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Driving Mechanisms of Cropland Abandonment from the Perspectives of Household and Topography in the Poyang Lake Region, China

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Abstract: Cropland abandonment is driven by various mechanisms and is best viewed from multiple perspectives to suggest targeted policy changes which may change the status quo of abandonment. Here, we systematically analyze the characteristics of abandonment and its driving mechanisms by different farming households (pure, part-time, and non-farm) in three topographic regions of the Poyang Lake region using a binary logistic regression model. Results show that: (1) The overall abandonment probability in the Poyang Lake region is largest for non-farm households, followed by part-time households and pure households. In the mountainous region, abandonment is largest for non-farm households, followed by pure households and part-time households. Both the hilly and plain regions show the largest abandonment probability for pure households, followed by part-time households, and non-farm households. (2) The low agricultural economic benefits and the uneconomical investments of time in plots are the main abandonment determinants for pure households. Economic efficiency, both the time invested in plots and economic efficiency, are key abandonment determinants for pure households in the mountainous and plain regions, respectively. (3) Labor shortage and plots which are time-consuming and unfavorable to cultivation are the main abandonment determinants for part-time households, with different factors in different topographic regions. (4) For non-farm households, many factors can influence the occurrence of abandonment. Non-farm households in the mountainous and hilly regions are more influenced by non-farm work and the number of farming workers, respectively; in addition, the inconvenience of using agricultural machinery has a significant influence.

Keywords: cropland abandonment; driving mechanisms; farming household diversity; topography; Poyang Lake region

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1. Introduction

The process of urbanization and industrialization is accelerating with the development of social economies, leading to a decrease in the efficiency of agriculture, and a large migration of rural labor into cities [1–4], resulting in increased cropland abandonment in rural areas [5–8]. Data from the seventh census show that the urbanization rate of the resident population of China has rapidly increased over the past 10 years after surpassing 50%, and large-scale urban–rural migration is likely to continue, meaning cropland abandonment will be a long-term issue [7,9,10].

Cropland abandonment leads to the reduction of crop sowing areas, which threatens the food production security of regions and countries [11–14], threatens the stability of ecological environments [15–18], and increases fire risk [19,20]. Abandonment also causes

a loss of functional values such as landscape aesthetics, leisure tourism, and cultural heritage [21,22], and affects the stability of rural society as well as the promotion of agricultural modernization. More seriously, cropland abandonment can lead to the decline of rural areas [23], which in turn promotes the abandonment of cropland, forming a vicious circle which restricts the sustainable development of rural areas [12,24–26]. In recent years, a series of policies and measures for the development of rural agriculture have been introduced in China, but cropland abandonment is still increasing [14]. It is thus urgent to understand the patterns of cropland abandonment and the driving mechanism responsible to provide suggestions for improved agricultural at the regional and country level.

Significant research exists on the spatial distribution characteristics of cropland abandonment and its driving factors, as well as the impacts on ecological environments and society. However, the majority of previous research was conducted in developed regions such as Europe, where cropland abandonment is serious [27]. There is a limited amount of research in China on this topic, which is primarily concerned with remote hilly mountainous areas [28–31]. There are different factors for cropland abandonment in different topographic areas, and there is no uniform consensus on the relationship between topography and cropland abandonment. The probability of cropland abandonment in hilly mountainous areas may be lower than in plain areas because soil conditions in hilly mountainous areas are better than those in plain areas, and it is densely populated in hilly mountainous areas, agriculture is an important livelihood strategy for them [32]. Alternatively, cropland abandonment may first occur in hilly mountainous areas because location conditions, information flow costs, agricultural mechanization and development, and other conditions in hilly mountainous areas are worse than those in plain areas [6,18,33,34]. In addition, farming households are diverse and there are different driving mechanisms for cropland abandonment among different farming households. The issue of farming household diversity has been previously considered, but mainly for hilly mountainous areas, and most of them are treated as a whole, without distinguishing topography [35–38]. However, there are clear differences in economic development level and topographic conditions in different topographic areas, thus, treating them as a whole would weaken the determination of their differences in driving mechanisms of cropland abandonment [38]. In addition, plain regions are the main areas of grain production in China, so it is of great significance to clarify the status and driving mechanisms of cropland abandonment in plain regions for guaranteeing national food security. The consideration of multiple topographies and farming household types and systematically analyzing the factors of cropland abandonment may thus improve the development of effective development of agricultural policies.

The Poyang Lake region is one of the most important rice-growing areas of China and is also an important commodity grain base, and we here improve upon existing research to better understand cropland abandonment in the region [39]. We analyze conditions of cropland abandonment for diverse farming households under different topographic regions and its driving factors based on Farming Household Survey Data. We will address two primary questions here: (1) How do the characteristics of cropland abandonment vary by farming households under different topographic regions in the Poyang Lake region? (2) What are the driving factors of cropland abandonment for diverse farming households under different topographic regions in the Poyang Lake region? The results of the study will provide guidance for the development of agricultural policies, both locally and for other areas with similar characteristics.

2. Materials and Methods

2.1. Study Area

The Poyang Lake region is located in the northern Jiangxi Province, China. It is an important hub connecting the south and north as well as the coast and the interior. Our study area covers 51,200 km^2, which is at a high elevation at the periphery and low in the middle; mountains, hills, and plains account for about 36%, 42%, and 22% of the total area, respectively. The area is an important commercial grain production base of China,

where the main crop is rice, which accounts for more than 50% of the total cultivated area of crops in Jiangxi Province [40]. However, the investment of agricultural production is not sufficient, and grain productivity is low.

Wenquan Township in Lushan City, Jiangxi Province; Sujiadang Township in Gongqing City, Jiangxi Province; and Songhu Township in the Xinjian District, Nanchang City, Jiangxi Province are selected as typical sample regions of mountainous, hilly, and plain topography to analyze the driving factors of cropland abandonment for different farming households in the Poyang Lake region (Figure 1).

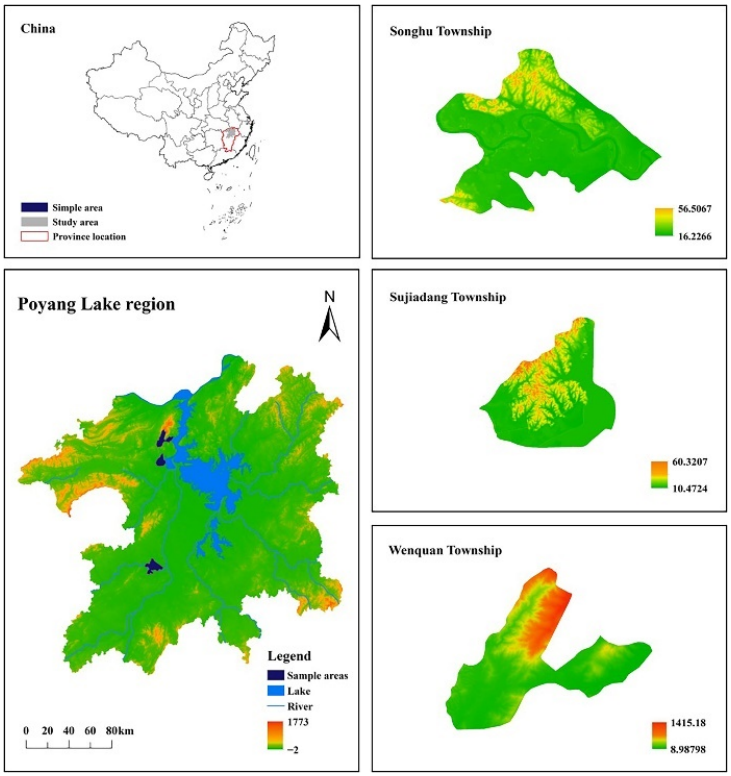

Figure 1. The location of the study domain.

2.2. Data Sources

Data were collected through four field surveys in the Poyang Lake region between July 2018 to December 2019. The sample households were selected by hierarchical sampling and systematic sampling. A semi-structured questionnaire was used to interview the households. The questionnaire obtained information on characteristics of farming households, business status, labor migration conditions, cropland utilization, resource endowment, characteristics of plots, policy satisfaction, disaster pollution awareness, and other factors. A total of 613 questionnaires were obtained, of which 415 were valid: 123 from the mountainous region, 165 from the hilly region, and 127 from the plain region.

2.3. Farming Household Division Criteria

Livelihood strategies are commonly identified by income composition, but this approach ignores the volatility of income and the uncertainty between input and output [41]. It is often more effective to differentiate livelihood strategies based on the allocation of inputs to various livelihood activities. For example, the input of labor invested in livelihood activities can directly reflect the livelihood strategies of farming households [42,43].

We apply these concerns along with the local actual situation to distinguish the pure farming laborers based on whether the members of the farming household are engaged in non-farm work; the remaining members are classified into part-time laborers or non-farm laborers based on whether they are involved in farming work. Farming households are

then classified into pure households, part-time households, and non-farm households according to the proportion of the three types of laborers. Specific standards used are as follows: When there is only one type of labor force in the household, the household is a labor force type. When there are two types of labor force in the household, the household is a type of labor force that accounts for more than 50% of the total laborers (The households with equal proportions of the two types of labor force are not considered). When there are three types of labor force in the household, the household is a labor force type that accounts for more than or equal to 50% of the total laborers (We exclude households with equal proportions of the three types of labor force and the two types of labor force).

2.4. Assumptions

The following assumptions are made about the driving factors of cropland abandonment in the Poyang Lake region according to the characteristics of diverse farming households:

(1) The majority of laborers of pure households are fully engaged in farming, and agricultural profits are their main goal, therefore, the behavioral decisions of pure households are close to Schultz's "rational peasant" [38]. Due to high input of agricultural materials, machinery and labor costs, and low output and low profits of agriculture, the plots that require large investments of time and energy are not cost-effective or not enough to make ends meet will be abandoned by pure households [38].

(2) Most of the laborers in part-time households are engaged in non-farm and farming work at the same time, or they only work in farming during the busy farming season. The non-farm jobs of the laborers working in non-farm work while working in farming work are generally unstable, and yields maximization is the goal of agricultural production for these households to ensure maximum agricultural output and to meet basic survival requirements, so they will not easily abandon the cropland [38]. However, the non-farm jobs of the laborers who work in farming only during the busy farming season are generally stable, and the household income can be secured through non-farm income, so some plots will be abandoned due to labor shortage. In addition, farming for these households is not focused on maximizing yields, but rather on obtaining basic household needs, or to obtain a sense of value and happiness in life; thus, the possibility of cropland abandonment will be relatively higher. In these cases, plots requiring more time and energy which are unfavorable to cultivation will be abandoned first.

(3) The driving factors of cropland abandonment for non-farm households are the most complex. The laborers of non-farm households are mainly engaged in non-farm work, and their household income is mainly non-farm income, which is enough to secure their survival. If their farming plots cannot be transferred, non-farm households may abandon them for many reasons.

2.5. Methods

The binary logistic regression model is a regression analysis model which considers dichotomous response variables and is effective for analyzing micro-individual decision-making behavior and driving factors [36]. The model assumes that the cumulative distribution function for the residual error of the explanatory variables follows a logistic distribution [44]. Because cropland abandonment is a binary response variable, a binary logistic regression model is an appropriate tool to determine the driving mechanisms of cropland abandonment [45]. Moreover, its application on the factors of cropland abandonment is well-demonstrated [36,44,45]. Here, we denote P as the probability of the occurrence of a "cropland abandonment" event, and $(1 - P)$ as the probability of the occurrence of cropland not being abandoned; Y denotes the dependent variable, indicating whether the cropland has been abandoned or not, if $Y = 1$, cropland abandonment occurs, if $Y = 0$, cropland abandonment does not occur. $X_1, X_2, X_3 \cdots X_{24}$ are the independent

variables. Analysis was carried out through SPSS25.0 statistical software to formulate the regression model:

$$log\left[\frac{P(y\leq j)}{1-P(y\leq j)}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_{24} X_{24}$$
$$= P(y \leq j) = \frac{Exp(\alpha+\sum \beta_i x_i)}{1} + Exp(\alpha + \sum \beta_i x_i)$$

α, β_0 are constant terms, $\beta_1, \beta_2, \beta_3 \ldots \beta_{22}$ are regression coefficients of the binary logistic regression equation, and Exp denotes the occurrence rate of the independent variable on the probability of the event. In the results, $B, Sig, Exp(B)$ denote the regression coefficient, the P value of the significance level of the regression coefficient, and the occurrence probability, respectively. When the regression coefficient B is positive, the independent variable has a positive impact on the dependent variable, and conversely, the independent variable has a negative impact on the dependent variable.

3. Variable Selection and Descriptive Statistical Analysis

3.1. Variable Selection and Definition

Five aspects of independent variables are selected based on the relevant literature about driving factors of cropland abandonment of households [34,38,46] and the actual situation of our investigations, including farming household characteristics, economic characteristics, policy evaluation, disaster pollution awareness, and plot characteristics. Farming household characteristics include: gender ratio, household size, average health level, average education level, farming laborers, and non-farm laborers. Economic characteristics include: agricultural income and expenditure, proportion of non-farm income, existence of large domestic animals, and the operation of economic forestry. Policy evaluations include: evaluation of agricultural subsidies, grain purchase price, and the direct grain subsidy policy for the households. Disaster pollution awareness includes the perception of changes in droughts and rainstorms of the farming household. Plot characteristics include plot size, plot type, distance to home, use of agricultural machinery, irrigation conditions, plot quality, and landform (Table 1).

Table 1. Variable definitions and assignment.

Variables	Definition and Description
Abandonment	If the farming household has abandoned the cropland (0 = no; 1 = yes)
Pure household	Farming household with mainly pure farming laborers
Part-time household	Farming household with mainly part-time laborers
Non-farm household	Farming household with mainly non-farm laborers
Farming household characteristics	
Gender ratio	Male/Female
Household size	Number of household members (1: ≤3 people; 2: 3–7 people; 3: ≥7 people)
Average health level	Average health level of household members (1 = good; 2 = fair; 3 = poor; 4 = very poor)
Average education level	Average education level of household members (1 = illiterate; 2 = elementary school education; 3 = junior high school education; 4 = higher secondary school education; 5 = college education and above)
Farming laborers	Farming household's farming laborers (number)
Non-farm laborers	Farming household's non-farm laborers (number)

Table 1. *Cont.*

Variables	Definition and Description
Economic characteristics	
Agricultural income and expenditure	Agricultural income minus agricultural expenditure (1 = positive; 2 = equilibrium; 3 = negative)
Proportion of non-farm income	The proportion of non-farm income in household income (%)
Existence of large domestic animals	1 = yes; 2 = no
Existence of economic forestry operations	1 = yes; 2 = no
Policy evaluation	
Evaluation of agricultural subsidies	Farming household's evaluation of existing agricultural subsidy policies (1 = very good; 2 = better; 3 = fair; 4 = not very good; 5 = very bad)
Evaluation of grain purchase price	Farming household's evaluation of existing grain purchase prices (1 = too low; 2 = low; 3 = fair; 4 = high)
Is the direct grain subsidy policy conducive to cropland conservation	If farming household thinks the existing direct grain subsidy policy is beneficial to cropland conservation (1 = yes; 2 = unable to say; 3 = no)
Disaster pollution awareness	
Changes in the number of droughts in recent years	Farming household's perceptions of droughts changes (1 = increase; 2 = no change; 3 = decrease; 4 = fluctuating change)
Changes in the number of rainstorms in recent years	Farming household's perceptions of rainstorms changes (1 = increase; 2 = no change; 3 = decrease; 4 = fluctuating change)
Plot characteristics	
Plot size	Size of each plot (mu *)
Plot type	Is this plot dry or paddy (1 = paddy field; 2 = dryland)
Distance to home	Distance of the plot to home (km)
Use of agricultural machinery	Use of agricultural machinery on the plot (1 = use; 2 = occasional use; 3 = no use)
Irrigation conditions	The irrigation condition on the plot (1 = rainfed; 2 = irrigated)
Plot quality	The quality of the plot (1 = high; 2 = medium; 3 = low)
Landform	Landform of the plot (1 = flat land; 2 = sloping land)

* 1 mu = 666.67 m^2.

3.2. Descriptive Statistical Analysis

As shown in Table 2 (Wenquan Township), Table 3 (Sujiadang Township) and Table 4 (Songhu Township), the household size of pure households is the smallest and the household size of non-farm households is the largest in all topographic regions. The household size of non-farm households in the plain region is greater than seven people; the household size of other types of households in other topographic regions is between three and seven people. There are four laborers participating in farming in part-time households, which is the largest proportion among all types of households. Only two laborers participate in farming in non-farm households, which is the lowest proportion among all types of households. The proportion of non-farm income of pure households is the smallest (63.09%), followed by part-time households (77.51%), and non-farm households (90.95%). There are many differences in size among plots of all topographic regions, with the average plot size in the mountainous region being small (~1 mu), about 2 mu in the hilly region, and largest in the plain region, about 4 mu. The plots are mainly paddy fields. The plots of all types of households in the mountainous region are less than 1 km away from their homes, the plots of all types of households in the hilly region are about 1 km from their homes, the plots of pure households in the plain region are about 2 km from their homes, and the plots of part-time and non-farm households are relatively close to their homes, about 1 km. The

frequency of agricultural machinery used by households in the plain region is the highest, and all types of households use agricultural machinery, followed by the hilly region, where all types of households occasionally use agricultural machinery. The frequency of agricultural machinery used by households in the mountainous region is the lowest, where pure and part-time households do not typically use agricultural machinery, and non-farm households only occasionally use machinery. Although there is little difference in quality between plots, the quality of the plots is relatively the worst in the mountainous region and the best in the plain region. The landform of all plots is mainly flat, with some sloping plots in the mountainous and hilly regions.

Table 2. Wenquan Township (mountainous topographic region).

Variables	Pure Households		Part-Time Households		Non-Farm Households	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Farming household characteristics						
Gender ratio	1.39	0.82	1.37	0.85	1.43	0.88
Household size	1.78	0.44	2.08	0.67	2.30	0.57
Average health level	1.78	0.83	1.24	0.50	1.32	0.50
Average education level	2.33	0.71	2.32	0.62	2.53	0.70
Farming laborers	4.11	1.97	4.13	2.60	1.76	1.86
Non-farm laborers	1.00	1.00	2.50	1.43	4.71	2.54
Economic characteristics						
Agricultural income and expenditure	2.17	0.98	2.15	0.74	1.95	0.56
Proportion of non-farm income	91.67%	0.13	88.97%	0.22	95.96%	0.14
Existence of large domestic animals	2.00	0.00	1.94	0.23	1.96	0.20
Existence of economic forestry operations	1.86	0.38	1.64	0.49	1.73	0.45
Policy evaluation						
Evaluation of agricultural subsidies	2.56	0.73	2.45	1.12	2.68	0.96
Evaluation of grain purchase price	2.63	0.92	2.46	0.86	2.41	0.76
Is the direct grain subsidy policy conducive to cropland conservation	1.71	0.76	1.29	0.52	1.42	0.63
Disaster pollution awareness						
Changes in the number of droughts in recent years	2.22	1.39	1.65	0.78	1.89	0.93
Changes in the number of rainstorms in recent years	2.14	1.35	2.13	1.07	2.15	1.08
Plot characteristics						
Plot size	0.78	0.75	0.64	0.84	1.22	1.43
Plot type	1.39	0.50	1.38	0.49	1.34	0.47
Distance to home	0.65	0.51	0.99	2.84	0.77	1.06
Use of agricultural machinery	2.50	0.76	2.67	0.69	2.30	0.89
Irrigation conditions	1.92	0.29	1.50	0.50	1.62	0.61
Plot quality	2.17	0.38	2.06	0.59	2.09	0.71
Landform	1.06	0.24	1.38	0.49	1.49	0.50

A Variance Inflation Factor (VIF) test was conducted to judge whether the independent variables are correlated with each other to avoid high multi-collinearity among the independent variables. If the value of VIF between the two variables is more than 10, a high collinearity between the two variables is indicated, meaning they cannot be included in same the model at the same time. If the VIF values of other independent variables are less than 10, the selection of these independent variables is reasonable. Because of the collinearity found among some variables, the factor of existence of large domestic animals in the models of pure households, part-time households in the hilly region and pure households in the plain region, and factors of plot type, landform in the model of pure households in the plain region are removed.

Table 3. Sujiadang Township (hilly topographic region).

Variables	Pure Households		Part-Time Households		Non-Farm Households	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Farming household characteristics						
Gender ratio	1.44	0.90	1.14	0.72	1.30	0.76
Household size	1.93	0.59	2.09	0.42	2.38	0.59
Average health level	1.54	0.78	1.09	0.29	1.17	0.38
Average education level	2.20	0.41	2.57	0.90	2.05	0.80
Farming laborers	2.87	1.06	3.09	1.28	1.30	0.80
Non-farm laborers	1.33	1.11	1.57	1.34	4.58	2.49
Economic characteristics						
Agricultural income and expenditure	1.40	0.51	1.52	0.68	1.82	0.55
Proportion of non-farm income	54.68%	0.44	79.4%	0.27	97.25%	0.08
Existence of large domestic animals	1.93	0.27	2.00	0.00	1.95	0.21
Existence of economic forestry operations	1.93	0.26	1.82	0.40	1.94	0.23
Policy evaluation						
Evaluation of agricultural subsidies	2.18	0.87	2.71	1.26	2.37	0.92
Evaluation of grain purchase price	2.00	0.71	2.25	0.86	2.20	0.81
Is the direct grain subsidy policy conducive to cropland conservation	1.50	0.76	1.40	0.60	1.57	0.68
Disaster pollution awareness						
Changes in the number of droughts in recent years	2.62	1.39	1.73	1.16	1.37	0.78
Changes in the number of rainstorms in recent years	2.55	1.13	1.76	1.14	2.01	0.94
Plot characteristics						
Plot size	2.06	2.13	0.96	0.84	1.92	11.30
Plot type	1.39	0.50	1.39	0.49	1.40	0.49
Distance to home	0.93	1.05	1.11	1.29	0.98	1.40
Use of agricultural machinery	2.00	0.74	1.71	0.93	1.76	0.91
Irrigation conditions	1.65	0.49	1.70	0.51	1.71	0.55
Plot quality	1.82	0.39	1.90	0.44	1.82	0.60
Landform	1.25	0.44	1.21	0.41	1.29	0.47

Six stepwise selection methods of forward (conditional), forward (LR), forward (Wald), backward (conditional), backward (LR), and backward (Wald) are integrated to select the factors that pass significance test in most methods as the variables that ultimately affect cropland abandonment.

Table 4. Songhu Township (plain topographic region).

Variables	Pure Households		Part-Time Households		Non-Farm Households	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Farming household characteristics						
Gender ratio	1.17	0.6	1.56	0.76	1.30	0.54
Household size	2.16	0.69	2.29	0.75	2.69	0.56
Average health level	1.27	0.46	1.30	0.47	1.28	0.48
Average education level	2.32	0.75	2.32	0.84	2.41	0.74
Farming laborers	2.11	0.94	3.29	1.81	1.56	1.07
Non-farm laborers	2.63	1.92	1.92	1.50	5.95	3.55
Economic characteristics						
Agricultural income and expenditure	1.32	0.67	1.21	0.51	1.37	0.52
Proportion of non-farm income	42.92%	0.40	64.15%	0.29	79.65%	0.31
Existence of large domestic animals	1.67	0.49	1.87	0.34	1.88	0.33
Existence of economic forestry operations	1.94	0.24	1.87	0.34	1.98	0.15

Table 4. *Cont.*

Variables	Pure Households		Part-Time Households		Non-Farm Households	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Policy evaluation						
Evaluation of agricultural subsidies	2.58	1.07	2.17	0.92	2.41	0.93
Evaluation of grain purchase price	1.58	0.51	1.92	0.83	1.79	0.70
Is the direct grain subsidy policy conducive to cropland conservation	1.21	0.54	1.13	0.34	1.22	0.52
Disaster pollution awareness						
Changes in the number of droughts in recent years	1.59	0.87	1.53	0.84	1.51	0.77
Changes in the number of rainstorms in recent years	2.53	0.87	2.29	1.01	2.07	0.89
Plot characteristics						
Plot size	4.01	6.35	4.35	5.65	3.55	5.23
Plot type	1.01	0.12	1.03	0.18	1.01	0.12
Distance to home	1.76	1.17	0.98	0.99	1.34	1.32
Use of agricultural machinery	1.07	0.31	1.10	0.42	1.15	0.45
Irrigation conditions	1.99	0.12	2.01	0.12	1.99	0.10
Plot quality	1.87	0.34	1.75	0.55	1.75	0.61
Landform	1.00	0.00	1.01	0.12	1.01	0.09

4. Results

4.1. Statistical Data-Based Analysis of Farming Households and Abandonment Characteristics

Statistical results of farming households in three topographic regions are given in Table 5. The overall characteristic of farming households in Poyang Lake area shows proportion of non-farm households is the largest (69%), followed by part-time households (21%) and pure households (10%). This proportion is consistent in all topographic regions.

Table 5. Characteristics of diverse farming households in three topographic regions.

Farming Households	The Mountainous Topographic Region	The Hilly Topographic Region	The Plain Topographic Region	Sum
Pure households	9	15	19	43
Ratio (%)	7.3%	9.1%	15.0%	10%
Part-time households	38	23	24	85
Ratio (%)	30.9%	13.9%	18.9%	21%
Non-farm households	76	127	84	287
Ratio (%)	61.8%	77.0%	66.1%	69%
Sum	123	165	127	415
Ratio (%)	100%	100%	100%	100%

Characteristics of cropland abandonment by diverse farming households in different topographic regions are shown in Figure 2. The probability of cropland abandonment is 18.5% in the Poyang Lake region. The abandonment probability of non-farm households is generally the largest, followed by part-time households, and pure households (19.7%, 17.0%, and 13.6%, respectively). However, there are significant differences among different topographic regions, with the abandonment probability in the mountainous region being largest for non-farm households, followed by pure households and part-time households. The abandonment probability in the hilly and plain regions is largest for pure households, followed by part-time households and non-farm households. In addition, the abandonment probabilities of all types of households in the plain region are significantly lower than that of households in other topographic regions.

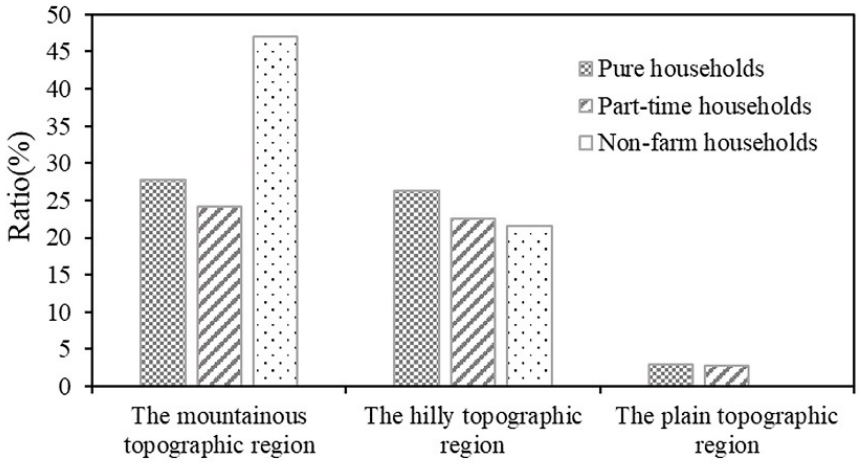

Figure 2. Characteristics of cropland abandonment by diverse farming households in three topographic regions.

4.2. The Driving Factors of Cropland Abandonment by Pure Households

4.2.1. The Driving Factors of Cropland Abandonment by Pure Households in the Mountainous Topographic Region

Few households among pure farming households in the mountainous region have abandoned cropland, so the data are not statistically significant. However, the relevant data of our questionnaire suggest that low economic efficiency is the main factor influencing cropland abandonment among pure households, in agreement with [47,48]. The average health level of pure households in the mountainous region is fair and their labor capacity is limited. Due to topographic constraints, they do not use large agricultural machinery, thus, the agricultural production efficiency is low, the agricultural economic efficiency is low, and the agricultural income is not enough to meet household living expenses, so they mostly cultivate plots of better quality, and abandon plots of poor quality or those far from home.

4.2.2. The Driving Factors of Cropland Abandonment by Pure Households in the Hilly Topographic Region

As shown in Table 6, distance to home has a significant positive impact on cropland abandonment at a 0.05 level. For every 1 km increase in the distance of the plot to home, the probability of cropland abandonment is 4.014 times larger. It is not convenient to use agricultural machinery because of topography and plot fragmentation. Coupled with the difficulty of managing plots of far from home, abandonment will typically occur first for plots far from home.

Table 6. Abandonment factors of pure households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)			The Hilly Topographic Region (Sujiadang Township)			The Plain Topographic Region (Songhu Township)		
	B	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**
Plot Characteristics									
Plot size							0.403	0.087 *	1.497
Distance to home				1.390	0.035 **	4.014	1.789	0.088 *	5.986

* $p < 0.1$; ** $p < 0.05$.

4.2.3. The Driving Factors of Cropland Abandonment by Pure Households in the Plain Topographic Region

As shown in Table 6, both plot size and distance to home have a significant positive impact on cropland abandonment at a level of 0.1. For each unit increase in plot size

and distance to home, the probability of cropland abandonment increases by 1.497 and 5.986 times, respectively. Due to high costs of agricultural materials, labor, and machinery, and low purchase prices of agricultural products, the input–output ratio of cropland is large, thus, the larger the plot size, the more agricultural inputs, and farming households will face the risk of not being able to make ends meet. In these situations, households are more willing to release a small portion of laborers to engage in non-farm work to improve the living standards of the household [49]. When non-farm income is not enough to hire laborers and machinery to cultivate the plots and the plots are difficult to transfer, the plots will be abandoned. In addition, the average plot size of pure households in the plain topographic region is large, so an increase in plot size requires more energy, which will increase the pressure of farming laborers. As living standards improve, the demand for leisure time of farmers increases. Thus, plots which need more money, time, and effort, and those that are far from home and difficult to manage will be abandoned first to reduce the burden of farming households.

4.3. The Driving Factors of Cropland Abandonment by Part-Time Households

4.3.1. The Driving Factors of Cropland Abandonment by Part-Time Households in the Mountainous Topographic Region

As shown in Table 7, plot type, plot quality, and landform have a significant positive impact on cropland abandonment at 0.05, 0.1, and 0.01 levels, respectively. Dryland, plots of poor quality, and sloping plots are most likely to be abandoned. Sloping plots in the mountainous region are mainly dry, the plot quality poor, and they are prone to soil erosion and low soil fertility, which leads to low productivity. It is time-consuming and inefficient to manage these plots (as compared to electing non-farm work), and it is inconvenient to cultivate and use agricultural machinery on these plots. They are also highly susceptible to damage by wild animals such as wild boars. As a result, these plots are often abandoned by farming households. Irrigation conditions have a significant negative impact on cropland abandonment at a 0.05 level. Most plots of part-time households in the mountainous region are paddy fields with a high demand for water, so the probability of cropland abandonment will reduce with better irrigation conditions.

Table 7. Abandonment factors of part-time households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)			The Hilly Topographic Region (Sujiadang Township)			The Plain Topographic Region (Songhu Township)		
	B	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**
Disaster Pollution Awareness									
Changes in the number of rainstorms in recent years				2.773	0.087 *	16			
Plot Characteristics									
Plot type	2.639	0.019 **	14						
Irrigation conditions	−1.654	0.022 **	0.191						
Plot quality	2.374	0.057 *	10.739						
Landform	1.935	0.003 ***	6.924						

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

4.3.2. The Driving Factors of Cropland Abandonment by Part-Time Households in the Hilly Region

As shown in Table 7, the perception on rainstorm changes has a significant positive impact on cropland abandonment at a level of 0.1. Rice cultivation is the largest in this region, and water for irrigation comes from reservoirs. With an increase in precipitation, the reservoir volume increases, and it is helpful for the irrigation of plots, so the probability of cropland abandonment reduces.

4.3.3. The Driving Factors of Cropland Abandonment by Part-Time Households in the Plain Topographic Region

There are few part-time households and fewer households which have abandoned cropland in the plain region, so our data are not statistically significant. The relevant data of our questionnaire suggest that labor shortage is a potential factor of cropland abandonment by part-time households in the plain region. Higher wages are more common for non-farm work, so young and strong laborers of part-time households in the plain region tend to work in non-farming capacities, leaving women and the elderly to carry out the farm work. Due to a lower quantity and quality of the remaining laborers, some plots of poor quality and those far from home are likely to be abandoned.

4.4. The Driving Factors of Cropland Abandonment by Non-Farm Households

4.4.1. The Driving Factors of Cropland Abandonment by Non-Farm Households in the Mountainous Region

As shown in Table 8, average health level has a significant negative impact on cropland abandonment at a 0.05 level. As the average health level of the household improves, the probability of cropland abandonment increases. Household members with good physical health tend to work in non-farm work due to the higher income available, thus part of the cropland will often be abandoned.

Table 8. Abandonment factors of non-farm households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)			The Hilly Topographic Region (Sujiadang Township)			The Plain Topographic Region (Songhu Township)		
	B	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**
Farming Household Characteristics									
Household size				−2.145	0.017 **	0.117			
Average health level	−1.586	0.013 **	0.205						
Average education level				1.501	0.028 **	4.484			
Farming laborers				−0.502	0.05 **	0.605			
Economic Characteristics									
Proportion of non-farm income	0.275	0.009 ***	1.316						
Policy Evaluation									
Evaluation of agricultural subsidies	−2.526	0.027 **	0.08						
Plot Characteristics									
Use of agricultural machinery	1.547	0.035 **	4.696	1.131	0.017 **	3.097			
Irrigation conditions	−3.481	0.000 ***	0.031	1.204	0.081 *	3.335			
Plot quality	−2.197	0.025 **	0.111	1.489	0.009 ***	4.431			
Landform	2.548	0.000 ***	12.779	−1.219	0.040 **	0.295			

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

As shown in Table 8, the proportion of non-farm income has a significant positive impact on cropland abandonment at a level of 0.01. For each 1% increase in proportion of non-farm income, there is a 31.6% increase in the probability of cropland abandonment. Non-farm income is the main economic income of non-farm households in the mountainous region, and as proportion of non-farm income increases, more plots will be abandoned by farming households.

As shown in Table 8, evaluation of agricultural subsidies has a significant negative impact on abandonment at a 0.05 level. The evaluation of non-farm households in the mountainous region on existing agricultural subsidy policies is between good and average, with average predominating, and most households do not rely on agricultural subsidies. Therefore, it does not affect the abandonment behavior of households.

As shown in Table 8, use of agricultural machinery and landform have a significant positive impact on cropland abandonment at the 0.05 and 0.01 levels, respectively. The less agricultural machinery used, the higher the probability of cropland to be abandoned. The topography of the mountainous region is restrictive for the access of large agricultural machinery, and it is time-consuming to rely on manual farming, so the probability of cropland abandonment increases when the frequency of use of agricultural machinery decreases. The probability of sloping plots to be abandoned is 12.779 times higher than that of flat plots, for reasons similar to those of part-time households in the mountainous region. Irrigation conditions and plot quality have a significant negative impact on cropland abandonment at the 0.01 and 0.05 levels, respectively. Some plots in the mountainous region may be abandoned due to inadequate irrigation facilities, so when irrigation facilities are available and the plots can be adequately irrigated, the probability of cropland abandonment will reduce. The difference in quality among plots in the mountainous region is small, and the quality of plots is essentially medium. Even when the quality of the plots is relatively good, disadvantages such as poor irrigation conditions and difficult access to agricultural machinery can lead to abandonment.

4.4.2. The Driving Factors of Cropland Abandonment by Non-Farm Households in the Hilly Region

As shown in Table 8, average education has a significant positive impact on cropland abandonment at a level of 0.05. The higher the average education of the household, the higher possibility of cropland abandonment. Individuals with higher education have more room for job choices, and most of them are willing to choose non-farm work. Both household size and farming laborers have a significant negative impact on cropland abandonment at a 0.05 level. The number of farming laborers among non-farm households in the hilly region is small: about one person. When the household size expands, the farming workers increase, more laborers are engaged in farming work, and the probability of abandonment will decrease.

As shown in Table 8, use of agricultural machinery has a significant positive impact on cropland abandonment at a 0.05 level, and the reasons are similar to those of non-farm households in the mountainous region. Irrigation conditions have a significant positive impact on cropland abandonment at a level of 0.1. There is less time for non-farm households in the hilly region to take care of plots. If plots with poor quality or sloping plots need to be irrigated, the investment of money and labor is not worth it, and these plots will be abandoned. Plot quality has a significant positive impact on cropland abandonment at a 0.01 level. When the quality of the plots is poor, the productivity of the plots is low, and the probability of cropland abandonment will increase. Landform has a significant negative impact on cropland abandonment at a 0.05 level. The plots in the hilly region are essentially flat, with a few sloping plots, but flat plots with poor quality, poor irrigation conditions, and those far from home are also likely to be abandoned.

4.4.3. The Driving Factors of Cropland Abandonment by Non-Farm Households in the Plain Region

There is no abandonment among non-farm households in the sample plain region, which indicates that less cropland abandonment by non-farm households occurs in the plain region. The quality of plots in the plain region is good, and non-farm income can be used to hire farming workers and agricultural machinery; even if they do not want to cultivate the plots, they can be transferred to others for further cultivation.

5. Robustness Check

Endogenous problems usually affect the robustness of results, mainly caused by omitted variables, selection bias, bidirectional causality, and measurement error. For example, there may be a bidirectional causality between labor migration and cropland abandonment [8,46,50]. Therefore, there may be a causal relationship between farming laborers, non-farm laborers, agricultural income and expenditure, and the proportion

of non-farm income and cropland abandonment. One way to solve the endogeneity problem is to find the instrumental variables based on the aggregated data at the regional level [51]. Therefore, following [8,46,50], the average proportion of farming laborers, non-farm laborers, agricultural income and expenditure, and non-farm income of other households in the same village except for the household i are selected as instrumental variables, respectively, according to: $IVx_i = (x_1 + \ldots + x_{i-1} + x_{i+1} + \ldots + x_n)/(n - 1)$. The IV-Probit model was used for estimation, and a Durban–Wu–Hausman test was performed. The results showed that the value of P was greater than 0.1, and the null hypothesis could not be rejected. In other words, IV regression is not significantly different from the basic regression, and there is no significant endogenous problem caused by estimation bias in the basic regression, so the results of the basic regression are adopted [52].

In addition, considering that the behavior of cropland abandonment by households is self-selective rather than random, the robustness of the estimation results may be affected by non-random selection and measurement error. Therefore, in order to further increase the credibility of the results, each subsample was randomly selected from the total sample to test the previous regression results [46]. The results are shown in Tables 9–11, which are all robust. A bootstrap sampling method was adopted to assess the robustness of previous regression results; these results are shown in Tables 12–14, with robust results seen except that distance to home no longer had a significant effect on the abandonment behavior of pure households in the hilly region, and average education level no longer had a significant effect on the abandonment behavior of non-farm households in the hilly region.

Table 9. Subsample results of pure households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)			The Hilly Topographic Region (Sujiadang Township)			The Plain Topographic Region (Songhu Township)		
	B	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**
Plot Characteristics									
Plot size							0.116	0.098 *	1.123
Distance to home				3.447	0.048 **	31.398	1.779	0.093 *	5.924

* $p < 0.1$; ** $p < 0.05$.

Table 10. Subsample results of part-time households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)			The Hilly Topographic Region (Sujiadang Township)			The Plain Topographic Region (Songhu Township)		
	B	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**
Disaster Pollution Awareness									
Changes in the number of rainstorms in recent years				2.89	0.074 *	18			
Plot Characteristics									
Plot type	1.747	0.022 **	5.736						
Irrigation conditions	−1.575	0.076 *	0.207						
Plot quality	2.2	0.048 **	9.026						
Landform	2.794	0.000 ***	16.354						

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 11. Subsample results of non-farm households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)			The Hilly Topographic Region (Sujiadang Township)			The Plain Topographic Region (Songhu Township)		
	B	Sig	Exp(B)	B	Sig	Exp(B)	B	Sig	Exp(B)
Farming Household Characteristics									
Household size				−2.327	0.01 ***	0.098			
Average health level	−1.649	0.032 **	0.192						
Average education level				1.513	0.024 **	4.541			
Farming laborers				−0.477	0.071 *	0.621			
Economic Characteristics									
Proportion of non-farm income	0.286	0.007 ***	1.331						
Policy Evaluation									
Evaluation of agricultural subsidies	−2.526	0.027 **	0.08						
Plot Characteristics									
Use of agricultural machinery	1.338	0.071 *	3.812	1.213	0.011 **	3.365			
Irrigation conditions	−7.063	0.000 ***	0.001	1.241	0.077 *	3.458			
Plot quality	−2.127	0.015 **	0.119	1.285	0.022 **	3.616			
Landform	2.561	0.000 ***	12.953	−1.293	0.031 **	0.275			

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 12. Bootstrap sampling results of pure households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)		The Hilly Topographic Region (Sujiadang Township)		The Plain Topographic Region (Songhu Township)	
	B	Sig	B	Sig	B	Sig
Plot Characteristics						
Plot size					0.402	0.002 ***
Distance to home					2.127	0.004 ***

*** $p < 0.01$.

Table 13. Bootstrap sampling results of part-time households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)		The Hilly Topographic Region (Sujiadang Township)		The Plain Topographic Region (Songhu Township)	
	B	Sig	B	Sig	B	Sig
Disaster Pollution Awareness						
Changes in the number of rainstorms in recent years			23.472	0.089 *		
Plot Characteristics						
Plot type	1.152	0.076 **				
Irrigation conditions	−0.905	0.127 *				
Plot quality	1.785	0.092 *				
Landform	4.005	0.014 **				

* $p < 0.1$; ** $p < 0.05$.

Table 14. Bootstrap sampling results of non-farm households in three topographic regions.

Variables	The Mountainous Topographic Region (Wenquan Township)		The Hilly Topographic Region (Sujiadang Township)		The Plain Topographic Region (Songhu Township)	
	B	Sig	B	Sig	B	Sig
Farming Household Characteristics						
Household size			−1.441	0.086 *		
Average health level	−1.831	0.019 **				
Average education level						
Farming laborers			−0.517	0.111 *		
Economic Characteristics						
Proportion of non-farm income	0.438	0.014 **				
Policy Evaluation						
Evaluation of agricultural subsidies	−37.332	0.01 ***				
Plot Characteristics						
Use of agricultural machinery	1.423	0.083 *	2.236	0.007 ***		
Irrigation conditions	−6.531	0.001 ***	0.972	0.197 *		
Plot quality	−2.526	0.02 **	1.429	0.014 **		
Landform	2.409	0.001 ***	−1.033	0.096 *		

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

6. Discussion

6.1. Characteristics of Cropland Abandonment

In China, farmers cannot be fully integrated into urban society, so cropland allows social security, and is not be easily abandoned by households. There is an inverted U-shaped relationship between non-farm employment and cropland abandonment in non-farm households [53]. Generally, when the non-farm employment rate is below a critical value, the non-farm income is relatively low, the remaining laborers cannot maintain the cultivation of all plots, and the non-farm income is not enough to cover the costs of production outsourcing, in which case plots may be abandoned. When the non-farm employment rate is above a critical value, non-farm income is higher and part of the non-farm income will be used to hire laborers to cultivate plots and pay for production costs, and the abandonment will be reduced [53]. Overall characteristic shows the abandonment probability of households in the Poyang Lake region is largest for non-farm households, followed by part-time households and pure households, in line with the findings of [7,8,54,55]. The plots of non-farm households are more likely to be abandoned, indicating that the overall non-farm employment rate of non-farm households and the non-farm income in the Poyang Lake region are relatively low. The cropland abandonment probability of households in the mountainous region is largest for non-farm households, followed by pure households and part-time households. When the non-farm employment rate of non-farm households and the non-farm income are relatively low and the existence of part-time households hinders abandonment [8], the non-farm jobs of part-time households will not be stable. The abandonment probability of households in the hilly and plain topographic regions is largest for pure households, followed by part-time households and non-farm households. When the non-farm employment rate of non-farm households and the non-farm income are relatively high, part of the non-farm income is used for the employment of farming laborers and other production costs by some non-farm households. The abandonment probabilities of all types of households in the plain region are significantly lower than in other topographic regions. This is because plot size in the plain region is relatively large (Table 4), so plot fragmentation degree is lower, and is easier to manage. The topography in the plain region is also flat, which is convenient for the use of agricultural machinery, saving time and effort. In addition, irrigation conditions are relatively good, which plays

an important role in restraining the abandonment behavior. Finally, the agricultural income and expenditure of households in the plain region is basically positive, better than other topographical regions, and agricultural production can obtain significant income.

6.2. Abandonment Driving Factors

Our results are consistent with existing studies which consider factors such as labor shortage [7,18,56,57], low economic efficiency in agriculture [49,58–60], distance to home [18,45,60,61], low mechanization of agriculture [18,62], and a large proportion of non-farm income [7,63–65], all of which have a positive impact on cropland abandonment. In addition, it has been previously demonstrated that small plot size [7,60,61], poor plot quality [10,18,60], sloping plots [6,18,45], and poor irrigation conditions [49] may also have a positive impact on the abandonment behavior. However, our results show that a large plot size has a positive impact on abandonment of pure households in the plain region, consistent with [49]. Factors such as plot quality, landform, and irrigation conditions have different directions of impact on cropland abandonment. Therefore, the question of how plot factors such as plot size affect the abandonment behavior of diverse farming households in different topographic areas requires further consideration. In addition, it is worth further exploring and verifying whether the distance to home affects the abandonment behavior of pure households in hilly regions and whether the average education level has an impact on the abandonment behavior of non-farm households in hilly regions.

6.3. Innovation and Shortcomings

Our approach presented here is novel and more comprehensive than previous efforts, which primarily focused on abandonment in mountainous and hilly areas but not plain areas, and did not distinguish different topographies. In addition, we considered the heterogeneity of farming households and differences in topography. One of the shortcomings of this paper is that the selection of independent variables is not comprehensive enough. The authors of [59,66] suggest that the aging of the rural population is an important driver of cropland abandonment, the authors of [67] emphasize that the early life experiences of farmers influence the behavior of cropland abandonment, and the authors of [68] suggest that traffic conditions affect the cultivation of the cropland. In addition, the distance to towns and roads, soil types [69], political factors (land market, property rights) [14,45,67,70], and structural environment (market structure, subsistence farming or contractors, etc.) all have different levels of impact on cropland abandonment. Therefore, possible improvements needed in future research include the addition of more independent variables, the selection of more research areas, and dynamic tracking surveys of farming households to combine the spatial distribution information of cropland abandonment with the information of farming households to explore the spatial correlation of the land use of households. In addition, a comparative study combining other analytical methods, such as factor analysis and cluster analysis, to deeply investigate the driving mechanisms of cropland abandonment would likely be instructive, as would a tracking study on cropland abandonment in the context of non-grain production within cultivated land to find the changes in cropland abandonment by households in different topographic regions, the driving mechanism and the future use of cropland under the influence of new policies. These tasks could improve the analysis of abandonment patterns and can lead to targeted suggestions for the sustainability of the livelihoods of farming households.

7. Conclusions and Policy Recommendations

7.1. Conclusions

We here proposed various hypotheses on the factors of cropland abandonment by different types of farming households in three topographic regions according to the characteristics of topography and farming households and employ a binary logistic regression model using 415 questionnaires to empirically verify the accuracy of our hypotheses.

Our results show that among pure households, low economic efficiency in agriculture and uneconomical investment of time and energy have a decisive impact on cropland abandonment. Pure households in the mountainous region are relatively more affected by economic efficiency of agriculture, and low economic efficiency is the main factor of cropland abandonment. Pure households in the hilly region may be affected by the time invested in plots, while plots far from home and those which need more time for development are more likely to be abandoned. Time and money invested in plots have a greater impact on cropland abandonment for pure households in the plain region, as it is not economical to invest much money, time, and energy in plots that are large or far from home, so plots may be abandoned to reduce their burden.

Among part-time households, labor shortage and plots that are time-consuming and unfavorable to cultivation are the main factors for abandonment. Cropland abandonment by part-time households in the mountainous region occurs because some plots are time-consuming and unfavorable to cultivate, specifically including plot type, plot quality, landform, and irrigation conditions. Cropland abandonment by part-time households in the hilly region occurs because some plots are unfavorable to cultivate, and plots with poor irrigation conditions will be abandoned first. Labor shortage is the key factor of abandonment for part-time households in the plain region.

Among non-farm households, health status, the number of farming laborers, proportion of non-farm income, and plot features are all factors for cropland abandonment. The abandonment of non-farm households in the mountainous region is more influenced by non-farm work, and the abandonment of non-farm households in the hilly region is more influenced by the number of farming laborers. In addition, the inconvenience of using agricultural machinery has a greater impact on non-farm households in both mountainous and hilly regions. Factors such as better health level, more non-farm workers, larger proportion of non-farm income, and plot factors are the main reasons for abandonment by non-farm households in the mountainous region. The plot factors include low frequency of agricultural machinery use, sloping land, and poor irrigation conditions. In the hilly region, plots are abandoned by non-farm households because of smaller household size, small number of farming laborers, and plot factors, which include low frequency of agricultural machinery use and poor quality of plots, and the question of whether a higher average education level has an effect on abandonment requires further study. There is very little cropland abandonment for non-farm households in the plain region.

7.2. Policy Recommendations

Our results show that cropland abandonment is most serious in the mountainous and hilly topographic regions of the Poyang Lake region. The improvement of rural revitalization in China, and the preservation of sufficient cropland may be achieved by the following policy suggestions:

Many plots are abandoned by non-farm households and part-time households in the mountainous region due to sloping land and poor irrigation conditions, as well as cropland abandonment by some non-farm households in the mountainous region due to the inconvenience of using agricultural machinery. Cropland resources should be revitalized by village collectives in the mountainous region, speeding up plot transfer among part-time households and non-farm households, and carrying out large-scale leveling work on the transferred plots to achieve the effects of leveling sloping plots, expanding plot size, improving irrigation conditions, adapting to mechanical farming, and increasing production efficiency. Since non-farm income is the main income of non-farm households in the mountainous region, the number of farming laborers is small, and the probability of abandonment is the largest, the possibility of transferring plots is greatest here [71,72]. In contrast, the cropland abandonment probability of part-time households in the mountainous region is the smallest, non-farm work is unstable, and the quality of plot-transfer services is uncertain, so plots of part-time households in the mountainous region are less likely to be transferred out [72,73]. Part-time households are more sensitive to social and

economic changes than pure households, so part-time households in the mountainous region should be cultivated to be new agricultural business subjects and can develop industrial agriculture by transferring in plots of non-farm households for large-scale cultivation. High-quality basic cropland is mainly for food production and can be better utilized to form a scale of service demand. Reasonable government standards for plot transfer fees may help ensure the interests of farmers who transfer out their plots while raising the enthusiasm of new agricultural operators to use cropland for food production. The specific allocation of funds for leveling plots after the transfer, irrigation system construction, and maintenance [14] may increase support for new agricultural operators, and can uniformly perform services to reduce production costs, provide scientific farming technology guidance, natural disaster risk insurance services, loans to protect their agricultural income. Cropland abandonment by part-time households in the mountainous region because of the dryland and the poor quality of the plots may be addressed through the development of special industries such as the planting of vegetables, fruits, tobacco, herbs, seedlings, or orchards according to the natural and social conditions of the village to increase the income of farmers. Cropland abandonment by pure households in the mountainous region due to low economic efficiency may be addressed by government recruitment of agricultural professionals to provide agricultural technology guidance to new agricultural operators while organizing pure households to learn techniques such as soil improvement, fertilization, and planting management. The promotion of small agricultural machinery to improve labor productivity and increase agricultural income [66,74]. The increase in agricultural subsidies and providing additional subsidies to households according to the topography may help address these concerns.

If some plots are abandoned by pure households in the hilly region because of the distance to home, it can be improved by the organization villagers to exchange plots or redistribute plots after cropland remediation, so as to eliminate the impact of the distance to home on farming households. Cropland abandonment of part-time households in the hilly region due to poor irrigation conditions and cropland abandonment of non-farm households in the hilly region due to the lack of easy access to agricultural machinery may be addressed via leveling cropland and building water conservancy facilities and roads. Adopting a similar approach as the part-time households in the mountainous region to develop special industries by the non-farm households in the hilly region may also provide improvement.

Cropland abandonment by pure households in the plain region due to the distance to home may also be addressed by plot exchange among households. Cropland abandonment by pure households in the plain region because of the large size of the plots may be addressed by mobilizing households to transfer the plots outside their capacity to improve the utilization of the cropland. Cropland abandonment by part-time households in the plain region due to labor shortage can be addressed by improving village habitat and infrastructure, developing rural industries, revitalizing the countryside, and keeping the part-time laborers in the countryside to reduce abandonment.

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