Article

Livelihood Capital and Land Transfer of Different Types of Farmers: Evidence from Panel Data in Sichuan Province, China

Huanxin Yang [1], **Kai Huang** [1], **Xin Deng** [2] and **Dingde Xu** [3,*]

1   College of Management, Sichuan Agricultural University, Chengdu 611130, China;
    yanghuanxin@stu.sicau.edu.cn (H.Y.); hk666@stu.sicau.edu.cn (K.H.)
2   College of Economics, Sichuan Agricultural University, Chengdu 611130, China; dengxin@sicau.edu.cn
3   Sichuan Center for Rural Development Research, College of Management, Sichuan Agricultural University,
    Chengdu 611130, China
*   Correspondence: dingdexu@sicau.edu.cn; Tel.: +86-13-4085-98819

Abstract: Farmers' livelihood and land have been the focus of academic and political attention for a long time. In the process of rapid urbanization in China, as farmers change their livelihood strategies and livelihood capital allocation driven by economic interests, farmland abandonment increases, which is not conducive to the guarantee of food security. This study aims to explore the characteristics of livelihood capital and land transfer of farmers under different livelihood strategies and the effect of livelihood capital on land transfer. Based on the data obtained from Sichuan Province in 2012, 2016 and 2019 by the China Rural Development Survey Group, this paper divides farmers into pure farmers, part-time farmers and non-farmers according to the proportion of non-agricultural income in total income, and constructed the panel binary Logit model and panel Tobit model. The analysis points to the following results: (1) pure farmers tend to shift other capitals toward natural capital, so their livelihood capital total index value decreased. The part-time farmers have different shift characteristics but their livelihood capital total index value both increased first and then decreased. Non-farmers tend to shift natural capital towards other livelihood capitals, so their livelihood capital total index value increased. (2) The higher the natural capital and human capital, the higher the probability of land transfers in. The higher the natural capital, the larger the area of land transfers in. The higher the financial capital, the higher the probability of land transfers out. The higher the financial capital and social capital, the larger the area of land transfers out. It is expected to provide suggestions for the policy of farmers' land transfer under different livelihood capital endowments.

Keywords: livelihood capital; livelihood strategy; land transfer; transfer scale; Sichuan Province

1. Introduction

China, as a populous country [1,2], has faced a prominent dichotomy in its man–land relationship for a long time [3,4]. Rapid urbanization and agricultural modernization promote the rural labor force to go out for work in large numbers driven by economic interests [5,6], which changes the livelihood capital structure and livelihood strategy of farmers, and also changes the land structure [7–9]. According to existing studies, due to the large number of out-migrating labor forces and the low income of agricultural workers, many villages in hilly areas of China have idle and abandoned land [2,10]. Land use has been the focus of geography, economics and other disciplines for a long time [11,12]. However, land use is not immutable; it will be transformed with the economic and social development of a country or region [13,14]. Scholars have also carried out many studies on land use transition [15–22]. Among them, land use forms are the core content of land use transition research, including dominant and recessive forms. Dominant forms refer to the structure of the main land use types in a country or region during a specific period, including quantity and spatial structure. Recessive forms refer to the land use forms that are not easy to detect and can only be obtained after analysis and investigation [23]. As

one of the key measures in the reform of land management, land transfer belongs to the category of hidden land use [24]. The reason why the phenomenon of land abandonment is increasing is closely related to the deep-rooted land complex of farmers. Land transfer can not only revitalize the abandoned farmland in rural areas, but also help to improve the scale and intensive management of land. However, farmers know little about the merits of land transfer policy and prefer to abandon their land rather than transfer their land to other individuals or organizations who are capable and willing to manage it. Therefore, paying attention to land transfer plays an important role in solving the problem of land abandonment [25,26]. Some scholars found that the reasonable transfer of land can reduce agricultural cost, achieving the appropriate scale of land management, and then solve the problem of land abandonment [27–29]. In China, ownership, contracting rights and management rights of rural land are separated. Land ownership belongs to public collectives, while contracting rights are granted to farmers, and the operating rights are controlled by capital (the contracted farmers transfer the land to other individuals or organizations for operation, and other individuals or organizations obtain the right to operate the land) [30]. Rural land transfer refers to the practice that rural families retain the contracting right and transfer the management right only to other farmers or economic organizations by subcontracting, transferring, becoming a shareholder, cooperating, leasing or exchanging the contracted land. However, in view of the current situation of China, due to the fragmentation of land, there is a low proportion of land transfer and the coexistence of land abandonment in many regions [31], which is not conducive to the guarantee of national food security [32].

As the most basic resource of famers, land and its utilization mode and structure will be directly affected by their livelihood strategies [28,33–35]. Therefore, the research on land transfer cannot be separated from research on farmers' livelihood capital and livelihood strategy. However, although there is some research on household livelihood and land use, there is relatively little research on the whole. For example, some scholars have explored the correlation between household livelihood and land use [36,37], sustainable livelihood and conversion of farmland to forest [38–40]. At the same time, a review of existing studies shows that most scholars explore the effect of livelihood capital on land transfer using static cross-section data [41,42]. However, in the existing studies, the analysis based on panel data mostly focuses on risk, new agricultural insurance and other aspects, and there is almost no study on the dynamic characteristic changes and the effect of livelihood capital on land transfer [43,44]. In the context of rapid urbanization and agricultural modernization, it is necessary to use dynamic panel data to systematically reveal the dynamic change characteristics and the effect of livelihood capital on land transfer under different livelihood strategies.

Based on this, using the survey data of Sichuan Province in 2012, 2016 and 2019, and using the sustainable livelihoods framework, the paper divides livelihood capital into five categories: human capital, natural capital, financial capital, physical capital and social capital. According to the proportion of non-agricultural income in the household income, farmers are divided into pure farmers, part-time farmers and non-farmers. Considering land transfer direction and area, the paper systematically analyzes the characteristics of household livelihood capital, livelihood strategies and land transfer, building panel econometric models to explore the effect of livelihood capitals on land transfer. Although this study only focuses on Sichuan Province of China, the index system, theoretical analysis framework design and research ideas of this study can provide references for other developing countries or developed countries. The two research questions to be answered in this study are as follows:

1. What are the characteristics of household livelihood capital and land transfer under different livelihood strategies in different periods? What is the effect of livelihood capitals on land transfer?
2. In answering these questions, the paper contributes to analyze the characteristics of farmers' capital and land transfer under different livelihood strategies, as well

as the effect of natural capital, human capital, financial capital, physical capital and social capital on land transfer. Livelihood capital, as the core of farmers' survival and development, has an effect on land transfer. It is expected to provide suggestions for the policy of farmers' land transfer under different livelihood capital endowments.

2. Materials and Methods

2.1. Data Sources

Based on the data collected by China Rural Development Survey Group in Sichuan Province in 2012, 2016 and 2019, the study mainly investigates the livelihood capital status and land use of farmers. In order to ensure the typicality and representativeness of the data, the principle of stratified equal probability random sampling was adopted to determine the sample households. Specifically, according to the research results of He et al. [45], Rozelle [46], Shui et al. [47] and Xue et al. [48], the index of per capita industrial gross output was used to cluster all districts and counties in Sichuan Province into 5 categories from high to low, and 1 district or county from each category was randomly selected as the sample. After the sample districts and counties were selected, the towns in the sample districts and counties were divided into high income group and low income group according to the order of per capita industrial output value, and then 1 township in each group was randomly selected as the sample town. After the sample towns were selected, the sample towns were divided into high income group and low income group according to the order of per capita industrial output value, and 2 sample villages were selected from each sample town. After the sample village was determined, 20 households were randomly selected according to the list of farmers. According to this principle, a sample of 400 households was obtained in 2012, 2016 and 2019. Simple data processing was carried out, and the famers' samples in all the three phases were retained. Finally, 299 famer household samples were obtained for subsequent analysis.

2.2. Theoretical Analysis Framework

The livelihood of farmers has been of wide concern in many countries and regions as well as academic circles [49–51]. Early livelihood studies mainly focused on poverty alone; that is, they focused on income level, consumption capacity and other factors related to basic living needs [52]. With the deepening of research, on the basis of a large number of poverty alleviation practices and theoretical development, income and consumption are no longer the only criteria to measure poverty [53]. In 1992, the United Nations Conference on Environment and Development proposed the concept of "sustainable livelihood" and advocated using the amount of livelihood capital of farmers to represent the strength of their capabilities [8]; thus the sustainable livelihood analysis method came into being [53]. Due to different understandings of livelihood, there are many different methods of livelihood sustainability analysis [52]. Among them, the sustainable livelihoods approach (SLA), established by the UK's Department for International Development (DFID), has been widely used by many organizations and scholars [6,29], which divides livelihood capital into five types: human capital, natural capital, physical capital, financial capital and social capital.

In this study, the sustainable livelihoods framework of DFID was slightly adjusted. We combined it with the direction and area of land transfer to construct a framework, as shown in Figure 1. This paper focuses on the effect of farmers' livelihood capital on land transfer, and adds a new solid line arrow of "livelihood capital→land transfer". In addition, livelihood strategy has indirect influence on land transfer through livelihood capital, and may also directly affect farmers' land transfer, which is not discussed in this study. So the path "livelihood strategy→land transfer" adopts the dashed arrow. Other paths of DFID are also shown with dashed lines.
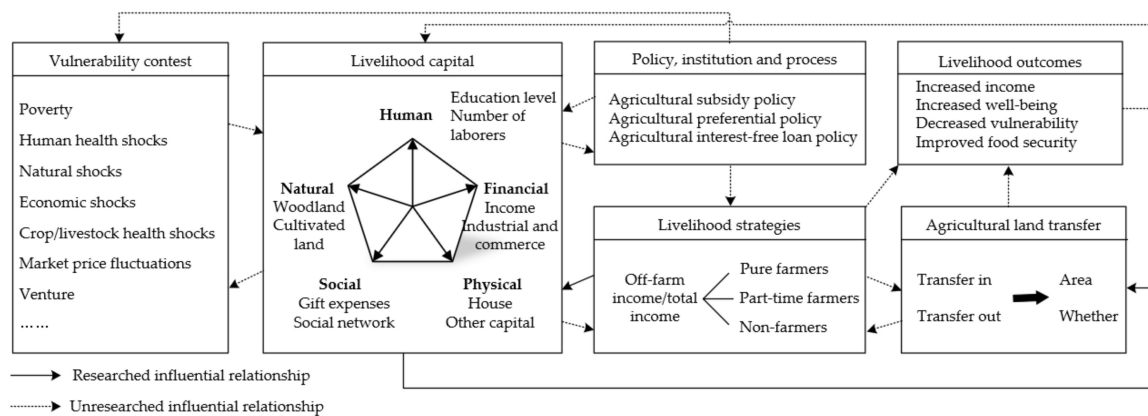
Figure 1. Analysis frame diagram of household livelihood capital and land transfer.

Farmers survive and develop against a background of fragility; they are affected and suppressed by internal and external dangers [54,55]. Under the effect of the external risk, farmers can mitigate the effect on their families through reasonable allocation of livelihood capital, selection of appropriate livelihood strategies, land transfer decisions, cooperation with agricultural policies, etc., so as to maximize utility and minimize risk [3,7,35], and achieve a positive livelihood output.

This study focuses on the characteristics of livelihood capitals and land transfer under different livelihood strategies and the effect of livelihood capitals on land transfer. Theoretically, different livelihood strategies adopted by farmers will lead to different allocations of livelihood capital, which will have an effect on land transfer decisions [56] (livelihood strategy→livelihood capital→land decision). Taking the natural capital and human capital owned by farmers as an example, when the natural capital of farmers is high and the human capital is low, the family labor force cannot meet the demand of labor required for the cultivation of the land, and when the cost of employing other labor forces is higher than the income from the cultivation of this part of land, the farmers are more likely to transfer part of their land out. When the natural capital is high and the human capital is also high, the family labor force meets or even exceeds the demand of labor required for the cultivation of the land; the farmers are more likely to transfer in the land of other farmers to realize the appropriate scale of land management, so as to maximize the utility. However, according to the existing research, there is no unified understanding of the effect of livelihood capitals on land transfer

In terms of natural capital, on the one hand, some scholars found that the increase of natural capital will promote land transfer in. For example, the empirical study by Ji et al. [57] and the theoretical study by Long et al. [58] showed that if the cultivated land is contiguous and the area is large, the soil quality is good, and the production efficiency is high, farmers will be inclined to transfer in land to realize the large-scale operation of land. On the other hand, some scholars reported that the increase of natural capital will promote land transfer out. For example, the empirical researches by the authors of [9,59,60] concluded that the land in many regions is fragmented and scattered, so it is difficult to realize the proper scale of centralized and continuous operation. At this time, the high input and low return of land will inhibit the enthusiasm of farmers in agricultural production, and may promote the transfer out of land. Although there is no unified understanding about the influence of natural capital on land transfer in the academic circle, the mainstream view is that the increase of natural capital will promote land transfer in. Based on this, this study proposes research Hypothesis H1:

Hypothesis (H1). *The higher the natural capital of farmers, the higher the probability of land transfer in and the larger the areas of land transfer in.*

In terms of human capital, on the one hand, some scholars found that the increase of human capital will promote land transfer in [61]. For example, the empirical studies by Zhang et al. [62], Zhu et al. [63] showed that in some regions, when the labor force of farmers meets the labor force of land demands, the farmers are more inclined to transfer land in due to their dependence on land; they are able and willing to cultivate the land. On the other hand, some scholars found that the increase of human capital will promote land transfer out. For example, the theoretical study by Ge et al. [64] and the empirical study by Yuan et al. [65] concluded that with the rapid development of secondary and tertiary industries, the income of non-agricultural industry is higher than that of agriculture, so the income loss of farmers who put labor into agricultural production instead of putting labor into non-agricultural production will increase; that is, the opportunity cost of agricultural production will increase. Farmers are likely to put more energy into non-agricultural industries to increase the overall income of families through the increase of wage income. Although there is no unified understanding of the influence of human capital on land transfer in the academic circle, but in most empirical studies, the increase of human capital tends to promote land transfer in. Based on this, this study proposes research Hypothesis H2:

Hypothesis (H2). *The higher the human capital of farmers, the higher the probability of land transfer in and the larger the areas of land transfer in.*

In terms of financial capital, on the one hand, some scholars found that the increase of financial capital will promote land transfer in [66]. For example, the empirical study by Liu et al. [67] and the theoretical study by Martin and Clapp [68] showed that high financial capital will increase farmers' investment in agriculture, such as adopting advanced agricultural technology and purchasing more agricultural machinery, and then increasing their income through proper scale operation of land. On the other hand, some scholars found that the increase of financial capital will promote land transfer out. For example, the empirical studies by Su et al. [69] and Xu et al. [8,9] reported that the income of non-agricultural industry is generally higher than that of agricultural industry, and the increase of financial capital will encourage farmers to transfer to the secondary and tertiary industries, and invest more capital and labor into the non-agricultural industry. Although there is no unified understanding about the influence of financial capital on land transfer in the academic circle, most scholars advocate that the increase of financial capital will promote land transfer out. Based on this, this study proposes research Hypothesis H3:

Hypothesis (H3). *The higher the financial capital of famers, the higher the probability of land transfer out and the larger the areas of land transfer out.*

In terms of physical capital, on the one hand, some scholars found that the higher the farmers' physical capital is, the more inclined they are to transfer in land. For example, the empirical study by Wang et al. [70] concluded that in some areas, rural resources are well endowed and ecological environment is good. At the same time, if the type and structure of rural houses are good, many rural households will tend to live in the countryside and generate income through agriculture due to the influence of various factors such as enjoyment psychology. On the other hand, some scholars found that the increase of physical capital will encourage farmers to transfer out land. For example, the empirical study by Wen et al. [71] showed that for farmers with higher physical capital, the risk of transferring out land is low and they are more willing to participate in the outflow. Although there is no unified understanding about the influence of physical capital on land transfer in the academic circle, the view that the increase of physical capital will promote land transfer in occupies the mainstream position. Based on this, this study proposes research Hypothesis H1:

Hypothesis (H4). *The higher the physical capital of farmers, the greater the probability of land transfer in and the larger the areas of land transfer in.*

In terms of social capital, on the one hand, some scholars found that the increase of social capital will encourage farmers to transfer in land. For example, the empirical study by Deng et al. [10] reported that one of their relatives is a village cadre, which to some extent means that they have a great influence on the village. It is easier for such farmers to obtain technology, information and financial help, and they are more inclined to transfer in land to carry out large-scale agricultural production. On the other hand, some scholars found that the higher the social capital, the more land is transferred out. For example, the empirical study by Xu et al. [1] and the case study by Lu et al. [72] concluded that with the development of farmers' social network, they will have more contacts and can master more non-agricultural information, and then participate in other sideline businesses to realize the diversification of livelihood strategies and reduce livelihood risks. Although there is no unified understanding about the influence of social capital on land transfer in the academic circle, the results of most research show that the increase of social capital will promote land transfer out. Based on this, this study proposes research Hypothesis H5:

Hypothesis (H5). *The higher the social capital of farmers, the greater the probability of land transfer out and the larger the areas of land transfer out.*

2.3. Variable Measure

2.3.1. Measurement of Livelihood Capital

Referring to the framework to analyze sustainable livelihoods [73], the division of farmers' livelihood capital and the measurement of farmers' livelihood capital studied by Peng et al. [3], Guo et al. [27] and Kuang et al. [74], this study also divides livelihood capital into five categories: human capital, natural capital, financial capital, physical capital and social capital, and then sets up specific indexes to measure them (Table 1). Among them, natural capital refers to the natural resources and services that people rely on for survival and development [75]. In this paper, farmers' per capita cultivated land area and per capita forestland area are used to measure natural capital. Human capitals include the knowledge and skills mastered by farmers, as well as their physical health status and potential ability [76]. The number of their labor force and the education level of the head of the household are used to measure the human capital. Financial capital refers to the cash that farmers can independently manage and raise, and its sources mainly include their own income, loans and free assistance. Annual cash income and whether they run their own businesses are taken as two indexes to measure financial capital. Physical capital refers to the facilities and equipment used by farmers for production and living [7]. In order to reduce the interference of other factors, this paper converted all kinds of physical capital of farmers into present value for comparison, mainly including the converted present value of houses and other capital other than houses, such as farm tools, draft animals and furniture. Social capital refers to the social network owned by farmers [3]. This paper uses two indexes to measure social capital: annual gift expenditure and whether there are public officials among relatives and friends. All the indexes in the table are the original indexes for the subsequent calculation of the core independent variables.

Table 1. Household livelihood capital index system.

Category	Index Attributes and Evaluation Methods	Obs	Mean	SD	Entropy	Weight [b]
1. Natural capital						
Cultivated land	Per capita operating cultivated land area (Mu [a])	299	1.356	2.599	0.897	0.062
Woodland	Per capita operating forestland area (Mu [a])	299	0.260	0.722	0.602	0.236
2. Human capital						
Labor	Number of labor force (people)	299	2.928	1.428	0.971	0.017
Education level	Years of education for head of household (years)	299	5.894	3.238	0.966	0.020
3. Financial capital						
income	Annual cash income (10,000 yuan)	299	4.984	4.741	0.944	0.033
Industrial and commerce	There are self-employed businesses (0 = No, 1 = Yes)	299	0.235	0.424	0.743	0.153
4. Physical capital						
house	Present value of the house (10,000 yuan)	299	23.596	74.486	0.848	0.090
Other physical capital	Present value of farm tools, draft animals and furniture other than houses (10,000 yuan)	299	2.525	4.937	0.854	0.086
5. Social capital						
Gift expenses	Annual gift expenditure (10,000 yuan)	299	0.294	0.356	0.910	0.053
Social network	Members or relatives serving as village cadres (0 = No, 1 = Yes)	299	0.091	0.288	0.578	0.250

Note: [a] Mu is a unit of land area commonly used in rural China, 1 mu ≈ 0.067 ha; [b] the weights are calculated by the entropy method, the details of calculative process can be found in Appendix A.

2.3.2. Measurement of Land Transfer

Land transfer involves the direction and area. The direction of land transfer is measured by whether farmers have transferred land in or out, and the area of land transfer is measured by the area of farmers' land inflow and the area of land outflow [8,9].

2.4. Research Methods

2.4.1. Entropy Value Method

One of the objectives of this study is to explore the relationship between farmers' livelihood capital and land transfer. In order to achieve this goal, it is necessary to obtain the information about the livelihood capital index value and land transfer of farmers. Referring to the studies of He et al. [77], Ning et al. [78] and Xu et al. [79], this study adopts the entropy value method of objective assignment method to determine the weight of each livelihood index and the comprehensive score of the five types of livelihood capital, so as to avoid the error of subjective judgment. The detailed calculation steps of the entropy method are in Appendix A.

2.4.2. Regression Model

Considering that the data used in this study are three periods of balance panel data in 2012, 2016 and 2019, this study adopts the panel binary Logit and panel Tobit models according to the characteristics of the dependent variables, and uses Stata16.0 for processing.

Since the direction of land transfer (whether it transfers in/out) is a dichotomous dependent variable, this study adopts the panel binary Logit model to analyze the effect of livelihood capitals on land transfer. The study estimates the results of fixed effect and random effect, and finally, determined by the Hausman Test, that land transfer in is suitable for fixed effect estimation and land transfer out is suitable for random effect estimation. The main formula for panel binary Logit is as follows:

$$p(Y_{it} = 1|X_{it}, \beta_i) = p(Z_{it} > 0) = p(u_{it} > -\beta_i X_{it}) = F(\beta_i X_{it}) \tag{1}$$

$$p(Y_{it} = 1|X_{it}, \beta_i) = F(\beta_i X_{it} + u_{it}) = \frac{1}{1 + e^{-(\beta_i X_{it} + u_{it})}} \tag{2}$$

This study introduces qualitative variables as dependent variables (whether the farmer "*i*" had land transfer in/transfer out in the "*t*" period), and $Y_{it} = 1$ when the phenomenon under study occurs, $Y_{it} = 1$ when it does not occur. All explanatory variables are X_{it} (the

livelihood capital index values of the farmer "*i*" in the "*t*" period). Since the index value of the probability of occurrence of the event can only be 0~1, an unobserved reference variable Z_{it} is introduced to replace the virtual dependent variable Y_{it}. When the estimated $Z_{it} > 0$, $Y_{it} = 1$; otherwise, $Y_{it} = 0$. u_{it} is the random disturbance term.

Since the area of land transfer (transfer in/out area) is quite concentrated on the number 0, which belongs to the left merge data, this study adopts the panel Tobit model to re-estimate the trunking distribution of the restricted dependent variable, so as to make it conform to the actual distribution, and then analyze the effect of livelihood capitals on land transfer. Because the panel Tobit model cannot be used for fixed effect estimation in Stata 16.0, this study only estimates the results of random effect. The main formula of the panel Tobit model is as follows:

$$Y'_{it} = \alpha + \beta X'_{it} + \varepsilon \tag{3}$$

In this study, Y'_{it} is introduced as the dependent variable (the area of land transfer in/out of the farmer "*i*" in the "*t*" period). All explanatory variables are X'_{it} (the livelihood capital index values of the farmer "*i*" in the "*t*" period). α is the constant term, β is the regression coefficient, ε is the random disturbance term.

The ultimate purpose of this study is to explore the relationship between livelihood capitals and land transfer under different livelihood strategies. To achieve this goal, it is necessary to obtain the index value of livelihood capital and the index value of land transfer. The livelihood capital index values of farmers under different strategies are obtained by entropy method (Appendix A). The land circulation of different types of farmers can be obtained by simple summation.

3. Results

3.1. Livelihood Strategies

Referring to the classification of farmers by Zhang et al. [80], Zhou et al. [81], this study divides farmers into pure farmers, part-time farmers (including first part-time farmers and second part-time farmers) and non-farmers according to the proportion of non-agricultural income in total income. Among them, pure farmers refers to those with non-agricultural income below 20% of total household income, first part-time farmers refers to those with non-agricultural income accounting for 20–50% of total household income (including 20%), and second part-time farmers refers to those with non-agricultural income accounting for 50–80% of total household income (including 50%). Non-farmers refers to those with non-agricultural income accounting for 80% or more of total household income (Table 2).

Table 2. Farmer types and sample distribution in each year.

Farmer Types		Year	Sampling Number	Proportion
Pure farmers		2012	76	25.42%
		2016	76	25.42%
		2019	76	25.42%
Part-time farmers	First part-time farmers	2012	21	7.02%
		2016	14	4.68%
		2019	7	2.34%
	Second part-time farmers	2012	19	6.36%
		2016	28	9.36%
		2019	57	19.06%
Non-farmers		2012	183	61.20%
		2016	181	60.54%
		2016	159	53.18%

As can be seen from Table 2, in the survey of three periods, non-farmers accounted for the largest proportion, followed by pure farmers, and part-time farmers were the least. Among them, the number of pure farmers in three periods of the survey did not

change, while the proportion of part-time farmers (including first part-time farmers and second part-time farmers) and non-farmers changed to different degrees. Specifically, in the three period surveys in 2012, 2016 and 2019, the proportion of pure farmers was 25.42%, the proportion of part-time farmers was 13.38%, 14.04% and 21.40%, respectively, and the proportion of non-farmers was 61.20%, 60.54% and 53.18%, respectively. Among the part-time farmers, the proportion of first part-time farmers decreased by 7.02%, 4.68% and 2.34, respectively, while the proportion of second part-time farmers increased by 6.36%, 9.36% and 19.06%, respectively. It can be seen that in both 2016 and 2019, some of the first part-time farmers and non-farmers switched to become second part-time farmers.

3.2. Descriptive Statistical Analysis

3.2.1. Characteristics of Household Livelihood Capital in Different Periods

Table 3 shows the livelihood capital index value of farmers in three periods. It can be seen from Table 3 that, based on the changes in the three periods, the natural capital of pure farmers increased, while for part-time farmers and non-farmers it decreased. The human capital of non-farmers increased, while for pure farmers and part-time farmers it decreased. The social capital of part-time farmers and non-farmers increased, while for pure famers it decreased. The financial capital, physical capital and the total index value of livelihood capitals of non-farmers increased, while for pure farmers and part-time farmers it decreased.

Table 3. Household livelihood capital index value.

Farmer Types		Year	Natural Capital	Human Capital	Financial Capital	Physical Capital	Social Capital	Total
Pure farmers		2012	0.083	0.059	0.088	0.086	0.067	0.383
		2016	0.115	0.052	0.065	0.058	0.055	0.344
		2019	0.123	0.039	0.019	0.026	0.028	0.237
Part-time farmers	First part-time farmers	2012	0.076	0.072	0.162	0.120	0.108	0.538
		2016	0.048	0.086	0.153	0.248	0.124	0.660
		2019	0.058	0.064	0.126	0.117	0.162	0.527
	Second part-time farmers	2012	0.077	0.071	0.132	0.090	0.078	0.448
		2016	0.060	0.070	0.114	0.072	0.133	0.451
		2019	0.049	0.072	0.062	0.064	0.102	0.349
Non farmers		2012	0.058	0.069	0.040	0.050	0.061	0.279
		2016	0.049	0.071	0.054	0.056	0.057	0.287
		2019	0.047	0.078	0.089	0.085	0.069	0.368

Note: the livelihood capital index values in this table are obtained from Table 1 by entropy method, and are dimensionless values between 0 and 1.

Natural capital includes the area of cultivated land and forestland. The average area of per capita cultivated land of pure farmers, first part-time farmers and second part-time farmers and non-farmers was 2.138 mu, 1.598 mu, 1.278 mu and 1.038 mu, respectively, indicating that pure farmers had higher natural capital. Human capital includes the age of the head of the household, the education level and the number of the labor force. In general, the longer the education and the larger the number of the labor force, the higher the human capital. Taking the education level of the head of the household as an example, the average education of the part-time farmers was 7 years, higher than that of non-farmers and pure farmers. Financial capital includes annual cash income and whether they have self-employed businesses. The average annual cash income of the first part-time farmers was 75,120, which was at least 18,220 higher than that of other farmers. The main factors to measure physical capital are the converted present value of houses, and the converted present value of other physical capital such as farm tools, draft animals and furniture. The average converted present value of other physical capital of the first part-time farmers was 52,080, at least 22,680 higher than that of other farmers. Annual gift expenditure of households is one of the important factors affecting social capital. Horizontal comparison shows that the annual gift expenditure of part-time farmers was 1.2–1.5 times that of

non-farmers and pure farmers. Longitudinal comparison showed that based on 2012, the expenditure of non-farmers increased by 25.37%, while that of pure farmers and part-time farmers decreased by 17.88% and 15.56%, respectively.

The changes of total livelihood capital index value of farmers under different livelihood strategies show different characteristics. In 2012 and 2016, the total capital index value of the first part-time farmers was the highest, followed by that of the second part-time farmers, pure farmers and finally non-farmers. In 2019, the total capital index value was the highest for first part-time farmers followed by non-farmers, second part-time farmers and finally pure farmers. In general, the total livelihood capital index value of pure farmers decreased; the total livelihood capital index value of non-farmers increased; the total livelihood capital index value of first part-time farmers and second part-time farmers increased first and then decreased.

In order to more intuitively compare the changes of livelihood capital of different types of farmers in the three-year survey in 2012, 2016 and 2019, this paper analyzes the changes of the five livelihood capitals of pure farmers, part-time farmers and non-farmers through a radar chart. As can be seen from Figure 2, the pure farmers showed a shift of other livelihood capital towards natural capital (Figure 2a), the first part-time farmers' capital shift characteristics were not obvious (Figure 2b), the second part-time farmers showed a shift of natural capital, physical capital and financial capital towards social capital (Figure 2c), while the non-farmers showed a shift of natural capital towards other livelihood capital (Figure 2d).
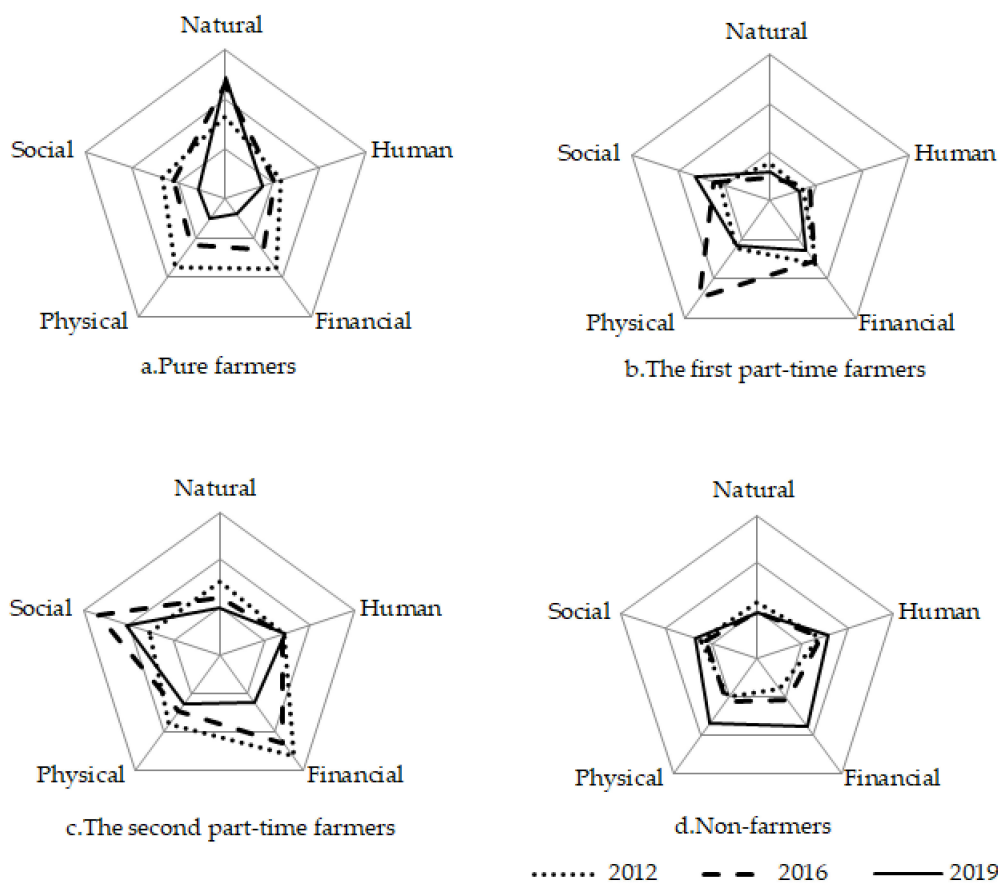

Figure 2. Changes in livelihood capital allocation of different types of farmer households. Note: (**a**) Table 3. (**b**) The maximum value of the coordinate axes in (**a**–**d**) is 0.15, the scale unit is 0.05; the maximum value of the coordinate axis in (**b**) is 0.3, the scale unit is 0.1; and the minimum value of the axes of all graphs is 0.

3.2.2. Characteristics of Farmers' Land Transfer in Different Periods

In order to grasp the situation of land transfer, land transfer is divided into land transfer in and land transfer out according to the direction, and the areas of land transfer in and out of different types of farmers in 2012, 2016 and 2019 are calculated respectively (Table 4).

The direction of land transfer shows that the total area of land transfer out exceeded the total area of land transfer in this phenomenon is based on the total area of land transfer of all investigated farmers. Specifically, the survey data in 2012 showed that the area of land transfer in of pure farmers, first part-time farmers, second part-time farmers and non-farmers was larger than the land transfer out area, and the areas of land transfer in were 33.60 mu, 9.70 mu, 17.17 mu and 117.50 mu, respectively. The areas of land transfer out were 30.30 mu, 8.10 mu, 6.40 mu and 32.13 mu, respectively. In 2016, the first part-time farmers had a phenomenon that the area of land transfer out was larger than the area of land transfer in: the area of land transfer in was 1.00 mu, and the area of land transfer out was 8.90 mu. In 2019, the area of land transfer out of all types of farmers was larger than the area of land transfer in. The areas of land transfer in of pure farmers, first part-time farmers, second part-time farmers and non-farmers were 22.89 mu, 1.30 mu, 11.16 mu and 11.57 mu, respectively. The areas of land transfer out were 29.99 mu, 2.57 mu, 16.76 mu and 35.20 mu, respectively.

From the area of land transfer, on the whole, the total area of land transfer shows a trend of increasing first and then decreasing. Specifically, in 2016, the areas of land transfer in of pure famers, second part-time farmers and non-farmers increased by 22.10 mu, 1.83 mu and 33.60 mu, respectively, compared with that in 2012; the areas of land transfer out of first part-time farmers, second part-time farmers and non-farmers increased by 0.80 mu, 6.30 mu and 22.87 mu, respectively, compared with that in 2012. In 2019, the areas of land transfer in of pure famers, second part-time farmers and non-farmers decreased by 32.81 mu, 7.84 mu and 139.53 mu, respectively, compared with that in 2016; while the areas of land transfer out of first part-time farmers and non-farmers decreased by 6.33 mu and 19.8 mu, respectively, compared with that in 2016.

Table 4. Farmers' total land transfer area [a] [c] (*n* = 299).

Farmer Types		Year	Transfer in Area (Mu [b])	Transfer out Area (Mu [b])
Pure farmers		2012	33.60 (18.88%)	30.30 (39.39%)
		2016	55.70 (24.56%)	29.46 (27.78%)
		2019	22.89 (35.48%)	29.99 (35.48%)
Part-time farmers	First part-time farmers	2012	9.70 (5.45%)	8.10 (10.53%)
		2016	1.00 (0.44%)	8.90 (8.39%)
		2019	1.30 (2.77%)	2.57 (3.04%)
	Second part-time farmers	2012	17.17 (9.64%)	6.40 (8.32%)
		2016	19.00 (8.38%)	12.70 (11.97%)
		2019	11.16 (23.79%)	16.76 (19.83%)
Non-farmers		2012	117. 55 (66.03%)	32.13 (41.76%)
		2016	151.10 (66.62%)	55.00 (51.86%)
		2019	11.57 (24.66%)	35.20 (41.65%)

Note: [a] data in brackets are the proportion of such famers in the total area of land transfer in/transfer out in the current survey period. [b] Mu is a unit of land area commonly used in rural China, 1 mu ≈ 0.067 ha. [c] The land transfer in/transfer out area in this table is based on Table 2, simply summing up the land transfer in/transfer out areas of all farmers in the same type.

3.3. Analysis of Regression Results

Table 5 shows the regression results of livelihood capital and land transfer. Before building the model, we conducted correlation analysis on the independent variables of the model, and the coefficients of the correlation analysis were all less than 0.5, indicating that there was no problem of multicollinearity. In addition, although we cannot estimate the robust standard error of the panel binary Logit model and the panel Tobit model in Stata16.0, when we use the entropy method to determine the comprehensive index, the

variables are standardized, and the deviation trend will not be very strong. Therefore, theoretically, there will be no heteroscedasticity problem. Due to the panel data including only 299 famers and the small number of some types of farmers, it is not suitable for further regression with the livelihood strategy, so this study only carried out overall regression. Model 1 and Model 2 show the regression results of household livelihood capital and whether there is land transfer or not, while Model 3 and Model 4 show the regression results of household livelihood capital and its land transfer area. According to the overall significance test results of the models, all the four models were statistically significant at the 0.05 level, indicating that at least one of the independent variables and the dependent variables have a statistically significant influence, which can be used for subsequent analysis.

Table 5. Regression results of livelihood capital and land transfer.

Variable	Panel Logit Model		Panel Tobit Model	
	Model 1	Model 2	Model 3	Model 4
	Whether Transfer In	Whether Transfer Out	Area of Transfer In	Area of Transfer Out
Natural capital	290.2499 *** (50.3092)	26.1096 (17.2572)	9.3034 *** (2.6800)	1.2900 (1.4974)
Human capital	165.6151 * (88.4463)	41.9614 (54.3115)	3.4148 (27.0636)	14.4909 (14.6734)
Financial capital	25.2693 (24.7348)	55.3376 *** (17.8329)	1.8055 (9.4044)	14.3344 *** (5.1902)
Physical capital	10.4350 (22.4749)	10.4649 (14.3151)	0.1215 (5.3519)	3.1917 (2.9826)
Social capital	15.1650 (16.2948)	6.2124 (9.7411)	7.0181 (5.3447)	5.6876 * (2.9286)
LR/Wald chi2(5)	75.56 ***	13.55 **	13.74**	13.74 **

Note: data in brackets are standard errors. ***, ** and * represent statistical significance at 1%, 5% and 10%, respectively.

It can be seen from Model 1 that natural capital and human capital had a statistically significant positive effect on whether farmers transferred land in, while financial capital, physical capital and social capital had no statistically significant obvious effect on whether farmers transferred land in. This indicates that the higher the farmer's natural capital and human capital score, the higher the probability of land transfer. According to Model 2, financial capital had a statistically significant positive effect on whether farmers transferred land out, while natural capital, human capital, physical capital and social capital had no statistically significant obvious effect on whether farmers transferred land out. This shows that the higher the financial capital scores of farmers, the greater the probability of their land transfer out. According to Model 3, natural capital had a statistically significant positive effect on the area of farmers' land transfer in, while human capital, financial capital, physical capital and social capital had no statistically significant obvious effect on the area of farmers' land transfer in. This indicates that the higher the farmers' natural capital score, the larger the areas of land transfer in. According to Model 4, financial capital and social capital had a statistically significant positive effect on the area of farmers' land transfer out, while the effect of natural capital, human capital and physical capital on the area of farmers' land transfer out was not statistically significant. This indicates that the higher the score of financial capital and social capital, the larger the areas of land transfer out.

4. Discussion

Farmer livelihood sustainability and land use have been the focus of research for a long time [82,83]. In fact, the United States, Europe, Australia, Spain and other developed countries as well as Latin America, Southeast Asia, China and other developing countries have reported varying degrees of farmland wastage [8,84–86], which is gradually evolving into a global social and economic phenomenon [87–89]. In China, a populous country, the dichotomy between human and land use has been prominent for a long time, which is representative to a certain extent. Since the mid-1980s, China has formulated a series of land policies to promote rational land transfer [79]. For example, the steady promotion of farmland ownership confirmation and certification can provide good conditions for land transfer [90,91]. With the promotion and advocacy of land transfer policy, the problem of

land abandonment has been alleviated. Some scholars have also proved that land transfer is conducive to solving the problem of land abandonment. For example, Shao et al. [92] found that land transfer is conducive to the more effective use of cultivated land resources and the reduction of land abandonment. Zhang and Li [93] found that there was a strong negative correlation between the transfer ratio and the abandonment ratio of farmland. Zhu and Xu [94] advise strengthening of land contract management and accelerating the pace of land transfer, and put forward that land transfer is one of the important measures to solve the problem of land abandonment. Therefore, by studying the effect of livelihood capital on land transfer, this study can help better implement land transfer policy and provide a reference for solving the land abandonment problem. This study is based on the analysis of the survey data of five districts and counties in Sichuan Province in 2012, 2016 and 2019, using the sustainable livelihoods framework to establish the index system and analysis logic, and the panel binary Logit model and panel Tobit model according to the characteristics of dependent variables. This study explores the characteristics of livelihood capital and land transfer under different livelihood strategies and the effect of livelihood capitals on land transfer.

In terms of the characteristics of livelihood capital and land transfer, this study found that the characteristics of change were different for livelihood capitals of farmers under different livelihood strategies, and land transfer also changed. In terms of livelihood capital, the natural capital of pure farmers increased, while the human capital, financial capital, physical capital, social capital and total capital all decreased, which showed the characteristics of other livelihood capital shifted to natural capital. Pure farmers have been dependent on land for survival for a long time, so they were more inclined to transfer land in. In 2012, their average area of land was 1.227 mu, which increased by nearly 108.15% in 2019. First part-time farmers had no obvious shift characteristics. Different from pure farmers, first part-time farmers had started to engage in non-agricultural industries and did not completely depend on the land for survival. The farmers needed to consider whether it was beneficial for them to engage in non-agricultural industries. Therefore, these farmers were more inclined to maintain their original status, and the shift characteristics were not obvious. The second part-time farmers' natural capital, financial capital, physical capital and total capital decreased, social capital increased, and human capital did not change obviously. Second part-time farmers tended to shift natural capital, physical capital and financial capital towards social capital. Compared with the first part-time farmers, the second part-time farmers had a higher non-agricultural labor force. They had more vocational skills and a wider network of social connections. This was mainly reflected in expenditure on gifts, which increased from 2426 yuan in 2012 to around 3989 yuan in 2016 and 2019. The natural capital of non-farmers decreased while their human capital, financial capital, physical capital, social capital and total capital increased; they tended to shift natural capital towards other livelihood capital. Non-farmers got 80% or more of their total income from non-agricultural industries; their dependence on the countryside and land was very low. In addition, in the survey, the number of years of education (5.7→6.3), per capita annual cash income (3.8→7.5), the converted present value of houses (10.2→38.0) and annual gifts of family (2417.5→3644.0) of non-farmer households all increased. This promotes the increase of human capital, financial capital, physical capital and social capital. In terms of land transfer, it shows that the total area of land transfer out exceeded the total area of land transfer in. The reason is that among the 299 farmers in the sample, some farmers transferred land in and some farmers transferred land out. The land transferred out was not necessarily transferred to the 299 sample farmers in this study, but to other farmers in the same village. So the total area of land transferred out exceeded the total area of land transferred in. In addition, the obvious reason why the total area of land transfer could be logically different was that this study only analyzed 299 sample farmers and did not ask all farmers in a region. In the total population of farmers, the total area of land transfer in must logically equal the area of land transfer out.

In the results of this study, some hypotheses are supported and others are rejected. At the same time, there are similarities and differences with the results of existing studies. In terms of natural capital and financial capital, the research hypothesis H1 and H3 are supported. This study found that the higher the natural capital of farmers, the higher the probability of land transfers in and the larger the area of land transfers in. The higher the financial capital of farmers, the higher the probability of land transfers out and the larger the area of land transfers out. The results are also supported by Xu et al. [8,9], Ji et al. [57], Long et al. [58], Su et al. [69], Bian et al. [95] and Peng et al. [96]. In terms of human capital, the research hypothesis H2 is partly supported; human capital had a statistically significant positive effect on the probability of land transfer in; however, it had no statistically significant effect on the area of land transfer in. The results of this study are different from those of Zhang et al. [60], Muchomba [61], Liu et al. [97], who concluded that human capital has a statistically significant positive effect on land transfer in, and different from those of Ge et al. [64], Yuan et al. [65] and Peng et al. [96], who concluded that human capital has a statistically significant positive effect on land transfer out. This may be due to the differences of samples in the study area. The samples investigated in this study were all samples from the hilly area. Generally speaking, most of them were small-scale farmers with a small land holding in areas where young rural laborers were forced to go out for work in large numbers driven by economic interests. In addition to the farmers who stayed in the countryside to conduct moderate-scale land management, most of the farmers who stayed in the countryside were the elderly. Due to the limitation of the elderly's labor ability, they are difficult to engage in non-agricultural industries. So they are more inclined to rely on the land they are familiar with for survival; they prefer to transfer land in. Meanwhile, in order to facilitate farming, most of the lands they transferred in are close to home and of high quality. In addition, in order to match their labor capacity, they will not transfer much land in. Therefore, for farmers with higher human capital, the government can take different training measures according to different groups. For farmers who want to engage in proper scale operation of land, the government can encourage farmers to transfer land in more, and further strengthen farmers' training in agricultural planting, harvesting, disease and insect control, so as to improve farmers' production capacity in agriculture. For the elderly who just want to maintain their basic living needs, the government can encourage farmers to transfer land in within the scope of their labor force, giving agricultural subsidies to elderly farmers. In terms of physical capital, the research hypothesis H4 is rejected. This study finds that the physical capital of farmers has no statistically significant effect on the probability and area of land transfer. The results of this study are different from those of Ji et al. [57], Zhu et al. [63] and Wang et al. [70], who concluded that physical capital has a statistically significant positive effect on land transfer in, and different from those of Wen et al. [71], who concluded that physical capital has a statistically significant positive effect on land transfer out. Possibly because China's agricultural technology has improved in recent years, farmers have been able to further liberate labor by using farm machinery, which means less labor is needed for land than before. Sichuan is a big agricultural province, agriculture has a long history, and the development of agricultural technology training is relatively good. Therefore, whether farmers change their livelihood strategy to transfer land out or transfer land in to realize the appropriate scale management of land, both can help families maintain their livelihood and output. Therefore, for the farmers with high physical capital, different encouragement measures can be taken. If the urban population is under great pressure and the employment rate is low, the government can encourage farmers to transfer land in and provide farmers with training on agricultural planting. If there are many jobs in the secondary and tertiary industries in local towns and cities, and many jobs in non-agricultural industries, the government can encourage farmers to transfer their land out and provide vocational skills and training in the non-agricultural industries, so as to enhance their adaptability to the cities. In terms of social capital, the research hypothesis H5 is partly rejected. This study finds that the social capital of farmers has no statistically significant effect on the probability of land transfer out; however, it has

a statistically significant positive effect on the area of land transfer out. The results of this study are different from those of Deng et al. [10] and Zhu et al. [63], who concluded that social capital has a statistically significant positive effect on land transfer in, and different from those of Xu et al. [1], Lu et al. [72] and Peng et al. [96], who concluded that social capital has a statistically significant positive effect on land transfer out. This may be due to differences in variable measures and research methods. The indexes used in this study to measure social capital are annual gift expenditure and members or relatives serving as village cadres. Additionally, the panel binary Logit model and panel Tobit model were constructed for regression, which was different from other studies. For example, Zhu et al. [63] measured the social capital by the number of households of the village relatives, the degree of trust in people around them and the favor expenditure, then constructed the binary Logit model for regression. Xu et al. [1] measured the social capital by the social network of relatives and friends available for assistance when seeking non-farm work, the social network of relatives and friends available for assistance when in urgent need of a lot of money and whether farmers participated in a farming association, then an ordered Logistic model was contrasted for regression. The wider the social network of farmers, the more people will accept their land, and the more the area of land is transferred out. Therefore, for farmers with high social capital, the government can encourage farmers to transfer their land out, and encourage farmers to use their strong social network to actively expand income channels. Through the above discussion, this study finds that different types of livelihood capitals have different statistically significant effects on the direction and area of land transfer. In the future land transfer market, the difference of farmers' capital structure should be considered to make land decisions.

Compared with the existing research, this research has a core innovation point: in the research design, this study combines the sustainable livelihoods framework and land transfer, and uses dynamic panel data from the perspective of dynamic analysis to explore the characteristics of farmers' livelihood capital and land transfer under different livelihood strategies, and the effect of livelihood capital on land transfer. In addition, there are some limitations in this study, which need to be solved in future studies. Firstly, this study is only based on the panel data of Sichuan Province of China for analysis and discussion. Although it can provide a reference for other relevant studies and regions, it remains to be verified to what extent it can be generalized to other regions and whether it is applicable to other developing or developed countries. Secondly, this study only focuses on the status of the three survey time periods in 2012, 2016 and 2019, without considering the change of the intermediate years, which can be further explored in future studies. Finally, in terms of causality, this study only analyzes one direction, that is, the effect of farmers' livelihood capital on land transfer. It does not discuss the effect of land transfer on livelihood capital, or the effect of the same third factor on livelihood capital and land transfer, which can be further discussed in future studies.

5. Conclusions

Through analysis, this study mainly draws the following two conclusions:

1. The livelihood capital and land transfer of farmers under different livelihood strategies show different characteristics. In terms of livelihood capital, pure farmers tend to shift other livelihood capital towards natural capital, so their total index value of livelihood capital decreased. First part-time farmers had no obvious shift characteristics and strong dependence on the original path, so their total index value of livelihood capital increased first and then generally decreased. Second part-time farmers tended to shift natural capital, physical capital and financial capital towards social capita, so their total index value of livelihood capital increased first and then generally decreased. Non-farmers tended to shift natural capital towards other livelihood capital, so their total index value of livelihood capital increased. In terms of land transfer, from the direction of land transfer, the total area of land transfer out

exceeded the total area of land transfer in; from the area of land transfer, all types of farmers showed a trend of increasing first and then decreasing.

2. Livelihood capital affects the direction and area of land transfer. The higher the natural capital and human capital, the higher the probability of land transfer in. The higher the natural capital, the larger the area of land transfers in. The higher the financial capital, the higher the probability of land transfers out. The higher the financial capital and social capital, the larger the area of land transfers out.

This study is expected to provide suggestions for the policy of farmers' land transfer under different livelihood capital endowments. Based on the above analysis, the study has two policy implications: (1) Suggesting the government strengthen the support of pure farmers and part-time farmers in agricultural production and promote the return of a rural labor force. The study found that in the three periods of the survey, only the livelihood capital total index value of non-farmers increased, while the livelihood capital total index value of both pure farmers and part-time farmers decreased, indicating that only the living of non-farmers was improving, which is one of the reasons for the large rural labor force emigration. Based on this, we suggest that the government take appropriate measures to strengthen the support and encouragement of pure farmers and part-time farmers, so as to increase their livelihood capital total index value. (2) Suggesting that the government take into account the difference of livelihood capital endowment to encourage farmers to transfer land. Considering that natural capital and human capital have a statistically significant positive effect on land transfer, we suggest that the government encourage farmers with higher natural capital and human capital to increase the operating area of land according to their own needs and ability, promoting land transfer in. Considering that financial capital and social capital have a statistically significant negative impact on land transfer, we suggest that the government encourage farmers with higher financial capital and social capital to use their financial capital advantages and social network to broaden income channels and transfer land out. Considering that physical capital has no statistically significant effect on land transfer, we suggest that the government should take different measures for farmers with higher physical capital according to the employment pressure of local non-agricultural industries.

Appendix A

The process of measuring the weight of each livelihood index and the comprehensive score of the five types of livelihood capital by the entropy value method is as follows:

1. Dimensionless treatment

In order to avoid the adverse impact of different measurement units on the measurement of livelihood capital, the indexes are treated as dimensionless. Since the 10 indexes in this paper are all positive indexes, the calculation formula is as follows (A1):

$$X_{ij} = \frac{x_{ij} - m_j}{M_j - m_j}, i = 1, 2, 3, \ldots, p; j = 1, 2, 3, \ldots, q \tag{A1}$$

Among them, x_{ij} is the original value of the farmer "i" in the "j" index, M_j is the maximum value of x_{ij}, m_j is the minimum value of x_{ij}, and X_{ij} is the standardized value of the farmer "i" in the "j" index. Meanwhile, in order to eliminate zero and make the data operation processing meaningful, the standardized value is moved overall; that is, $X'_{ij} = X_{ij} + \alpha$, in this paper, $\alpha = 0.0001$.

2. Calculation of numerical proportion

To calculate the proportion of the index"j" of the farmer "i" in the total number of the index"j", the formula is as follows (A2):

$$P_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{p} X'_{ij}}, i = 1, 2, 3, \ldots, p \tag{A2}$$

3. Calculation of entropy

To calculate the entropy value of the index "j", the formula is as follows (A3):

$$E_j = -\frac{1}{lnp} \sum_{i=1}^{p} P_{ij} \ln(P_{ij}), i = 1, 2, 3, \ldots, p \tag{A3}$$

4. Calculation of index difference coefficient

To calculate the index difference coefficient of the index"j", the formula is as follows (A4):

$$D_j = 1 - E_j \tag{A4}$$

5. Calculation of weight

To calculate the weight of the index"j", "q" is the number of livelihood capital indexes. The formula is as follows (A5):

$$w_j = \frac{D_j}{\sum_{j=1}^{q} D_j}, j = 1, 2, 3, \ldots, q \tag{A5}$$

6. Calculation of farmer household single index evaluation score

To calculate the single index evaluation score of the farmer "i" in the "j" index, the formula is as follows (A6):

$$S_{ij} = w_j * X_{ij} \tag{A6}$$

7. Calculation of farmers' livelihood capital index value

After determining the weight of each index and the evaluation score, the scores of natural capital, human capital, financial capital, physical capital and social capital of farmers can be obtained by adding the comprehensive scores of each index in the same dimension.

References

1. Xu, D.; Zhang, J.; Rasul, G.; Liu, S.; Xie, F.; Cao, M.; Liu, E. Household Livelihood Strategies and Dependence on Agriculture in the Mountainous Settlements in the Three Gorges Reservoir Area, China. *Sustainability* **2015**, *7*, 4850–4869. [CrossRef]
2. Xu, D.; Guo, S.; Xie, F.; Liu, S.; Cao, S. The impact of rural laborer migration and household structure on household land use arrangements in mountainous areas of Sichuan Province, China. *Habitat Int.* **2017**, *70*, 72–80. [CrossRef]
3. Peng, L.; Xu, D.; Wang, X. Vulnerability of rural household livelihood to climate variability and adaptive strategies in landslide-threatened western mountainous regions of the Three Gorges Reservoir Area, China. *Clim. Dev.* **2018**, *11*, 469–484. [CrossRef]
4. Xie, Y.; Jiang, Q. Land arrangements for rural–urban migrant workers in China: Findings from Jiangsu Province. *Land Use Policy* **2016**, *50*, 262–267. [CrossRef]
5. Deng, X.; Xu, D.; Zeng, M.; Qi, Y. Does Internet use help reduce rural cropland abandonment? Evidence from China. *Land Use Policy* **2019**, *89*, 104243. [CrossRef]
6. Deng, X.; Xu, D.; Zeng, M.; Qi, Y. Does early-life famine experience impact rural land transfer? Evidence from China. *Land Use Policy* **2019**, *81*, 58–67. [CrossRef]
7. Xu, D.; Deng, X.; Guo, S.; Liu, S. Sensitivity of Livelihood Strategy to Livelihood Capital: An Empirical Investigation Using Nationally Representative Survey Data from Rural China. *Soc. Indic. Res.* **2018**, *144*, 113–131. [CrossRef]
8. Xu, D.; Deng, X.; Guo, S.; Liu, S. Labor migration and farmland abandonment in rural China: Empirical results and policy implications. *J. Environ. Manag.* **2019**, *232*, 738–750. [CrossRef] [PubMed]
9. Xu, D.; Deng, X.; Huang, K.; Liu, Y.; Yong, Z.; Liu, S. Relationships between labor migration and cropland abandonment in rural China from the perspective of village types. *Land Use Policy* **2019**, *88*, 104164. [CrossRef]
10. Deng, X.; Zeng, M.; Xu, D.; Qi, Y. Does Social Capital Help to Reduce Farmland Abandonment? Evidence from Big Survey Data in Rural China. *Land* **2020**, *9*, 360. [CrossRef]
11. Long, H.; Wu, X.; Wang, W.; Dong, G. Analysis of Urban-Rural Land-Use Change during 1995-2006 and Its Policy Dimensional Driving Forces in Chongqing, China. *Sensors* **2008**, *8*, 681–699. [CrossRef]
12. Deng, X.; Huang, J.; Rozelle, S.; Zhang, J.; Li, Z. Impact of urbanization on cultivated land changes in China. *Land Use Policy* **2015**, *45*, 1–7. [CrossRef]
13. Grainger, A. National land use morphology: Patterns and possibilities. *Geography* **1995**, *80*, 235–245. Available online: https://www.jstor.org/stable/40572668 (accessed on 14 April 2021).
14. Long, H. Land Use Transition: A New Integrated Approach of Land Use/Cover Change Study. *Geogr. Territorial Res.* **2003**, *19*, 87–90. (In Chinese)
15. Long, H.; Li, X. Cultivated-land Transition and Land Consolidation and Reclamation in China: Research Progress and Frame. *Prog. Geogr.* **2006**, *25*, 67–76. (In Chinese)
16. Long, H.; Tu, S. Land Use Transition and Rural Vitalization. Chin. *Land Sci.* **2018**, *32*, 1–6. (In Chinese)
17. Long, H.; Qu, Y. Land use transitions and land management: A mutual feedback perspective. *Land Use Policy* **2018**, *74*, 111–120. [CrossRef]
18. Long, H.; Ge, D.; Wang, J. Progress and prospects of the coupling research on land use transitions and rural trans-formation development. *Acta Geogr. Sinica.* **2019**, *74*, 2547–2559. (In Chinese)
19. Long, H.; Chen, K. Urban-rural integrated development and land use transitions: A perspective of land system science. *Acta Geogr. Sinica.* **2021**, *76*, 295–309. (In Chinese)
20. Grainger, A. The Future Role of The Tropical Rain Forests in The World Forest Economy. Ph.D. Thesis, University of Oxford, Oxford, UK, 1986.
21. Guo, S.; Zhang, P. The need for land use transition near Shenzhen special economic zone from Guanlan. *Plan. Perspecitves.* **2008**, *24*, 72–77. (In Chinese)
22. Yang, Y.; Yang, X. Research on urban spatial expansion and land use inner structure transformation of the large valley-basin cities in China from 1949 to 2005 & mdash｜A case study of Lanzhou. *J. Nat. Resour.* **2009**, *24*, 37–49. (In Chinese)
23. Long, H. Land Use Transition and Rural Transformation Development. *Prog. Geogr.* **2012**, *31*, 131–138. (In Chinese)
24. Long, H. Land use transition and land management. *Geogr. Res.* **2015**, *34*, 1607–1618. (In Chinese)
25. Pi, X.; Lou, B. Reasons analysis and countermeasures of rural land abandonment. *Seeker* **2002**, *1*, 25–27. (In Chinese)
26. Milenov, P.; Vassilev, V.; Vassileva, A.; Radkov, R.; Samoungi, V.; Dimitrov, Z.; Vichev, N. Monitoring of the risk of farmland abandonment as an efficient tool to assess the environmental and socio-economic impact of the Common Agriculture Policy. *Int. J. Appl. Earth Obs. Geoinf.* **2014**, *32*, 218–227. [CrossRef]
27. Guo, S.; Lin, L.; Liu, S.; Wei, Y.; Xu, D.; Li, Q.; Su, S. Interactions between sustainable livelihood of rural household and agricultural land transfer in the mountainous and hilly regions of Sichuan, China. *Sustain. Dev.* **2019**, *27*, 725–742. [CrossRef]
28. Long, H.; Tu, S.; Ge, D.; Li, T.; Liu, Y. The allocation and management of critical resources in rural China under restructuring: Problems and prospects. *J. Rural. Stud.* **2016**, *47*, 392–412. [CrossRef]
29. Xu, D.; Ma, Z.; Deng, X.; Liu, Y.; Huang, K.; Zhou, W.; Yong, Z. Relationships between Land Management Scale and Livelihood Strategy Selection of Rural Households in China from the Perspective of Family Life Cycle. *Land* **2020**, *9*, 11. [CrossRef]
30. Hong, Z.; Sun, Y. Power, capital, and the poverty of farmers' land rights in China. *Land Use Policy* **2020**, *92*, 104471. [CrossRef]
31. Huang, K.; Deng, X.; Liu, Y.; Yong, Z.; Xu, D. Does off-Farm Migration of Female Laborers Inhibit Land Transfer? Evidence from Sichuan Province, China. *Land* **2020**, *9*, 14. [CrossRef]

32. Jiang, S.; Su, Q. Off-farm Employment of Rural Labor Force and Land Transfer—A Study Based on a Dynamic Perspective. *Econ. Surv.* **2012**, *2*, 110–114. (In Chinese)

33. Gao, J.; Liu, Y.; Chen, J. China's initiatives towards rural land system reform. *Land Use Policy* **2020**, *94*, 104567. [CrossRef]

34. Liu, Y.; Zou, L.; Wang, Y. Spatial-temporal characteristics and influencing factors of agricultural eco-efficiency in China in recent 40 years. *Land Use Policy* **2020**, *97*, 104794. [CrossRef]

35. Zhou, Y.; Li, X.; Liu, Y. Rural land system reforms in China: History, issues, measures and prospects. *Land Use Policy* **2020**, *91*, 104330. [CrossRef]

36. Davis, J.; Lopez-Carr, D. Migration, remittances and smallholder decision-making: Implications for land use and livelihood change in Central America. *Land Use Policy* **2014**, *36*, 319–329. [CrossRef] [PubMed]

37. Rignall, K.; Kusunose, Y. Governing livelihood and land use transitions: The role of customary tenure in southeastern Morocco. *Land Use Policy* **2018**, *78*, 91–103. [CrossRef]

38. Soini, E. Land use change patterns and livelihood dynamics on the slopes of Mt. Kilimanjaro, Tanzania. *Agric. Syst.* **2005**, *85*, 306–323. [CrossRef]

39. Xie, F.; Xu, D.; Zhang, J.; Yang, Y. Change and Influencing Factors of Farmers' Livelihood Based on the Policy of Returning Farmland to Forest. *Guizhou Agric. Sci.* **2015**, *43*, 220–226. (In Chinese)

40. Yi, F.; Chen, Z. Analysis of the influence of returning farmland to forest on non-agricultural employment. *Soft Sci.* **2006**, *8*, 31–40. (In Chinese)

41. Xu, D.; Yong, Z.; Deng, X.; Zhuang, L.; Qing, C. Rural-Urban Migration and its Effect on Land Transfer in Rural China. *Land* **2020**, *9*, 81. [CrossRef]

42. Zhao, L.; Kang, X.; Shi, J. The Empirical Analysis on the Effects of the Farmland Transfer on Household Trans-formation. *Chin. J. Agric. Resour. Reg. Plann.* **2017**, *38*, 158–162. (In Chinese)

43. Wang, Q.; Guan, R.; Yu, J. Impacts of Risk Attitude and Risk Perception on Land Transfer—Based on Panel Data of 1429 Households in Henan, Shandong, Hebei, Anhui, and Jiangsu. J. Huazhong. *Agric. Univ.* **2019**, *2019*, 149–158. (In Chinese)

44. Zhang, Y.; Bai, Y.; Zhen, L.; Xin, L. Could the new rural social pension insurance promote farmers' land transfer: Based on three waves panel data of CHARLS. *J. Nat. Resour.* **2019**, *34*, 1016–1026. (In Chinese)

45. He, C.; Peng, L.; Liu, S.; Xu, D.; Xue, P. Factors influencing the efficiency of rural public goods investments in mountainous areas of China—Based on micro panel data from three periods. *J. Rural. Stud.* **2016**, *47*, 612–621. [CrossRef]

46. Rozelle, S. Stagnation Without Equity: Patterns of Growth and Inequality in China's Rural Economy. *China J.* **1996**, *35*, 63–92. [CrossRef]

47. Shui, Y.; Xu, D.; Liu, Y.; Liu, S. The Influence of Human Capital and Social Capital on the Gendered Division of Labor in Peasant Family in Sichuan, China. *Soc. Indic. Res.* **2021**, *18*, 1–18. [CrossRef]

48. Xue, K.; Xu, D.; Liu, S. Social Network Influences on Non-Agricultural Employment Quality for Part-Time Peasants: A Case Study of Sichuan Province, China. *Sustainability* **2019**, *11*, 4134. [CrossRef]

49. Barrett, C.; Reardon, T.; Webb, P. Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics, and policy implications. *Food Policy* **2001**, *26*, 315–331. [CrossRef]

50. Donohue, C.; Biggs, E. Monitoring socio-environmental change for sustainable development: Developing a Multidimensional Livelihoods Index (MLI). *Appl. Geogr.* **2015**, *62*, 391–403. [CrossRef]

51. Liu, Z.; Liu, L. Characteristics and driving factors of rural livelihood transition in the east coastal region of China: A case study of suburban Shanghai. *J. Rural. Stud.* **2016**, *43*, 145–158. [CrossRef]

52. Su, F.; Xu, Z.; Shang, H. An Overview of Sustainable Livelihoods Approach. *Adv. Earth Sci.* **2009**, *24*, 61–69. (In Chinese)

53. He, R.; Liu, S.; Chen, G.; Xie, F.; Yang, X.; Liang, L. Research progress and tendency of sustainable livelihoods for peasant household in China. *Adv. Earth Sci.* **2003**, *32*, 657–670. (In Chinese)

54. Mensah, E.J. The sustainable livelihood framework: A reconstruction. In *Global Youth Alliance*; l'Oasis Development Group: Accra, Ghana, 2011.

55. Scoones, I. Sustainable rural livelihoods: A framework for analysis. In *IDS Working Paper 52*; IDS: Brighton, UK, 1998.

56. Ma, L.; Long, H.; Tu, S.; Zhang, Y.; Zheng, Y. Farmland transition in China and its policy implications. *Land Use Policy* **2020**, *92*, 104470. [CrossRef]

57. Ji, H.; Cai, Y. Influence of heterogeneous livelihood capital on farm households' land transfer behavior—A case study of 516 respondents in Wuhan suburb. *Changjiang Liuyu Ziyuan Yu Huanjing* **2017**, *26*, 220–226. (In Chinese)

58. Long, H.; Qu, Y.; Tu, S.; Zhang, Y.; Jiang, Y. Development of land use transitions research in China. *J. Geogr. Sci.* **2020**, *30*, 1195–1214. [CrossRef]

59. Zhang, G. Analysis on Current Situation of Livelihood Capital of Farmers on Land Transfer in Jilin Province under the Framework of Sustainable Livelihood Analysis. *Rural Econ. Sci. Technol.* **2018**, *29*, 142–143. (In Chinese)

60. Zhang, Y.; Long, H.; Li, Y.; Ge, D.; Tu, S. How does off-farm work affect chemical fertilizer application? Evidence from China's mountainous and plain areas. *Land Use Policy* **2020**, *99*, 104848. [CrossRef]

61. Muchomba, F.M. Women's Land Tenure Security and Household Human Capital: Evidence from Ethiopia's Land Certification. *World Dev.* **2017**, *98*, 310–324. [CrossRef]

62. Zhang, Y.; Halder, P.; Zhang, X.; Qu, M. Analyzing the deviation between farmers' Land transfer intention and behavior in China's impoverished mountainous Area: A Logistic-ISM model approach. *Land Use Policy* **2020**, *94*, 104534. [CrossRef]

63. Zhu, L.; Cai, Y. The Impacts of Farmer Households' Livelihood Endowment on Farmland Transfer: Cases in Different Types of Functional Areas of Hubei Province. *J. Nat. Resour.* **2016**, *31*, 1526–1539. (In Chinese)

64. Ge, D.; Long, H.; Qiao, W.; Wang, Z.; Sun, D.; Yang, R. Effects of rural–urban migration on agricultural transformation: A case of Yucheng City, China. *J. Rural. Stud.* **2020**, *76*, 85–95. [CrossRef]

65. Yuan, D.; Chen, M.; Liao, C.; Xie, X.; Liao, X.; Yao, D. Differentiation of Livelihood Capital of Farmers and the Change of Livelihood Strategy. *Res. Soil Water Conserv.* **2019**, *26*, 349–354. (In Chinese)

66. Liu, M.; Yang, L.; Bai, Y.; Min, Q. The impacts of farmers' livelihood endowments on their participation in eco-compensation policies: Globally important agricultural heritage systems case studies from China. *Land Use Policy* **2018**, *77*, 231–239. [CrossRef]

67. Liu, Z.; Chen, Q.; Xie, H. Comprehensive Evaluation of Livelihood Assets of Farmers in Western Mountains—Taking Zunyi City as an Example. *J. Resour. Ecol.* **2018**, *9*, 154–163. (In Chinese)

68. Martin, S.J.; Clapp, J. Finance for Agriculture or Agriculture for Finance? *J. Agrar. Chang.* **2015**, *15*, 549–559. [CrossRef]

69. Su, C.; Bi, R.; Liu, H.; Guo, Y. Land Transfer and Abandonment Behavior of Rural Households in Poor Mountainous Areas: A Study of 275 Farmers in Heshun County, Shanxi Province. *J. Agric.* **2019**, *9*, 89–96. (In Chinese)

70. Wang, Q.; Gen, S.; Gui, M. Empirical Analysis of Land Leasing Behavior. *Neimenggu Nongye Daxue Xuebao Ziran Kexueban* **2007**, *4*, 45–47. (In Chinese)

71. Wen, B.; Li, Z. A Study on the Departure between Farmers' Willing and Behavior of Land Transfer under Livelihood Capital. *South. Agric. Mach.* **2020**, *51*, 40–62. (In Chinese)

72. Lu, J.; He, Q. Analysis of Farmers' Willingness to Land Transfer and Its Influencing Factors from the Perspective of Livelihood—Based on Field Investigation of LongCun, a County in Henan Province. *Rural Econ.* **2016**, *2*, 39–43. (In Chinese)

73. The UK's Department for International Development. *Sustainable Livelihoods Guidance Sheets*; DFID: London, UK, 1999; p. 445.

74. Kuang, F.; Jin, J.; He, R.; Ning, J.; Wan, X. Farmers' livelihood risks, livelihood assets and adaptation strategies in Rugao City, China. *J. Environ. Manag.* **2020**, *264*, 110463. [CrossRef]

75. Ekins, P.; Simon, S.; Deutsch, L.; Folke, C.; De Groot, R. A framework for the practical application of the concepts of critical natural capital and strong sustainability. *Ecol. Econ.* **2003**, *44*, 165–185. [CrossRef]

76. Zeng, X.; Guo, S.; Deng, X.; Zhou, W.; Xu, D. Livelihood risk and adaptation strategies of farmers in earthquake hazard threatened areas: Evidence from sichuan province, China. *Int. J. Disaster Risk Reduct.* **2021**, *53*, 101971. [CrossRef]

77. He, A.; Yang, X.; Chen, J.; Wang, Z. Impact of Rural Tourism Development on Farmer'S Livelihoods—A Case Study of Rural Tourism Destinations in Northern Slop of Qinling Mountains. *Econ. Geogr.* **2014**, *34*, 174–181. (In Chinese)

78. Ning, Z. Rural Household's Sustainable Livelihood Capitals and Targeting Poverty. *Huanan Nongye Daxue Xuebao* **2017**, *16*, 86–94. (In Chinese)

79. Xu, D.; Liu, E.; Wang, X.; Tang, H.; Liu, S. Rural Households' Livelihood Capital, Risk Perception, and Willingness to Purchase Earthquake Disaster Insurance: Evidence from Southwestern China. *Int. J. Environ. Res. Public Health* **2018**, *15*, 1319. [CrossRef]

80. Zhang, C.; Peng, C.; Kong, X. Evolutionary Logic, Historical Evolution and Future Prospect of Rural-household Dif-ferentiation. *Reform* **2019**, *300*, 5–16. (In Chinese)

81. Zhou, W.; Guo, S.; Deng, X.; Xu, D. Livelihood resilience and strategies of rural residents of earthquake-threatened areas in Sichuan Province, China. *Nat. Hazards* **2021**, *106*, 255–275. [CrossRef]

82. Li, Y.; Li, Y.; Westlund, H.; Liu, Y. Urban–rural transformation in relation to cultivated land conversion in China: Implications for optimizing land use and balanced regional development. *Land Use Policy* **2015**, *47*, 218–224. [CrossRef]

83. Yan, X.; Bauer, S.; Huo, X. Farm Size, Land Reallocation, and Labour Migration in Rural China. *Popul. Space Place* **2013**, *20*, 303–315. [CrossRef]

84. Alonso-Sarría, F.; Martínez-Hernández, C.; Romero-Diaz, A.; Cánovas-García, F.; Gomariz-Castillo, F. Main Environmental Features Leading to Recent Land Abandonment in Murcia Region (Southeast Spain). *Land Degrad. Dev.* **2015**, *27*, 654–670. [CrossRef]

85. Baumann, M.; Kuemmerle, T.; Elbakidze, M.; Ozdogan, M.; Radeloff, V.C.; Keuler, N.S.; Prishchepov, A.V.; Kruhlov, I.; Hostert, P. Patterns and drivers of post-socialist farmland abandonment in Western Ukraine. *Land Use Policy* **2011**, *28*, 552–562. [CrossRef]

86. Queiroz, C.; Beilin, R.; Folke, C.; Lindborg, R. Farmland abandonment: Threat or opportunity for biodiversity conservation? A global review. *Front. Ecol. Environ.* **2014**, *12*, 288–296. [CrossRef]

87. Cao, Z.; Li, Y.; Liu, Y.; Chen, Y.; Wang, Y. When and where did the Loess Plateau turn "green"? Analysis of the tendency and breakpoints of the normalized difference vegetation index. *Land Degrad. Dev.* **2017**, *29*, 162–175. [CrossRef]

88. Levers, C.; Schneider, M.; Prishchepov, A.V.; Estel, S.; Kuemmerle, T. Spatial variation in determinants of agricultural land abandonment in Europe. *Sci. Total Environ.* **2018**, *644*, 95–111. [CrossRef] [PubMed]

89. Li, S.; Li, X.; Sun, L.; Cao, G.; Fischer, G.; Tramberend, S. An estimation of the extent of cropland abandonment in mountainous regions of China. *Land Degrad. Dev.* **2018**, *29*, 1327–1342. [CrossRef]

90. Zheng, J. A preliminary study on the interaction mechanism between farmland right confirmation and farmland transfer. *Rural Econ.* **2009**, *8*, 23–26. (In Chinese)

91. Liu, Y.; Xu, H. Influence of farmland right to rural land circulation—Based on the perspective of farmers differen-tiation. *J. Arid Land Resour. Environ.* **2016**, *30*, 25–29. (In Chinese)

92. Shao, J.; Wei, C.; Xie, D. Farmers' explanations of land transfer under the household responsibility system: The results from seven villages' analysis in Chongqing. *Geogr. Res.* **2007**, *26*, 275–286. (In Chinese)

93. Shao, J.; Zhang, S.; Li, X. Effectiveness of farmland transfer in alleviating farmland abandonment in mountain regions. *J. Geogr. Sci.* **2015**, *26*, 203–218. [CrossRef]

94. Zhu, D.; Xu, D. Investigation and analysis of the problem of rural land abandonment. *Issues Agric. Econ.* **2000**, *12*, 10–13. (In Chinese)

95. Bian, Q.; Zhou, S.; Ge, J. Analysis on the Influencing Factors of Land Transfer in Developed Region—Case of Zhejiang, China. *J. Agrotech. Econ.* **2010**, *6*, 28–36. (In Chinese)

96. Peng, Q.; Wang, C.; Deng, C. Potential land transfer-out contracted households, the spatial organization of agricul-tural management and livelihood capital. *Resour. Sci.* **2017**, *39*, 1477–1487. (In Chinese)

97. Liu, K.; Lin, J. Farmland Rental Markets Circulation and Land Redistribution: Theoretic and Empirical Analysis. *J. Quant. Tech. Econ.* **2005**, *11*, 99–111. (In Chinese)