | yes | yes |
| No of observations | 503 | 507 | 1578 | 1625 |
| $R^2$ | 0.138 | 0.181 | 0.083 | 0.254 |
| Adjusted $R^2$ | 0.104 | 0.149 | 0.070 | 0.244 |
| P-value | 0.000 | 0.000 | 0.000 | 0.000 |
| Underidentification | 0.000 | 0.000 | 0.000 | 0.000 |
| Overidentification | 0.527 | 0.211 | 0.740 | 0.195 |
| Weak identification | 23.810 | 15.705 | 41.455 | 30.393 |
| **Panel B: The impact of crop income** | | | | |
| | **Cambodia** | **Laos** | **Thailand** | **Vietnam** |
| crop income per hectare | -0.00009*** | -0.00015*** | -0.00004** | -0.00003** |
| | (0.00003) | (0.00002) | (0.00002) | (0.00001) |
| weather shock | 0.77334*** | 0.35476* | 0.13614 | 0.38417*** |
| | (0.28681) | (0.19685) | (0.11936) | (0.11187) |
| health shock | -0.11098 | -0.44104** | -0.20602* | -0.08859 |
| | (0.23884) | (0.19216) | (0.12258) | (0.11112) |
| market shock | 0.12583 | -0.69307 | 0.62870*** | 0.22213 |
| | (0.41762) | (0.64585) | (0.19733) | (0.21755) |
| control variables | yes | yes | yes | yes |
| No of observations | 503 | 507 | 1578 | 1625 |
| $R^2$ | 0.147 | 0.184 | 0.087 | 0.254 |
| Adjusted $R^2$ | 0.113 | 0.152 | 0.075 | 0.244 |
| P-value | 0.000 | 0.000 | 0.000 | 0.000 |
| Underidentification | 0.037 | 0.043 | 0.000 | 0.000 |
| Overidentification | 0.627 | 0.068 | 0.712 | 0.106 |
| Weak identification | 194.187 | 952.641 | 140.986 | 37.098 |

**** p<0.01, ** p<0.05, * p<0.1; robust standard errors in parentheses; the underidentification test is an LM test based on Kleibergen and Paap (2006) rk LM statistics with the null hypothesis that the model is underidentified. The overidentification test is based on the Hansen J test with the null hypothesis of all instruments being valid. For weak identification, Kleibergen-Paap rk Wald F statistics is reported.*

With regard to other household and village characteristics (see Table 5 for the whole sample and Appendices 6 and 7 for each country), better-off households (those with a higher value of total assets per capita) and better-educated households appear to have a lower value of extraction output. In particular, education is negatively associated with the value of extraction output for the whole sample and for Cambodia, Laos and Vietnam. The total asset value per capita is negatively correlated with the value of extraction output for the whole sample and for Vietnam and Thailand. Owning mobile phones is shown to demotivate households from extracting natural resources for the whole sample, Laos, and Vietnam. With regard to demographic characteristics, the age of household heads is positively associated with natural resource extraction for the whole sample and Laos, Thailand, and Vietnam. The number of male members positively affects the value of extraction output for the whole sample and for Vietnam. With regard to village characteristics, the distance to markets is positively correlated with natural resource extraction for the whole sample, Cambodia, and Vietnam. Meanwhile, having access to electricity is shown to negatively affect the extraction of rural households in Cambodia and Laos.

## 4. Discussion

Our estimation results show a significant and negative impact of weather shocks on agricultural productivity. The severe impact of weather shocks could be because households are less able to cope with extreme weather events as these shocks affect a large number of people in the region, causing severe damages to houses, croplands, and infrastructure, disrupting severely transportation and communication across regions, and limiting risk-sharing mechanisms as everybody in the community has been affected (Nguyen et al., 2020; Kurosaki, 2015; de Silva and Kawasaki, 2018). Moreover, weather shocks directly cause crop losses and failure. Figure 2 shows that weather shocks are most common in our study sites and cause the most severe damages to households. By countries, our findings show that weather shocks are negatively associated with crop yield and crop income in all countries, although the impact is not statistically significant in Laos. The insignificant impact in Laos could be because the average damages and losses due to weather shocks in Laos are less severe than in Vietnam and Thailand (see Figure 2). This is also consistent with Eckstein et al. (2019), who show that Laos is generally less vulnerable to climate risks than Vietnam, Thailand, or Cambodia.

Our results also show that education, tractor value, mobile phones, and irrigation land area are positively and significantly associated with crop yield. This makes sense as households with higher education levels might have better abilities to manage information, and owing mobile phones could facilitate the exchange of farm-related information. These results are also consistent with Ebers et al. (2017) and Sauer et al. (2015), who show that promoting farm mechanization and rural education could significantly reduce farm inefficiency. Our findings also show that land fragmentation negatively affects crop yield. This is particularly true in Vietnam where cropland is highly fragmented being a major cause of agricultural inefficiency (Huy et al., 2019). Land fragmentation may inhibit the adoption of machinery, and increase production and transportation costs. Our findings also show a u-shaped relationship between land area and crop yield. Land size is negatively correlated with farm productivity indicators, whereas the impact of the square of land area is positively significant. This is consistent with the findings of Helfand and Levine (2007), Omotilewa et al. (2021), and Sheng et al. (2019). It is argued that small-scale farmers tend to use land more intensively, monitor their production activities more closely, and more efficient in using their scarce resources (Ebers et al., 2017). However, if land area is large enough, farmers could adopt machinery and modern technologies in the production process, therefore fostering their productivity. With regard to village characteristics, the share of households with access to electricity is found to have a positive impact on agricultural productivity. An explanation is that electricity facilitates the adoption of machinery and accelerates agricultural mechanization processes. The impact is strongly significant in Cambodia and Laos, where only a limited share of the population has access to electricity. In addition, our results show that distance to markets is negatively associated with agricultural productivity in Vietnam. This could be explained by the fact that households living in remote areas face several barriers in accessing information, credit, inputs, and modern technologies (Ebers et al., 2017).

From the estimation of the value of natural resource extraction, we find that increasing agricultural production could discourage households to extract natural resources. This result is in line with Illukpitiya and Yanagida (2010) who show that natural resource extraction is a decreasing function of agricultural efficiency. Increasing agricultural productivity makes farming activities more profitable, therefore, increasing the opportunity cost of extraction activities. In addition, raising agricultural productivity makes farmers wealthier, allowing them to substitute market goods for forest goods. Regarding the impact of shocks on natural resource extraction, our findings show that exploitation of natural resources plays an important role as a buffer to mitigate the impact of weather shocks and market shocks. This is reasonable as these shocks affect most households in a community. Consequently, safety-net mechanisms that depend on the community (e.g., borrowing money, receiving remittance) may become less viable because relatives, friends, and neighbors may also be negatively affected by the same shock. The impact of market shocks is strongly significant in Thailand. This is reasonable as the economy in Thailand is more developed, households get more involved in markets, and they are more likely affected by market shocks. This is consistent with our results in Figure 2, showing that Thai farmers are more likely to be affected by market shocks and the damages due to market shocks are more severe than in the other surveyed countries. Our results also show that health shocks have negative impacts on natural resource extraction in all countries, but these are significant only in Laos and Thailand. It is argued that health shocks could have two-sided effects on natural resource extraction (Völker and Waibel, 2010). On the one hand, households are motivated to extract more natural resources to meet the increasing demand for health care treatment and compensate for income losses. On the other hand, reduced labor availability due to health shocks would lower the use of labor-intensive activities such as extracting natural resources (Wunder et al., 2014). The significant impact in Laos could be because compared to other surveyed countries, the damage of health shocks is more severe (see Figure 2). This is in line with Wagstaff (2014) who shows that health shocks are more common and more costly than other types of shocks in Laos. The negative and significant impact of health shocks in Thailand is because this country is the most developed. Nearly all Thai households have access to the national health insurance scheme, and other coping strategies (such as borrowing, receiving remittances) could be more available, therefore they might rely less on natural resource extraction to satisfy the increasing demand for health care treatment.

For other control factors, households with older heads and more male members are found to extract more natural resources. This could be because natural resource extraction activities are time-consuming and highly labor-intensive; therefore, households with more labor force, particularly, young labor force, can extract more natural resources. It is also argued that young households tend to rely more on natural resource extraction, as they have not yet accumulated sufficient assets, land, and other physical capital to serve as a buffer (Wunder et al., 2014). Better-off households (those with a higher value of total assets per capita) with higher education levels and owning more mobile phones appear to have a lower value of extraction output. This is because these households might have less access to remunerative response options; therefore, they rely more on natural resource-based coping strategies (Wunder et al., 2014). With regard to village characteristics, living in remote areas without access to electricity and far from markets is shown to motivate households to extract more natural resources. Angelsen et al. (2014) and Nguyen et al. (2020) also find that living in villages with lower degrees of market integration or far from markets would motivate households to extract more natural resources.

## 5. Summary and Conclusion

Natural resource extraction is among the most important livelihood strategies for rural households in many developing countries. However, in Southeast Asia and many other parts of the world, environmental resources are degrading at an alarming rate. Therefore, understanding the underlying factors of environmental resource dependence can help to reduce and prevent the degradation of environmental resources. Given an ambiguous interrelationship between shocks, agricultural productivity, and natural resource extraction, our study aims to investigate these relationships by using a large dataset of 4,213 households collected in four Southeast Asian countries, namely Cambodia, Laos, Thailand, and Vietnam. Methodologically, we first applied OLS models to investigate the impact of shocks, including health shocks, weather shocks, and market shocks on agricultural productivity. Then, we applied a heteroscedasticity-based instruments approach to study the impact of agricultural productivity on natural resource extraction. Our study makes some important contributions to the literature and provides useful information for policymakers. First, we enrich our understanding regarding the impact of agricultural productivity on natural resource extraction, which has received little attention in the previous literature with ambiguous findings. Second, we take into account the effect of shocks in examining the relationship between agricultural productivity and natural resource extraction, while previous studies tend to investigate the impact of shocks on agricultural productivity and natural resource extraction separately. Third, we deal with endogeneity problems in estimating the impact of agricultural productivity on natural resource extraction, which is not solved in previous studies (for example, Illukpitiya and Yanagida, 2010). Fourth, previous studies on natural resource extraction are often site-specific, which makes the generalization of the research findings difficult; our study is conducted in four different countries.

Our results also provide several important policy implications. The first suggestion for all countries is that enhancing agricultural productivity should be prioritized as it discourages rural households to extract natural resources. Second, the governments have to provide more assistance and support to farmers in mitigating the severe effects of weather shocks as these extreme events undermine not only agricultural productivity, but also push households into extraction activities. For Cambodia, supporting rural education, promoting local markets, facilitating rural households' access to electricity, and land defragmentation are recommended to enhance agricultural productivity and reduce households' reliance on extraction activities. For Laos, accelerating the development of the communication systems (use of mobile phones), facilitating rural households' access to electricity, and promoting education in rural areas should be given high priority. For rural Thailand, promoting education and providing more assistance and support to farmers in mitigating the severe effects of market shocks are highly recommended. For rural Vietnam, accelerating farm mechanization, land defragmentation, and supporting the development of communication systems and local markets, and promoting education should be encouraged.

Our study still suffers some limitations. First, it relies on cross-sectional data, therefore, we are not able to estimate the long-term impacts of shocks and agricultural productivity on natural resource extraction. Second, the extraction of natural resources might be embedded in the culture of some population groups in Southeast Asia but our data do not allow us to capture cultural factors. Third, also due to data limitations, we are not able to control for soil quality and altitude at household-level or parcel-level when estimating agricultural productivity. Last, our study includes only four countries. Extending the study to other countries would contribute to the generalization of the research findings for the Southeast Asian region.

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