Landslides and Cropland Abandonment in China's Mountainous Areas: Spatial Distribution, Empirical Analysis and Policy Implications

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Abstract: Cropland, as the largest land use type in the human landscape, contributes to not only biodiversity but also global food security. However, cropland abandonment not only is harmful to agricultural cultural landscapes but also threatens food security. Prior studies have suggested that changes in the social environment drive farmers to abandon cropland. In contrast, this study reveals that factors of the natural environment (e.g., landslides) have steadily and significantly affected cropland abandonment after controlling the factors of the social environment. More specifically, based on the survey data of a large sample of 4850 mountainous households in 24 provinces of China and following the theoretical framework of "environment → land use", this study quantitatively identified the impacts of landslides on cropland abandonment in mountainous areas using the Probit and Tobit models. The results show that: (1) There is a similar spatial agglomeration trend between landslides and cropland abandonment. Namely, an area that has a high incidence of landslides also has a high incidence of cropland abandonment. (2) There is a significant and positive correlation between landslides and cropland abandonment. Namely, compared with peasants who have not suffered from landslides, the probability that peasants suffering from landslides will abandon cropland and the area abandoned increase by 6.8% and 0.064 mu, respectively. (3) Elderly farmers (over 64 years old) and the development of urbanization help curb cropland abandonment in the mountains. The results of this study may provide reference for the government to implement effective policies for managing landslides and revitalizing unused cropland resources.

Keywords: natural environment; landslides; cropland abandonment; hazard management; mountainous area; China

1. Introduction

Natural hazards are closely related to climate change [1,2]. Climate change causes many extreme weather events [3] that lead to a series of natural hazards [4]. In particular, in mountainous areas, landslides are frequently caused by increased rainfall [1]. Landslides manifest as mountain attachments (e.g., rocks, debris and earth) sliding downward with gravity [5] that pose a great threat to the lives and property of residents [6–11]. Between 1990 and 2005, landslides accounted for 4.8% of the total number of global disasters [7]. Between 2004 and 2010, there were 2620 landslides in the world, causing at least 32,322 deaths [12]. However, although mountain landslides affect millions of people around the world each year, theoretical and empirical studies on the effects of landslides are still rare [9].

Meanwhile, with the development of the economy and society, the phenomenon of massive cropland abandonment has appeared worldwide [13]. The area of cropland abandoned since the 20th century amounts to approximately 385–472 million km^2 [14]. The impact of cropland abandonment on the ecological environment is two-sided. On the one hand, long-term cropland abandonment is conducive to the restoration of ecological diversity [15,16]. On the other hand, short-term cropland abandonment has many negative effects [17–19]. More specifically, sudden cropland abandonment causes soil loss [18] and reduces the agricultural landscape within a short period [17,19]. More importantly, cropland abandonment means a decline in the intensity of land use [20], which poses new challenges to safeguarding global food security. However, at present, most research on cropland abandonment is concentrated in economically developed countries [17,21,22]. China, as a developing country with rapid economic development and serous cropland abandonment, has not received sufficient attention [23].

In China, the mountainous area has become an area of simultaneous landslides and cropland abandonment. Mountainous areas represent 70% of China's land area [24–27] and are the main area prone to natural hazards [1,10,28]. Many mountain settlements are located in areas of landslides and suffer from landslides [29,30]. In 2016, 7403 landslides occurred in China (accounting for 76.2% of the total number of geological disasters) [31]. Furthermore, rural areas in China's mountainous areas also experience serious cropland abandonment. Cropland abandonment arises from the shortage of agricultural laborers [32]. In 2014, approximately 14.32% of the cropland in mountainous areas was abandoned [33]. In summary, landslides and cropland abandonment may have similar spatial agglomeration characteristics in mountainous areas. Therefore, the spatial distribution characteristics of landslides and cropland abandonment in China are still unknown.

In fact, the relationship between land use and the distribution of landslides has been a hotspot in the research on agricultural economics and geography. In general, the relief and precipitation are the key drivers of landslides. In mountainous areas, under the background of heavy relief and precipitation, most studies consider that changes in land use may be direct drivers of landslides [7,8,34–37]. Cropland is the largest land use type of human landscape [38]. In the short term, cropland abandonment can easily lead to landslides by altering surface runoff [37,39–41]. Conversely, landslides may easily destroy infrastructure [42], which would cause farmers to abandon cropland. However, few studies have quantitatively identified the microscopic impacts of landslides on cropland abandonment using peasant household survey data.

The village has long been an area of weak economic development in the world. The key issue of rural development is the aging of agricultural production and the uneven distribution of urban and rural resources [43]. To revitalize the countryside, the Communist Party of China proposed the "Village Revitalization Strategy" in 2017 [10,27] with the core goal of removing barriers to factor flow between urban and rural areas and making rural areas ecologically livable. However, landslides not only accelerate the aging (people engaging in agriculture is getting older) of agricultural production but also may lead to more rural resources becoming idle. The Chinese government will certainly make more efforts to effectively manage landslides and revitalize idle cropland resources. Therefore, it helps to understand the reason famers change behavior of cropland use through studying the driving factors of cropland abandonment [19], as the findings would provide some reference for government policies. The key research questions of this study are as follows:

(1)   From the perspective of spatial distribution, what is the distribution of landslides and cropland abandonment?
(2)   From the perspective of quantification, how great is the microscopic impact of landslides on cropland abandonment?

2. Theoretical Framework

The theory of the human–land relationship emphasizes the interaction and feedback between people and the environment [44]. The broad environment concerns not only the natural environment,

including hazards, but also the social environment, including urbanization. Previous studies on cropland abandonment have emphasized the impact of changes in the social environment on farmers' abandonment behavior. For example, the driving factor of cropland abandonment in Eastern Europe is institutional change [45], while in Australia, Portugal and Sweden it is socioeconomic development [17]. In general, changes in human factors (e.g., technology, institutions, and the economy) have contributed to the layout of the cropland landscape in Europe [46–48]. However, the impact of the natural environment on cropland abandonment should not be ignored in in-depth research [48–50], as changes in land use may be affected by both the natural and social environments. This study used the theoretical framework "environment → land use" (Figure 1) to explore the impact of landslides on cropland abandonment.
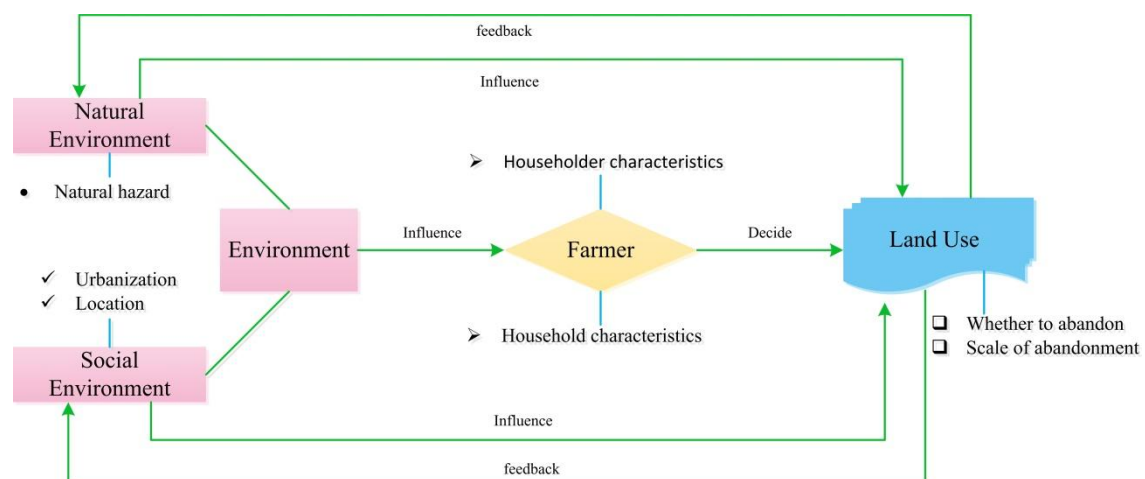

Figure 1. The theoretic framework of natural hazard on cropland abandonment.

The social environment influences land use, as shown in in Figure 1. China's rapid urbanization has promoted rural land abandonment [51]. Driven by economic interests, many rural laborers currently work in off-farm industries. This results in a labor shortage in agricultural production [52] and, consequently, cropland abandonment [32]. Moreover, location is a social factor driving cropland abandonment [19,53]. Transport cost increases with distance from the market, which may squeeze the net income of agricultural workers [54,55] and lead them to abandon cropland [32]. In Eastern European countries, cropland abandonment is also related to changes in social and economic systems that lead to agricultural policy adjustment or land system reform [53,56–59].

Figure 1 also shows the land use feedbacks in the influences of the social environment. Land is one of the important livelihood assets of peasant households [60]. Although cropland abandonment can decrease some agricultural income, it may also encourage the labors to engage in off-farm work [32]. Thus, if cropland abandonment triggers a large amount of off-farm employment, it would be possible to further increase the urbanization rate.

Figure 1 shows how the natural environment influences land use. Due to the combination of relief and rainfall, mountain areas are also the area most prone to natural hazards [1,10,28,61,62]. Landslides are one of the most common natural hazards that threaten the safety and property of mountain farmers [7]. Landslides leads to soil erosion [63], which can directly result in cropland abandonment. Meanwhile, landslides may destroy the farmland irrigation system and increase the difficulty of cropland management [64,65], which can indirectly result in cropland abandonment.

Figure 1 also shows the land use feedbacks in the influences of the natural environment. Changes in land use drive changes in hazard distribution [6,34–37,39]. More specifically, effective land management helps mitigate soil erosion [37,39]. In the short term, the surface runoff of abandoned cropland increases due to the lack of adequate vegetation cover [6,35,40,41]. Most mountainous cropland is on a slope. Thus, both surface runoff and slope may contribute to landslides formation.

In summary, if we want to achieve harmony between humans and the environment, we may need to focus on identifying the quantitative relationship between human behavior and the environment. However, we cannot sufficiently reveal the quantitative relationship by unilaterally exploring the impacts of land use on hazards. Thus, under the guidance of the theoretical framework of "environment → land use", this study focused on the quantitative impacts of landslides on cropland abandonment in mountainous areas.

3. Materials and Methods

3.1. Data Source

The individual-level data employed in this study come from a household survey drawn from the China Labor-force Dynamics Survey (CLDS) in 2014 and conducted by the Center for Social Science Survey at Sun Yat-sen University in Guangzhou, China. The data can be found on the website: http://css.sysu.edu.cn. The survey collected detailed information about China's social and economic development, including history of natural hazards, rural land use, and agricultural production. To ensure that the sample is nationally representative, the CLDS sample covered 29 provinces of mainland China (excluding Xizang and Hainan). A multistage cluster, stratified, probability proportional to size (PPS) sampling method was used. The data employed in this study were collected in 2014, which is the most recent year data have been published by the survey institutions. The 2014 survey covered 29 mainland provinces, 209 counties, 401 villages, and 14,214 households. During the data analysis, this study focused on land abandonment in mountainous rural region, thus, the households living in cities or living on plains were not included. After cleaning the data, data from 4850 valid household questionnaires were used for the analysis.

3.2. Variables

3.2.1. Dependent Variables

In this study, the dependent variable was cropland abandonment, which means the status that cultivable cropland has not been cultivated. Among them, cropland abandonment can be separated into behavior (whether peasants abandon cropland) and area (the area of cropland abandoned). When the dependent variable is the behavior (whether peasants abandon cropland), the dependent variable is binary and discrete. When the dependent variable is the area (the area of cropland abandoned), the dependent variable is left truncated and continuous.

3.2.2. Focal Variable

In this study, the focal variable was landslides, namely, whether a rural household has suffered landslides since 2012. A landslide is defined as the movement of a mass of rock, debris, or earth down a slope by gravity [5]. When CLDS interviewed the leaders of villages, the interviewer asked whether the villages had suffered from natural disasters and what types of disasters since 2012. Therefore, this study matched the village-level data to household-level data to know if farmers had suffered from landslides.

3.2.3. Control Variables

To reduce the impact of omitted variables on the estimated results, this study referred to the research by Yan et al. [66], Xu et al. [67], and Deng et al. [32]. More specifically, this study added the control variables closely affecting cropland abandonment. The control variables included householder characteristics (e.g., age and education), household characteristics (e.g., land area, land right, household size, employment, off-farm income, asset, etc.), social environment variables (e.g., distance and urbanization), and province dummies. The definition and assignment of all the variables are shown in Table 1.

Table 1. The definition and data description of the variables in the model.

Variables	Definition and Assignment	Mean	SD
Dependent variables: Abandonment			
Behavior	Whether rural households abandon cropland (0 = no; 1 = yes)	0.15	0.35
Area	The area of cropland abandonment in rural households (mu [a])	0.34	1.57
Focal Variable			
Landslide	Whether rural household has suffered landslides since 2012 (0 = no; 1 = yes)	0.26	0.44
Control variables			
Age	Age of household head in years (year)	53.79	13.37
Education	Whether householder has received a high school diploma or above (0 = no; 1 = yes)	0.11	0.31
Employment	The share of off-farm employment labors in total labors (%)	41.62	38.58
Household size	Total member of rural households (number)	4.67	2.23
Elder	Whether household has over 64 years old people engaging in agricultural production (0 = no; 1 = yes)	0.11	0.32
Land size	Managing land area of rural households (mu)	6.75	10.98
Land right	Whether rural households get the land confirmation certificate (0 = no; 1 = yes)	0.45	0.50
Off-farm income	The share of off-farm income in total income (%)	0.46	0.44
Fixed assets	Per capita of current market value of all the fixed assets that a household possesses (Wan Yuan [b]/person)	4.34	15.94
Agricultural assets	Per capita of current market value of all the agricultural assets that a household possesses (Wan Yuan [b]/person)	0.08	0.60
Distance	Distance from households to the nearest business center (Km)	8.69	10.81
Urbanization	The share of urban households in total households with same county in sample (%)	10.94	20.50

[a] 1 mu $\approx$ 667 m^2 or 0.067 ha. [b] During the study period, 1 USD was equal to 6.12 Chinese Yuan.

3.3. Empirical Model

This study aimed to explore the quantitative impacts of landslides on cropland abandonment. Cropland abandonment included abandonment behavior and abandonment area. Among them, the behavior is a binary variable, thus this study employed Probit model to explore the impacts of landslide on abandonment behavior. Area is a left truncated and continuous variable, thus this study employed Tobit model to explore the impacts of landslide on abandonment area. The models were set as follows:

$$Behavior_{ip} = \beta_0 + \beta_1 Landslide_{ip} + \gamma X + \delta_p + \varepsilon_{ip} \tag{1}$$

$$Area_{ip} = \beta_0^* + \beta_1^* Landslide_{ip} + \gamma^* X + \delta_p^* + \varepsilon_{ip}^* \tag{2}$$

where the subscripts of i and p represent household and province, respectively; *Behavior* is a dummy variable, where 1 represents that household has abandoned cropland and 0 represents otherwise; *Area* is a continuous variable, which represents the area of cropland abandonment; *landslide* is a dummy variable, where 1 represents that household has suffered landslides since 2012 and 0 represents otherwise; X is a vector of control variables; β_0 and β_0^* are constant; β_1 and β_1^* are estimated parameters; γ and γ^* are vectors of estimated parameters for control variables; δ and δ^* are province dummies; and ε and ε^* are random error terms.

4. Results

4.1. Spatial Distribution

From the existing literature, mountainous rural areas not only are prone to landslides but also have high levels of cropland abandonment. In terms of spatial distribution, what is the distribution of landslides and land abandonment? This study combined sample data and ArcGIS software to draw spatial distribution maps (with the province as a basic statistical unit). Figure 2 reports the share of households experiencing landslides in all households in the same province. Figure 3 reports the share of households abandoning cropland in all households in the same province. As shown in Figure 2, most of the sample provinces, except for some provinces (e.g., Tianjin, Jilin, and Liaoning), have suffered from landslides. Landslides in China are concentrated in mountainous areas. For example, the Qinling

Mountains (Gansu, Shaanxi, and Henan), Ta-pieh Mountains (Anhui and Hubei), and Bashan Mountains (Sichuan and Chongqing) are regions with a high concentration of landslides. Among them, the incidence of landslides is the highest in Anhui (approximately 59.44%). As shown in Figure 3, cropland abandonment also occurs mainly in mountainous areas. For example, the Qinling Mountains (Gansu), Ta-pieh Mountains (Anhui and Hubei), Wuyi Mountains (Jiangxi and Fujian), and Bashan Mountains (Sichuan and Chongqing) are the regions with high levels of cropland abandonment. Among them, the incidence of cropland abandonment is the highest in Gansu (approximately 36.59%).
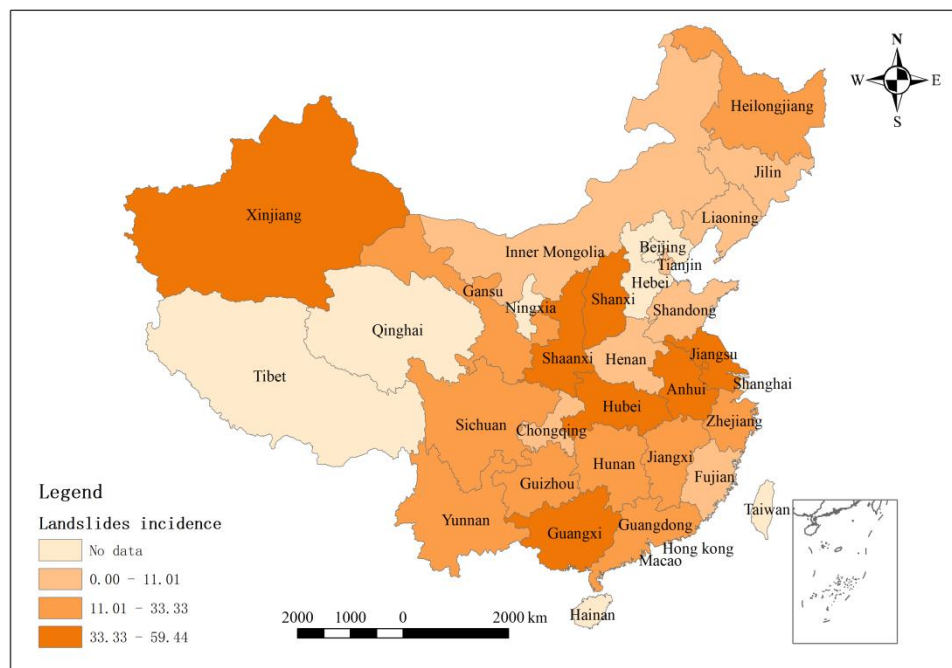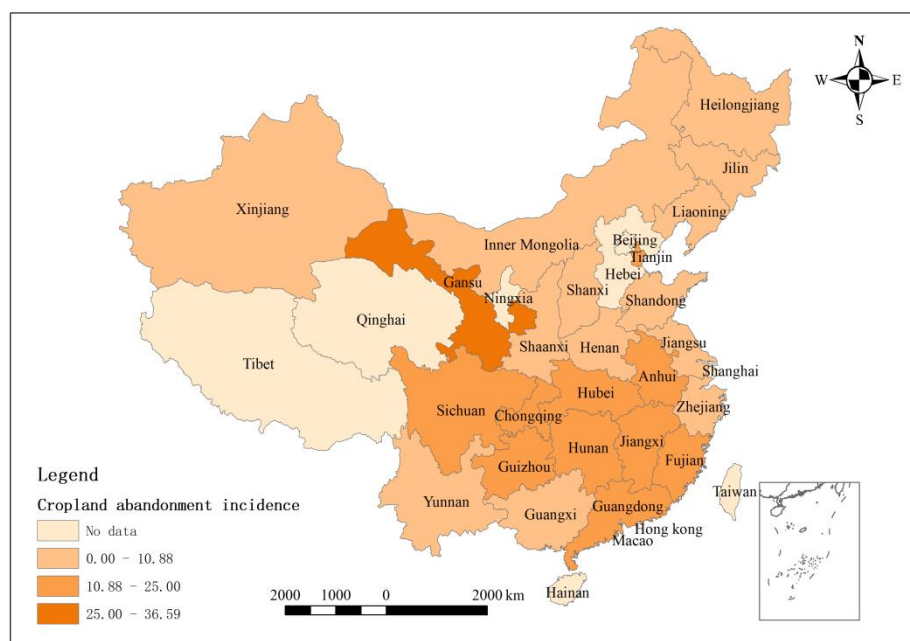

Figure 2. Landslides incidence.

Figure 3. Cropland abandonment incidence.

In summary, as shown in Figures 2 and 3, both landslides and cropland abandonment agglomerate in mountainous areas. Namely, the mountainous rural areas are not only the landslide-prone areas but also the concentrated areas of cropland abandonment. Thus, there is a similar spatial distribution between landslides and cropland abandonment. Namely, the region with a higher incidence of landslides is also the region with a higher behavior of cropland abandonment (e.g., Sichuan, Hubei, Anhui, Fujian, Guangdong, etc.). From the perspective of spatial distribution analysis, there may be a correlation between landslides and cropland abandonment. Thus, it is necessary to put emphasis on econometric models to further verify whether various correlation coefficients are significant.

4.2. Empirical Analysis

4.2.1. Impacts of Landslides on Cropland Abandonment

To explore the quantitative impact of landslides on cropland abandonment, this study divided cropland abandonment into abandonment behavior and abandoned area. In Table 2, the dependent variable of the Probit regression models, Models (1)–(3), is abandonment behavior (abbreviated to Behavior). In addition, in Table 2, the dependent variable of the Tobit regression models, Models (5)–(7), is the abandoned area (abbreviated to Area). The identification strategy of this study was to gradually introduce control variables and observe whether the focal variable is significant and stable. Additionally, because the probit and Tobit methods are nonlinear estimates, their estimation results cannot be directly used as quantitative coefficients. Thus, the quantitative coefficients are estimated by marginal effect estimation based on Models (3) and (7) for the Probit model and the Tobit model, respectively.

As shown in Table 2, in Model (1), only the focal variable *Landslide* is introduced; in Model (2), the province dummy variables are introduced on the basis of Model (1) to exclude estimation bias arising from geographical differences; in Model (3), the characteristics of householder, household and social environment are introduced on the basis of Model (2) to exclude estimation bias arising from other factors; Model (4) presents the marginal estimated results based on Model (3). In Models (1)–(3), the focal variable *Landslide* is always significant at a level of 1%, which is greater than zero. The results reveal that landslides are the determinant driving cropland abandonment. Based on the results of Model (4), *Landslide* has a positive and significant sign and a coefficient of 0.068. The results reveal that, if a farmer suffers from landslides, his probability of abandoning cropland will increase by 6.8% after keeping all other variables unchanged. Additionally, the control variables of *Age*, *Employment* and *Off-farm income* are significantly and positively correlated with *Behavior*, while the control variables of *Elder* and *Urbanization* are significantly and negatively correlated with *Behavior.* More specifically, keeping other variables unchanged, for every one-year increase in *Age*, the probability of cropland abandonment increases by 0.2%; for every 1% increase in *Employment*, the probability of cropland abandonment increases by 0.1%; for every 1% increase in *Off-farm income*, the probability of cropland abandonment increases by 3.4%; if elderly members of the household (over 64 years old) are engaged in agricultural production, the probability of cropland abandonment decreases by 2.9%; and for every 1% increase in *Urbanization*, the probability of cropland abandonment decreases by 0.1%.

As shown in Table 2, in Model (5), only the focal variable *Landslide* is introduced; in Model (6), the province dummy variables are introduced on the basis of Model (5) to exclude estimation bias arising from geographical differences; in Model (7), the characteristics of householder, household and social environment are introduced on the basis of Model (6) to exclude estimation bias arising from other factors; and Model (8) presents the marginal estimated results based on Model (7). In Models (5)–(7), the focal variable *Landslide* is always significant at a level of 1%, which is greater than zero. The results also reveal that landslides are the determinant driving cropland abandonment. Based on the results of Model (8), *Landslide* has a positive and significant sign, and a coefficient of 0.064. The results reveal that if a farmer suffers from landslides, his area of abandoning cropland will increase by 0.064 mu after keeping other variables unchanged. Additionally, the control variables of

Age, *Employment*, *Land size* and *Off-farm income* are significantly and positively correlated with *Area*; the control variables of *Elder* and *Urbanization* are significantly and negatively correlated with *area*. More specifically, keeping other variables unchanged, for every one-year increase in *Age*, the area of cropland abandonment increased by 0.002 mu; for every 1% increase in *Employment*, the area of cropland abandonment increases by 0.001 mu; for every 1 mu increase in *Land size*, the area of cropland abandonment increases by 0.001 mu; for every 1% increase in *Off-farm income*, the area of cropland abandonment increases by 0.031 mu; if elderly members of the household (over 64 years old) are engaged in agricultural production, the area of cropland abandonment decreases by 0.031 mu; and for every 1% increase in *Urbanization*, the area of cropland abandonment decreases by 0.001 mu.

Table 2. Econometric model estimation results of cropland abandonment in mountain area [a].

	Dependent Variable: Behavior				Dependent Variable: Area			
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Mode (6)	Model (7)	Model (8)
Landslide	0.284 ***	0.333 ***	0.325 ***	0.068 ***	1.586 ***	1.749 ***	1.661 ***	0.064 ***
	(0.048)	(0.055)	(0.057)	(0.012)	(0.361)	(0.397)	(0.378)	(0.010)
Age			0.010 ***	0.002 ***			0.052 ***	0.002 ***
			(0.002)	(0.000)			(0.011)	(0.000)
Education			0.030	0.006			0.336	0.013
			(0.077)	(0.016)			(0.398)	(0.015)
Employment			0.003 ***	0.001 ***			0.015 ***	0.001 ***
			(0.001)	(0.000)			(0.003)	(0.000)
Household size			0.007	0.001			0.056	0.002
			(0.012)	(0.003)			(0.063)	(0.003)
Elder			−0.139 *	−0.029 *			−0.812 **	−0.031 **
			(0.078)	(0.016)			(0.377)	(0.014)
Land size			0.009	0.002			0.107 **	0.004 **
			(0.006)	(0.001)			(0.050)	(0.002)
Land right			0.061	0.013			0.166	0.006
			(0.053)	(0.011)			(0.249)	(0.009)
Off-farm income			0.164 ***	0.034 ***			0.807 ***	0.031 ***
			(0.060)	(0.012)			(0.308)	(0.011)
Fixed assets			−0.004	−0.001			−0.021	−0.001
			(0.004)	(0.001)			(0.021)	(0.001)
Agricultural assets			−0.060	−0.013			−0.812	−0.031
			(0.134)	(0.028)			(0.736)	(0.027)
Distance			0.000	0.000			0.002	0.000
			(0.002)	(0.000)			(0.010)	(0.000)
Urbanization			−0.007 ***	-0.001 ***			−0.027 ***	−0.001 ***
			(0.001)	(0.000)			(0.007)	(0.000)
Constant	−1.141 ***	−0.674 ***	−1.250 ***		−6.611***	−2.698 *	−6.121 ***	
	(0.027)	(0.227)	(0.269)		(0.906)	(1.456)	(1.703)	
Province dummies	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observation	4850	4850	4850	4850	4850	4850	4850	4850

[a] Robust standard errors in parentheses; * Significant at $\alpha = 0.10$; ** significant at $\alpha = 0.05$; *** significant at $\alpha = 0.01$.

4.2.2. Robustness Check

The identification strategy used in the above regression was to gradually introduce control variables and observe whether the focal variable is significant and stable. To ensure the robustness of the estimation results, subsample regression and endogenous estimation methods were used. To eliminate the potential impact of different topographical features on the results, this study used subsamples of hills and mountains in the estimation. Furthermore, the theoretical framework suggests a potential relationship of reciprocal causation between landslides and cropland abandonment. To eliminate the impact of this potential relationship, this study used the instrumental variable method to estimate which instrumental variable other than a particular household in a given county impacts the likelihood of landslides. The models in Table 3 introduce the focal variables and all control variables.

In Table 3, when the dependent variable is *Behavior*, *landslide* has a significant and positive sign (at least at the 5% level of significance) in the hill and mountain subsamples. The results reveal that landslides steadily and positively affect the abandonment behavior in each subsample. Meanwhile, *landslide* has a significant and positive sign (at the 1% level of significance), with a coefficient of 0.358.

Compared with the coefficient and significance of *landslide* in Model (3) in Table 2, there is no significant change. The results indicate that the potential relationship of reciprocal causation has no significant impact on the estimated results. Similarly, when the dependent variable is *Area*, *landslide* has a significant and positive sign (at least at the 5% level of significance) in the hill and mountain subsamples. The results reveal that landslides steadily and positively affect the abandoned areas in each subsample. Furthermore, *landslide* has a significant and positive sign (at the 1% level of significance), with a coefficient of 1.772. Compared with the coefficient and significance of *landslide* in Model (7) in Table 2, there is no significant change. The results also indicate that the potential reciprocal causation relationship has no significant impact on the above estimated results. In summary, whether the subsample regression or the instrumental variable regression is used, the results on the impact of landslides on cropland abandonment are very robust.

Table 3. Results of robustness check [a].

	Dependent Variable: Behavior			Dependent Variable: Area		
	Hill	**Mountain**	**Endogenous**	**Hill**	**Mountain**	**Endogenous**
Landslide	0.189 **	0.359 ***	0.358 ***	1.314 **	1.497 ***	1.772 ***
	(0.086)	(0.098)	(0.076)	(0.629)	(0.075)	(0.530)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Province dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observation	2837	2013	4850	2837	2013	4850

[a] Robust standard errors in parentheses; * Significant at $\alpha = 0.10$; ** significant at $\alpha = 0.05$; *** significant at $\alpha = 0.01$.

5. Discussion

Based on the survey data of a large sample of peasant households in China and following the theoretical framework of "environment → land use", this study draws the spatial distribution of landslides and cropland abandonment and explores the quantitative impacts of landslides on cropland abandonment. Compared with prior studies, the marginal contributions are as follows: (1) this study revealed features of and relationships between landslides and cropland abandonment from the perspective of the spatial distribution; and (2) this study quantitatively identified the impacts of landslides on cropland abandonment in mountainous areas. Additionally, this study employed the survey data of a large sample of peasant households in China, which helps focus on the micro-level impacts of landslides on cropland abandonment in mountainous areas. More importantly, the results of this study may provide some reference for the government to implement effective policies for managing landslides and revitalizing unused cropland resources.

Interestingly, prior studies have quantitatively or qualitatively revealed the drivers of cropland abandonment from the perspective of change in the social environment [22,46,51,68]. The prior studies form the basis for quantitatively revealing the drivers of cropland abandonment from the perspective of change in the natural environmental. In this study, the results concerning the spatial distribution reveal that regions that have a high incidence of landslides also have a high incidence of cropland abandonment. Furthermore, the results of empirical analysis show that: after controlling for factors of the social environment, *Landslide* has a positive and significant sign in all models, the coefficients of *Landslide* are 0.068 in Model (4) and 0.064 in Model (8). Namely, landslides (a factor of the natural environment) significantly and positively affect cropland abandonment (land use). Many studies explore the relationship between the natural environment and land use. Most studies believe that the change in land use drives the change in the natural environment [6,34–37,39]. However, this study believes that changes in the natural environment also drive changes in land use. Possible reasons for these differences are as follows: On the one hand, China has a special land institution. Compared with most countries, China's peasant households have incomplete land rights [69]. China's land law gives the time-limited right of land management to peasant households but the time-unlimited ownership of land to the collective. On the other hand, most cropland is abandoned for only a short

time in China. China's land law stipulates that, if cropland is continuously abandoned for more than two years, the collective can confiscate the right of land management from the peasant households. Meanwhile, cropland can partly provide the function of social security [70]. Thus, most peasants would not abandon cropland for a long time. Namely, in China, most cropland abandoned in mountainous areas would not spontaneously shift to forest. As mentioned above, developing countries (e.g., China) should pay more attention to the impacts of change in the natural environment on change in land use, which may help make land use sustainable. By doing so, we could effectively protect agricultural cultural landscapes and address global food security issues.

Additionally, prior studies have focused on the impacts of the migration of laborers (age of 16–64) on cropland abandonment [17,46]. However, the phenomenon of "agricultural over-age labor" occurs in many developing countries in the world, including China ("agricultural over-age labor" means that elders over 64 years old are still engaged in agricultural production) [67]. This study found that: the coefficients of elder are −0.029 in Model (4) and −0.031 in Model (8), which means that, if people over 64 years old in a household are engaged in agricultural production, the household is not likely to abandon cropland. Although "agricultural over-age labor" helps improve the efficiency of land use, it is also harmful for the health of the elderly. Meanwhile, this study also found that the development of urbanization helps curb cropland abandonment in mountainous areas. This study's conclusion differs from the conclusions of prior studies, which report that the development of urbanization pushes cropland abandonment in mountainous areas [51,68]. The possible reasons for this different result are as follows: as the margins of urban areas continue to expand, cropland gradually moves to higher altitudes [71]. Thus, mountainous cropland becomes important to ensure global food security. Our results also support the concept of China's rural development, which revitalizes villages through urban–rural integration. Namely, the development of urbanization has reduced the waste of rural resources in mountainous areas, which contributes to the integrated development of urban and rural areas.

Finally, this study has several deficiencies, which can be addressed in future studies. (1) Landslides and cropland abandonment may have a dynamic relationship, so future research should employ panel data to analyze the relationship; (2) there may be the different impacts of landslides on different plots, so future research should employ plot data to analyze the relationship; and (3) in China, the right of land ownership belongs to the collective. The peasant household only holds the right of land management, while in certain countries, the rights of land ownership and management vest in the same individual (the collective or the private). Future research can verify whether the conclusion of this study is applicable in those countries.

6. Conclusions and Policy Implications

Based on the survey data of a large sample of 4850 mountainous households in 24 provinces of China and following the theoretical framework of "environment → land use", this study quantitatively identified the impacts of landslides on cropland abandonment in mountainous areas using the Probit and Tobit models. The results show that:

(1) There is a similar spatial agglomeration trend between landslides and cropland abandonment. Namely, an area that has a high incidence of landslides also has a high incidence of cropland abandonment.
(2) There is a significant and positive correlation between landslides and cropland abandonment. Namely, compared with peasants who have not suffered from landslides, the probability that peasants suffering from landslides will abandon cropland and the area abandoned increase by 6.8% and 0.064 mu, respectively.
(3) Elderly farmers (over 64 years old) and the development of urbanization help curb cropland abandonment in the mountains.

Our results have several policy implications. In mountainous areas, landslides, as one of the most common natural hazards threatening the safety of farmers [6–10], significantly promotes cropland abandonment. This may be harmful for ensuring food security and protecting agricultural landscapes, which suggests that the government should increase efforts to manage natural hazards and improve the resilience of peasants. For example, the government should strengthen the monitoring of areas sensitive to landslide disasters and guide the market to provide mountain farmers with more technology to stabilize failure-prone slopes. Furthermore, some rural elderly over 64 years old continue to engage in agricultural production; therefore, we should pay more attention to the health problems of the rural elderly. For example, the government should help establish mechanisms for the retirement of older peasants and guide young peasants who are skilled and capable of engaging in agricultural production. Additionally, the development of urbanization helps to curb cropland abandonment in mountains. This suggests that we need to achieve high-quality urbanization. For example, along with implementing the "Village Revitalization Strategy" in China, the government should focus on promoting the equal flow of "talents, capital and land" between urban and rural areas.

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