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Comparative Study on Farmland Circulation between Plains and Mountainous Areas in an Arid Region: A Case Study of Zhangye City in Northwest China

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Abstract: Farmland circulation is essential for agricultural scale management. Due to rapid urbanization and industrialization, a large number of rural laborers have migrated to cities, resulting in accelerated farmland circulation. Revealing the farmland circulation in different geographical environments is conducive to efficient farmland management but remain largely unknown. To this end, based on the questionnaire survey data and statistical data of Zhangye City, we compared the features of farmland circulation between plains and mountainous areas, and used the binary logistic regression model and other methods to analyze the main factors affecting differentiated farmland circulation at the plot level. The main circulation modes and proportions in the plains were leasing (54.4%), exchange (22.4%), and subcontracting (16.2%), while the single leasing mode in mountainous areas accounted for 89.5%. The scale management units of more than 33.33 ha accounted for 6.48% and 30.72% in plains and mountainous areas, respectively. The proportion of circulation periods exceeding 5 years were 28.13% and 2.23% in plains and mountainous areas, respectively. The factor of "degree of farmland fragmentation" positively affected ($p < 0.01$) the farmland circulation in plains areas but negatively affected ($p < 0.01$) that in mountainous areas. The "farmland circulation price" promoted ($p < 0.01$) farmland circulation in both plains and mountainous areas. Whereas the "actual water diversion" ($p < 0.01$) and "river source water" ($p < 0.05$) only had varying degrees of negative impacts on farmland circulation in plains areas. Decision makers should practice management measures such as regulating farmland circulation behavior, formulating reasonable farmland circulation pricing models, and integrating farmland to promote the circulation and efficient use of farmland.

Keywords: farmland circulation; differential circulation features; driving mechanism; plot level; plains and mountainous areas; Zhangye City

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1. Introduction

Farmland provides essential goods (e.g., food, fiber, and fuel) and vital ecosystem services for humans and is critical to food security and sustainable socio-ecological systems [1,2]. However, rapid urbanization and industrialization have driven unprecedented rural–urban migration in China [3], leading to the concomitant abandonment or underutilization of farmland. In addition, the farmland fragmentation in China [4], has caused negative impacts such as the increased cost [5,6] and reduced efficiency [7] of agricultural production as well as the decreased agricultural productivity and farmers' income [8,9]. These undesirable phenomena will hinder the improvement of farmland utilization. Farmland circulation has been proven to be a useful way to alleviate the above problems, realize rational and efficient utilization of farmland resources, and develop modern agriculture [10].

In recent years, the Chinese government has implemented many policies to promote farmland circulation. In 2008, the "Decision of the Central Committee of the Communist Party of China on Some Issues concerning the Improvement of Rural reform and Development" was presented to establish a sound market of contract and management rights for various modes of farmland circulation. In November 2014, the Chinese government issued the "Opinions on Guiding the Orderly Transfer of Rural Land Management Rights to Develop Moderate Scale Agricultural Operations", aiming to guide the orderly circulation of farmland management and the sustainable development of moderate-scale managements. The Chinese government took farmland circulation as a vital way to improve the quality and efficiency of agriculture in 2016. It can be seen that farmland circulation has been widely considered by the Chinese government [11]. Driven by these agricultural policies, China's rural economic development model has undergone profound changes [12], improving the efficiency of farmland use [13]. The "separation of three rights" policy implemented in 2014, namely, land ownership right, land contract right, and land management right, greatly promoted farmland circulation. Among them, "ownership right" belongs to the rural collective, the "contract right" belongs to the farmer who signed the contract, and the "management right" is owned by the farmland circulation subject. The clarity of "three rights" make the farmland circulation flexible, and more than 30% of China's 230 million rural households had circulated farmland as of June 2016 [14]. On a national scale, the findings of Zhang et al. [15] showed that the order of the farmland circulation rates in China was: the Northeast Region > the East Region > the Central Region > the Northwest Region > the Southwest Region. Wang et al. [16] revealed the regional differences in farmland circulation rate and rent between the north and south of China. There were also differences in farmland circulation at the provincial scale. Taking Jiangsu Province as an example, due to the gradient differences in economic development levels in southern Jiangsu, northern Jiangsu, and central Jiangsu, the farmland circulation rate and the growth rate were not the same [17]. In addition, there were obvious regional differences in the scale, behaviors, and rents of farmland circulation [18–20]. Previous studies have mainly focused on regional differences in farmland circulation on a large scale, and lacked small scale studies, such as the plains and mountainous areas studied in this paper, this will be detrimental to the targeted implementation of the farmland circulation policy.

Farmland circulation is generally influenced by natural, social, and economic factors. Many scholars have used different methods and models to evaluate these influencing factors from the perspectives of qualitative [21,22] and quantitative analyses [23–25]. Cao et al. [26] analyzed farmers' land supply behavior by setting the index of willingness to circulate farmland. Wang et al. [27] used factor analysis methods to summarize the factors affecting farmland circulation at the provincial level. Yu et al. [28] have found that agricultural machinery services can significantly facilitate farmland circulation, yet old age and off-farm labor had a negative impact on farmland circulation. Additionally, off-farm and part-time employment both had a significant impact on farmland circulation [29]. The regression models were commonly used to analyze the factors of farmland circulation in typical regions of China [30–34]. With the feminization of agriculture, Huang et al. [35] constructed IV-Probit and IV-Tobit models to explore the relationships between off-farm migration and rural farmland circulation; the results showed that the off-farm migration of female laborers inhibited farmland circulation rate. The improvement of farmland use efficiency is particularly important in arid regions with poor agricultural conditions. However, the existing research lacks the analysis of influencing factors at the plot scale. The combined analysis of plot-level information and agricultural planting conditions can more intuitively reveal the influencing factors of farmland circulation behavior.

Zhangye City is a typical arid agricultural area in Northwest China, and the plains and mountainous areas have large differences in natural conditions, especially in water resources that may lead to differences in farmland use efficiency. It is urgent to propose effective farmland circulation measures to promote the efficient utilization of farmland resources and the development of modern agriculture. Therefore, based on the farmer's

questionnaire survey at plot level, this paper compared the features of farmland circulation in the local plains and mountainous areas. A binary logistic regression model was used for influencing factor analysis. The purposes were to promote the rapid circulation and large-scale management of farmland, and to improve the efficiency of agricultural production. Furthermore, relevant policies were proposed to promote the farmland circulation with regional differences, and it is expected to provide a reference for agricultural production in other arid regions of the world.

2. Materials

2.1. Study Area

Zhangye City is a national modern agricultural demonstration area located in the middle of the Hexi Corridor in Northwest China (37°28′–39°57′ N, 97°12′–102°20′ E). Zhangye City is also an important ecological security barrier, the largest seed corn production area, and an important food, vegetable, and melon production area of China. According to the differences in natural conditions, it is divided into plain areas (i.e., Linze County, Ganzhou District, and Gaotai County) and mountainous areas (i.e., Minle County, Shandan County, and Sunan County). Sunan County was dominated by animal husbandry, the area of farmland was 7327 ha, which was only 0.35% of the total area of the county. The area of land circulation in Sunan County was 1507 ha, accounting for only 1.94% of the total farmland circulation area of Zhangye City. Therefore, the county was excluded from the study area (Figure 1).

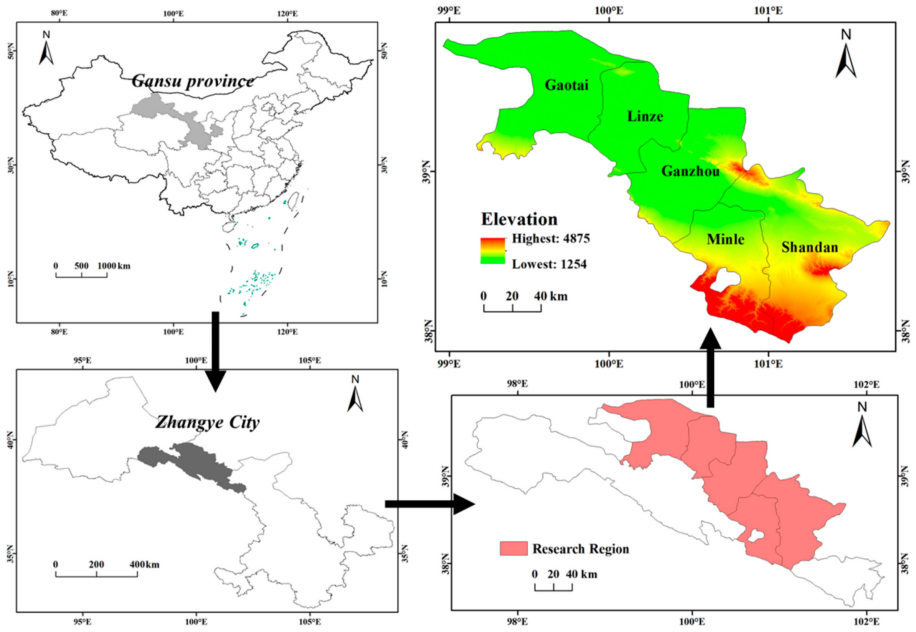

Figure 1. Location and elevation of Zhangye City.

The city implemented farmland circulation previously and carried out the development of agricultural modernization. Although Zhangye City plays an important role in China's agriculture, the current situation shows that there are huge differences in water resource conditions between plains and mountainous areas (Table 1). The "river source water" in plains is nearly 6 times that of the mountainous areas, the "actual water diversion" is nearly 4 times that of the mountainous areas, and the "crop irrigation quota" is nearly twice that of the mountainous areas. As a result, the "whole year actual irrigated area" is 140,000 ha in plains and only 59,687 ha in the mountainous areas. From this point of view, the water resources situation in plains is far better than that in the mountainous areas.

Table 1. Status of water resources in plain and mountainous areas of Zhangye City.

Geographic Division	River Source Water (10^8 m^3)	Actual Water Diversion (10^8 m^3)		Crop Irrigation Quota (m^3/ha)	Whole Year Actual Irrigated Area (ha)
		Main Water Supply	Groundwater		
Plain areas	22.62	14.56	4.72	499.67	210.00
Mountainous areas	3.78	3.72	1.27	251.50	89.53

Note: The data comes from the 2015 Annual Water Conservancy Management Report of Zhangye City.

2.2. Data Sources

Data used in this study include the following four main datasets. The first dataset consists of questionnaire survey data collected from a total of 144 farmers in 2015, which were randomly collected, and the interviewees included village cadres and farmers. The questionnaire mainly involved the modes, period, destinations, and scale of farmland circulations in each county. The influencing factors in the questionnaire that were used in this study are: plot area, degree of farmland fragmentation, farmland quality, farmland circulation price, and whether the crop type has changed. The second dataset is the Farmland Circulation Report of Zhangye City in 2015, including the area of farmland circulation in each county and the number of households participating in farmland circulation. The third dataset is the 2015 Zhangye Statistical Yearbook data (http://www.zhangye.gov.cn/tjj, accessed on 1 November 2020), from which we mainly collected data on natural conditions such as the altitude, the annual average temperature, the annual evaporation, and the annual precipitation. The last dataset is the 2015 Annual Water Conservancy Management Report (http://www.zhangye.gov.cn/swj, accessed on 1 November 2020), which provided agricultural irrigation conditions data such as the irrigation water source, the river source water, the actual water diversion, and the irrigation quota.

3. Methods

3.1. Overall Analysis Framework

In order to promote the development of agricultural modernization, the Chinese government proposed the "separation of three rights" (i.e., land ownership right, land contract right, and land management right) for farmland in 2014, aiming to comply with the wishes of farmers to retain land contract rights, circulate land management rights, and to promote farmland circulation. Thus, we established an analysis framework based on the "separation of three rights" policy to study the characteristics and drivers of farmland circulation (Figure 2). Specifically, we pointed out the farmland circulation situation in the plains and mountainous areas of Zhangye City, analyzed the feature differences of farmland circulation in different geographical environments, and revealed the influencing factors of different farmland circulation behaviors.

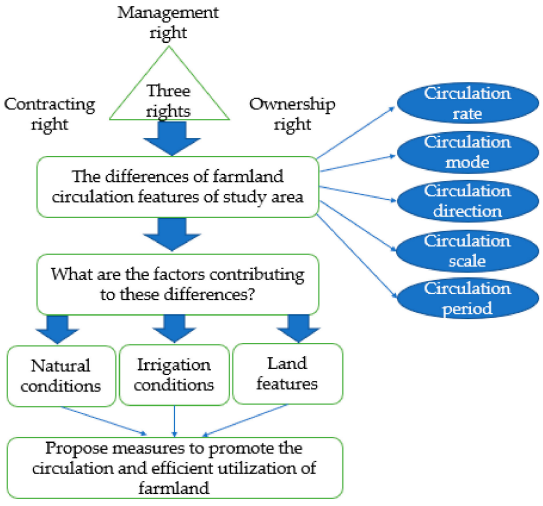

Figure 2. The analytical framework for farmland circulation.

3.2. Questionnaire Design

Two field surveys were conducted in the study area by August 2014 and July 2015, respectively. The first survey was to set up research points, and the second survey visited 144 households in 5 districts/counties of Zhangye City and collected 136 valid questionnaires from 261 plots. The number of questionnaires in each county/district was based on regional differences in agricultural development levels (Table 2).

Table 2. The number of questionnaires in each county/district.

Total	Ganzhou District	Gaotai County	Linze County	Minle County	Shandan County
136	83	13	11	17	12

According to the requirements of the survey error, we determined the sample size of the sampling survey through scientific calculations and controlled the error of the sampling survey within the allowable range. The sample size should be 5 to 10 times the number of questions; therefore, the appropriate number of questionnaires for this paper is between 85 and 170. A total of 136 valid questionnaires were collected in this survey, so the sample size was statistically significant.

We adopted a semi-structured approach to setting the questions, that is, the answers are both fixed and open. In order to ensure the high recovery rate and quality of the questionnaires, we communicated with farmers to obtain the valid first-hand data. In order to ensure the authenticity and representativeness of the survey, we first screened the research object, selected qualified farmers, then recorded the survey contents. In addition, we also conducted return visits to farmers to check whether the researcher's operation was standardized, so as to further ensure the authenticity of the survey and the representativeness of the sample.

3.3. The Binary Logistic Regression Model

The binary logistic regression model is a general regression linear model in which the dependent variable is binary. The binary logistic regression model has been widely used to analyze the influencing factors of farmers' decision-making with binary dependent variables [36]. In this paper, whether the behavior of farmland circulation occurs or not was the dependent variable of binary classification. Influencing factors of natural conditions, irrigation conditions, and farmland features were taken as independent variables, so the study used this model to analyze the driving factors of farmland circulation. A 0–1 dummy variable was used to represent the classification of farmland circulation: 1 meant that the farmland has been circulated, and 0 meant that it had not been circulated. In this way, the degree of influence of the independent variable (driving factor) on the dependent variable (the occurrence or not of farmland circulation) was determined. The model is given as follows:

$$p(\text{event}) = e^z / 1 + e^z \tag{1}$$

In the formula: $z = b_0 + b_1x_1 + b_2x_2 + \ldots + b_ix_i + \ldots + b_px_p$; $\boldsymbol{p}$ is the number of independent variables; x represents the driving factors of farmland circulation; b_0 represents regression intercept; and b_p represents the influence of explanatory variables on the probability of farmland circulation.

The probability of the event not occurring is:

$$p(\text{noevent}) = 1 - \text{prob}(\text{event}) \tag{2}$$

The ratio of the probability of occurrence to the probability of not occurring is:

$$\frac{p(\text{event})}{p(\text{noevent})} = e^{b_0 + b_1x_1 + b_2x_2 + \ldots + b_ix_i + \ldots + b_px_p} \tag{3}$$

In this study, Equation (3) determines the probability of farmland circulation. Taking the natural logarithm, then we obtain the standard logarithm model:

$$\ln \frac{P}{1-P} = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_i x_i + \ldots + b_p x_p \quad (4)$$

Equation (4) is called the logit form.

Based on the survey data and official statistics, we first paid attention to the features of the farmland. We conducted a comprehensive survey of farmers at plot level, which intuitively showed the features of local farmland circulation. The farmland features mainly included the plot area, the degree of farmland fragmentation, the farmland quality, the farmland circulation price, and whether the crop type had changed. Official statistics show that there are significant differences in the irrigation conditions between the plains and mountainous areas, and agricultural planting is closely related to water use. Therefore, this paper selected the irrigation condition indicators to analyze the influencing factors of farmland circulation. The specific indicators are the irrigation water source, the river source water, the actual water diversion, and the irrigation quota. Simultaneously, we observed the farmland circulation features from the perspective of natural conditions; the indicators were altitude, annual average temperature, annual evaporation, and annual precipitation (Table 3). The variables were tested for multicollinearity. Among them, the VIF values of annual precipitation, the annual average temperature, the annual evaporation, and the irrigation quota were greater than 10, indicating that they were multicollinear. The possible reason is that the climatic conditions between plains and mountainous areas were similar, so they were removed.

Table 3. Explanation and description of explanatory variables.

Variable Type	Variable	Variable Description/Unit
Farmland features	Plot area	ha
	Degree of farmland fragmentation	Divided into 1~4 levels
	Farmland quality	Divided into 1~5 levels
	Farmland circulation price	USD/ha
	Whether the crop type has changed	0: No; 1: Yes
Irrigation conditions	Irrigation water source	1: Surface water; 2: Ground water
	River source water	10^8 m^3
	Actual water diversion	10^8 m^3
	Irrigation quota	m^3/hm^2
Natural conditions	Altitude	m
	Annual average temperature	°C
	Annual evaporation	mm
	Annual precipitation	mm

4. Results

4.1. Differential Features of Farmland Circulation between Plains and Mountainous Areas in Zhangye City

The total farmland area of Zhangye City was approximately 269,000 ha, of which 166,733 ha was under family contract management. In recent years, this city had strengthened the overall advancement of farmland circulation. As of June 2015, the rural farmland circulation area in Zhangye City was 77,800 ha, which accounted for 28.92% of the total farmland areas and 46.66% of the households contracted farmland areas. The farmland circulation involved 99,000 households, which accounted for 36.01% of the households contracted farmers (Table 4).

Table 4. Farmland circulation data of Zhangye City.

Total Farmland Area	Area of Farmland Contracted by Households	Area of Plains/Farmland Circulation	Area of Mountains/Farmland Circulation	Area of Rural Land Circulation	Number of Farmers Participating in Farmland Circulation
269,000 ha	166,733 ha	140,144/26,347 ha	121,574/49,967 ha	77,800 ha	99,000 households

Note: The data comes from the Farmland Circulation Report of Zhangye City in 2015.

4.1.1. Farmland Circulation Rate in Plains Is Significantly Lower than That in Mountainous Areas

The area of farmland circulation in plains was 26,347 ha, which accounted for 18.80% of the farmland in plain areas, and 23.49% of households contracted farmers had participated in farmland circulation, whereas the area of farmland circulation in mountainous areas was 49,967 ha, which accounted for 41.10% of the farmland in mountainous areas, and 59.45% of households contracted farmers had participated in farmland circulation. In addition, it was found that there were many "whole village circulations" in the research area. The number of "whole village circulations" in the plains and mountainous areas were 15 and 51, accounting for 3.3% and 18.1% of the total number of administrative villages, respectively. Based on the concept of farmland circulation, "whole village circulation" refers to the circulation of land management rights. The circulation of the whole village involves many farmers and industrial and commercial enterprises, resulting in a high concentration of farmland and a large area of operation.

4.1.2. Various Modes of Farmland Circulation Exist in Plains, and the Mode of Leasing Has an Absolute Advantage in Mountainous Areas

Before carrying out this section of the analysis, the six types of farmland circulation modes in the article must be explained. Farmland leasing means that the contractor leases out the farmland management rights to collect rent; farmland exchange refers to the exchange of farmland management rights; farmland subcontracting means that the contractor circulates the farmland management rights to the third party; farmland transferring means that the contractor circulates the unexpired farmland management rights to others; share cooperation refers to joint agricultural production with others in the form of shares; and substitute farming refers to paid management by social service agencies. The farmland circulation in Zhangye City mainly included six modes: leasing, exchange, subcontracting, transferring, share cooperation, and substitutive farming. Six types of circulation existed in plains, and the main modes were leasing, exchange, and subcontracting, which comprised 54.44%, 22.43%, and 16.13%, respectively. Among them, the leasing mode accounted for the largest proportion in each county/district. Exchange mode was most prominent in Ganzhou District, while subcontracting mainly appeared in Linze County and Gaotai County. However, the farmland circulation in mountainous areas had an absolute advantage in the modes of leasing, which comprised 90.75%. The modes of exchange and subcontracting only comprised 0.82% and 4.99%, respectively, with no mode of transferring (Figure 3).

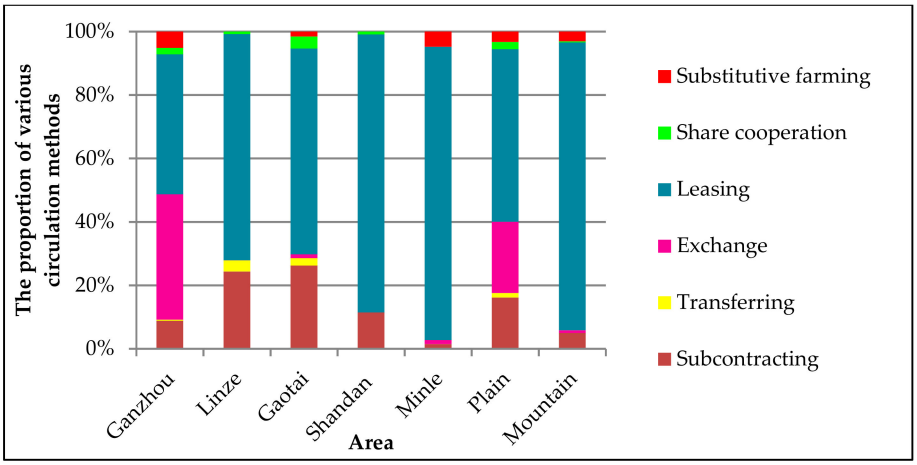

Figure 3. Proportion of farmland circulation modes in various districts of Zhangye city.

4.1.3. The Directions of Farmland Circulation Is Diverse in Plains, while Concentrated in Mountainous Areas

The directions of farmland circulation in the plain areas were mainly large sale growers, agricultural cooperatives, and family farms, which together comprised 86.55% of the total farmland circulation area in the plains. The farmland in the mountainous areas mainly circulated to large scale growers, which accounted for 70.14% of the farmland circulation area in these mountainous areas; this proportion was much higher than that of 40.58% in the plains. It was followed by the direction of agricultural cooperatives, which accounted for 18.81% of the farmland circulation area in the mountainous areas, this was lower than that of 27.35% in the plains. No farmland that had circulated to the industrial and commercial enterprises was present (Figure 4).

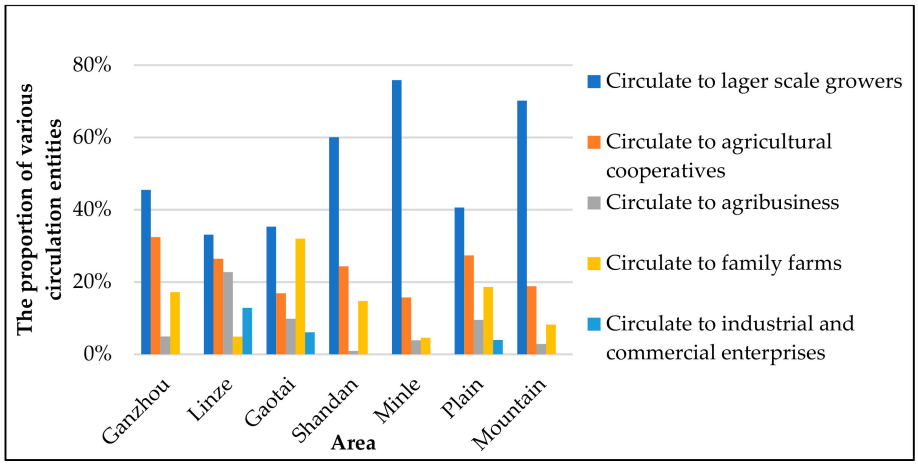

Figure 4. Proportion of farmland circulation directions in various districts of Zhangye City.

4.1.4. Large-Scale Operation Area of Farmland Circulation in Plains Is Significantly Smaller than That in Mountainous Areas

During the farmland circulation in Zhangye City, the scale management area of more than 3.33 ha was 70,133 ha, which accounted for 90.15% of the total area of farmland circulation. Among them were 19,393 ha in plain areas and 47,553 ha in mountainous areas, which accounted for 24.93% and 61.12% of the total area of farmland circulation, respectively. The number of largescale operating units in plain areas was 4356, and the large-scale management area was mainly concentrated in 3.33–6.67 ha and 6.67–33.33 ha. The number of large-scale operating units in mountainous areas was 1403, and the large-scale management area was concentrated in 6.67–33.33 ha and 33.33–66.67 ha. The proportion of more than 66.67 ha was as high as 12.26%. The scale of farmland circulation in plains was significantly smaller than that in the mountainous areas (Table 5).

Table 5. Number of scale management units of farmland circulation (unit: pcs).

Management Scale	Number in Plains	Number in Mountainous Areas	Proportion in Plains	Proportion in Mountainous Areas
3.33–6.67 ha	2991	27	68.66%	1.92%
6.67–33.33 ha	1083	945	24.86%	67.36%
33.33–66.67 ha	199	259	4.57%	18.46%
More than 66.67 ha	83	172	1.91%	12.26%
total	4356	1403	100.00%	100.00%

Note: The data comes from the Farmland Circulation Report of Zhangye City in 2015.

4.1.5. Farmland Circulation Periods in Plains Is Generally Longer than That in Mountainous Areas

The farmland circulation period refers to the terms for the use of farmland obtained in accordance with the law. There were differences in the proportion of farmland circulation periods between plains and mountainous areas (Table 6). The plains contained five types

of farmland circulation periods (Figure 5). For example, the circulation periods and proportions of Gaotai County were: 1 year (23.97%), 1–3 years (30.21%), 3–5 years. (13.66%), 5–10 years (14.36%), and more than 10 years (17.79%). However, the circulation periods in mountainous areas were mainly concentrated in 1 year and 3–5 years, such as Shandan County, 1 year (68.81%), 3–5 years (31.19%), and no circulation period exceeding 5 years.

Table 6. Proportion of various farmland circulation period in plains and mountainous areas.

Areas	<1 year	1–3 years	3–5 years	5–10 years	>10 years
Plain areas	13.00%	29.54%	29.33%	16.14%	11.99%
Mountainous areas	53.80%	9.83%	34.14%	2.23%	0

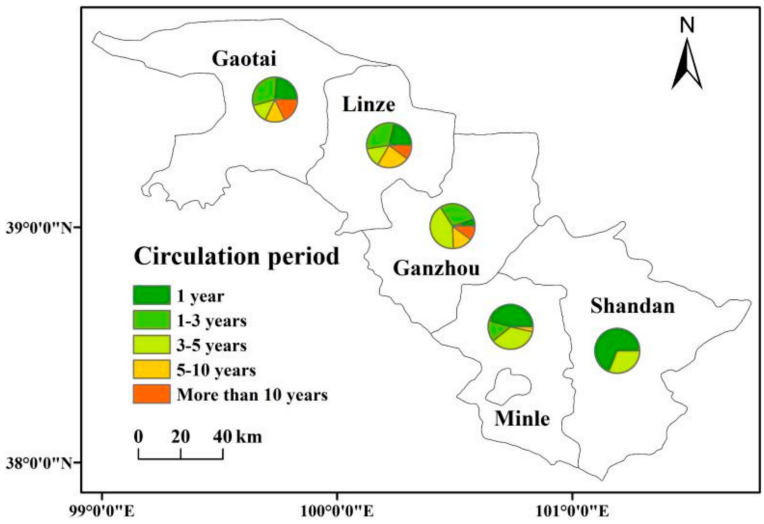

Figure 5. Spatial distribution of different circulation period in Zhangye City.

4.2. Influencing Factors of Farmland Circulation

Using SPSS 25.0 to perform logistic regression, the results of the collinearity test showed that the coefficients of determination of the regression models in plains and mountainous areas were 83.1% and 93.2%, and the Sig. values of the Hosmer–Lemeshow test results were 0.481 and 0.758, indicating that the fitting effect is good.

According to the regression results in Tables 7 and 8, the following conclusions are drawn. The "farmland circulation price" had a significant positive correlation ($p < 0.01$) to the farmland circulation in plains and mountainous areas. According to the survey, the farmland circulation prices of different regions were quite different, the circulation price per ha could be as low as \$235.8–707.4 (¥1500–4500), or as high as \$1650.6–2122.2 (¥10,500–13,500). In the case of such a large difference in the circulation price, the higher the circulation price of farmland, the more farmers tend to circulate the farmland. The "degree of farmland fragmentation" had a diametrically opposite influence on farmland circulation in plains and mountainous areas, the impact on plain areas was positive ($p < 0.01$), and the impact on mountainous areas was negative ($p < 0.01$). The fragmented management of farmland cannot play the scale effect of farmland utilization, which inhibits the improvement of land utilization efficiency, while farmland circulation is conducive to improving the fragmentation management and labor productivity.

The "actual water diversion" ($p < 0.01$) and "river source water" ($p < 0.05$) had different significant negative effects on farmland circulation in plains but were not significant in mountainous areas with poor irrigation conditions. The "altitude" was only negatively correlated with farmland circulation in mountainous areas ($p < 0.05$), indicating that high altitude hindered the occurrence of farmland circulation.

Table 7. Logistic regression results at plot level in plain areas.

Variable	B	S.E.	Wald	df	Sig.	VIF
Plot area	0.033	0.109	0.092	1	0.761	1.746
Degree of farmland fragmentation	1.068 ***	0.408	6.835	1	0.009	2.081
Farmland quality	−0.066	0.239	0.077	1	0.781	1.123
Farmland circulation price	0.008 ***	0.002	17.421	1	0.000	1.190
Whether the crop type has changed	−0.202	0.661	0.039	1	0.760	1.336
Altitude	−0.001	0.004	0.093	1	0.844	1.675
Irrigation water source	−0.022	0.521	0.002	1	0.966	1.408
Actual water diversion	−0.017 ***	0.007	6.968	1	0.008	3.541
River source water	−0.132 **	0.064	4.262	1	0.039	4.172

Note: ** and *** represent statistical significance of $p < 0.05$ and $p < 0.01$, respectively. The abbreviations of "B", "S.E.", "Wald", "df", "Sig.", and "VIF" refer to regression coefficient, standard error, significance of Wald test, freedom degree of variables, statistical significance, and collinearity test result, respectively.

Table 8. Logistic regression results at plot level in mountainous areas.

Variable	B	S.E.	Wald	df	Sig.	VIF
Plot area	−0.431	0.447	0.933	1	0.334	3.695
Degree of farmland fragmentation	−2.699 ***	0.926	8.497	1	0.004	3.915
Farmland quality	−0.028	0.452	0.004	1	0.951	1.108
Farmland circulation price	0.009 ***	0.002	14.453	1	0.000	1.473
Whether the crop type has changed	0.495	0.782	0.400	1	0.527	1.112
Altitude	−0.004 **	0.002	4.023	1	0.045	2.352
Irrigation water source	−0.426	1.442	0.087	1	0.768	3.279
Actual water diversion	−0.013	0.012	1.224	1	0.269	2.740
River source water	0.044	0.113	0.153	1	0.696	3.948

Note: ** and *** represent statistical significance of $p < 0.05$ and $p < 0.01$, respectively. The abbreviations of "B", "S.E.", "Wald", "df", "Sig." and "VIF" refer to regression coefficient, standard error, significance of Wald test, freedom degree of variables, statistical significance, and collinearity test result, respectively.

5. Discussion

5.1. Reasons for Differential Features and Their Influencing Factors of Farmland Circulation

Based on the questionnaire data and official statistics of farmers in various districts/counties of Zhangye City, we compared the features of farmland circulation between plains and mountainous areas. Furthermore, the logistic regression model was used to analyze the influencing factors of farmland circulation in the two areas at plot level. This study makes up for the lack of research on regional differences in farmland circulation at the plot level.

Firstly, a focus on the farmland circulation rate in the study area. The poor farming conditions in mountainous areas led farmers to choose the former between "migrating to work" and "cultivating at home" driven by comparative interests, which made it easier for farmers to circulate farmland in mountainous areas. In terms of the modes and destinations of farmland circulation, the plain areas had better natural conditions and water resources than that in mountainous areas, so the farmers in the plain areas had more choices in the modes and destinations of farmland circulation. Thus, the modes and destinations of farmland circulation in plains were more complex than those in mountainous areas.

Secondly, it was found that the comparison of the differences in "farmland circulation price" could be carried out from the following three perspectives: first, the irrigation conditions of the plains were better than those of the mountainous areas, resulting in a higher circulation price in plains; second, the farmland circulation destinations would affect the farmland circulation price, and under the same conditions, the price for farmland circulation between farmers in the same village was lower, while the price of farmers who circulate to other villages was higher; and third, different types of planting crops of circulation affected the farmland circulation price, where generally speaking, if the farmland was used for planting cash crops, the circulation price was much higher than that used for

planting crops. The survey data showed that the circulation price of farmland used for seed corn, wheat, and other crops was generally between $236–707 per hectare (¥1500–4500 per hectare), and for the planting of cash crops such as Chinese herbal medicine, the circulation price was generally between $1533–1887 per hectare (¥9750–12,000 per hectare).

Thirdly, the factor analysis of the "degree of farmland fragmentation" was carried out. The fragmentation of farmland hindered its large-scale operation [37] and reduces agricultural labor productivity [38]. There are two main reasons for the diametrically opposite correlation of "degree of farmland fragmentation" between the plains and mountainous areas. First, the demand for seed corn planting conditions in plain areas. According to the survey data, the plains were mainly planted with seed corn, the planting conditions of this crop were suitable climate, concentrated plots, and isolated zones. In order to meet the planting requirements, it was common for farmers to exchange farmland with each other, as a result, the exchange of farmland in plains was one of the main modes of circulation. Therefore, farmland fragmentation promoted farmland circulation in the plains. Second, the plot area in mountainous areas were relatively large, and large-scale operations were basically formed. The survey found that the average area of farmland in plains and mountainous areas was 0.127 and 0.433 ha, respectively. The larger farmland area in the mountainous areas is conducive to large-scale operations; however, farmland fragmentation will hinder the realization of large-scale agriculture. As a result, the index of "degree of farmland fragmentation" was negatively correlated with farmland circulation in mountainous areas.

Fourthly, according to information obtained from the investigation, we conducted a factor analysis of irrigation conditions. Different crops have different requirements for irrigation water, combined with field survey data, the crop types on the circulated farmland in Zhangye City included: wheat, field corn, seed corn, oil crops, Chinese herbal medicine, potatoes, vegetables, forest fruits, and grains. Among them, the four crops of wheat, seed corn, potatoes, and miscellaneous grains accounted for 22.05%, 19.34%, 14.79%, and 13.43%, respectively (Figure 6). In addition, Table 9 lists the net income and water consumption per hectare of different crops in Zhangye City. Therefore, the plain areas were suitable for planting crops with high irrigation water requirements and high net income, such as seed corn and vegetables, accounting for 50.6% and 23.5% of crops in the plain area, respectively. The mountainous areas were suitable for planting crops with low irrigation water requirements and low net income, such as wheat and potatoes, accounting for 31.3% and 20.6% of crops grown in the mountainous areas. (Figure 7).

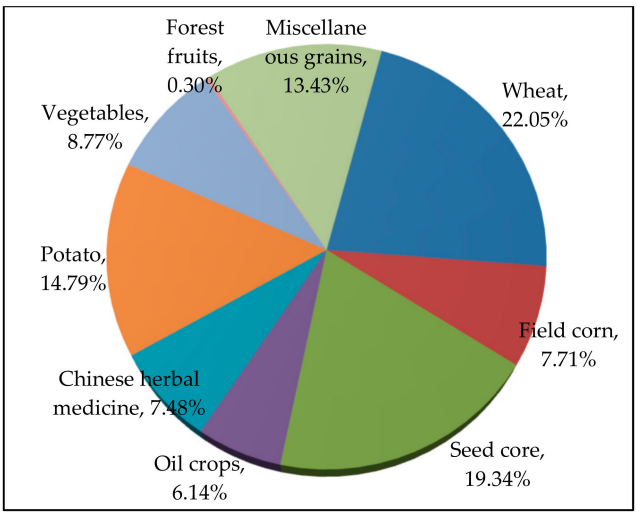

Figure 6. Proportion of planting types of scale management crops.

Table 9. Per hectare net income and water use of different crops in Zhangye City.

Crop Types	Net Income (Dollar/ha)	Water Usage (Times)
Seed core	1415–1651	Water 5
Wheat	1179–1415	Water 2
Barley	1179–1415	Water 2
Rape	943	Dryland planting
Tomato	4716	Water 5
Onion	3537–3773	Water 7–9
Potato	2358–3065	Water 4

Note: The data comes from the questionnaire data of farmers in 2015.

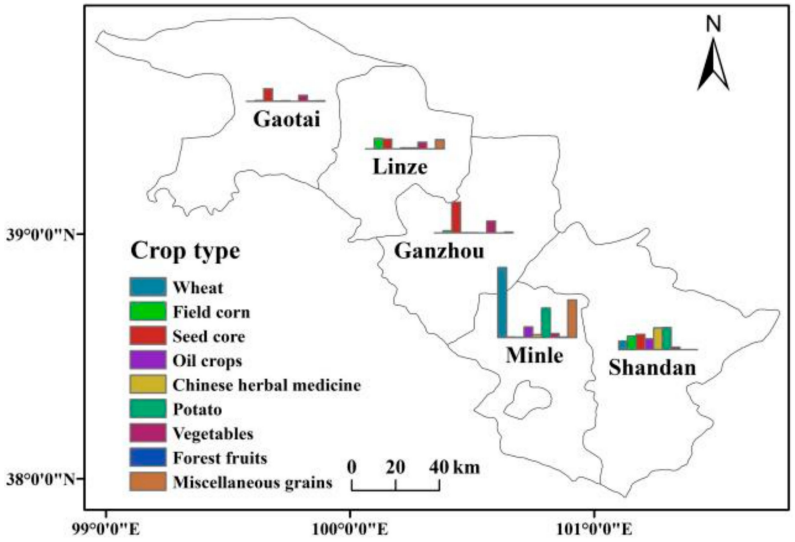

Figure 7. Spatial distribution of planting types of scale management crops.

5.2. Policy Implications

The issue of farmland scale management and agricultural efficiency have received extensive attention from scholars at home and abroad, and it is also the direction of future agricultural development. The efficient circulation of farmland is the key to agricultural modernization, especially for the typical study area selected in this study—Zhangye City in the arid region of Northwest China.

Circulation modes and destinations are more diverse in the plain areas, oral agreements and no written contracts are common, resulting in unclear responsibility relationships [39,40]. The survey found that the proportion of farmland circulation contracts signed in the plains is 79.3%, lower than 99.6% of the mountainous areas. Some scholars have conducted research on perfecting the farmland circulation system [41,42], and emphasized the importance of clear land property rights [43]. Taking the Heilongjiang province as the study area, Chen et al. [44] suggested improving the farmland circulation market to promote the non-agricultural employment of surplus labor. For the influencing factors of farmland circulation, the correct farmland circulation pricing mechanism can promote the farmland circulation. Due to the differences in farmland systems and national conditions, there were also differences in the research on farmland circulation price between China and other countries. Foreign scholars generally believe that the value of farmland was related to factors such as geographical location, psychology, and market. Sills and Caviglia-Harris [45] analyzed the determinants of land value in an Amazonian frontier settlement and found that land value was not only related to market distance, but also to investment and the quality of adjacent land. Rebelo [46] proposed a new method to improve the efficiency and fairness of land value assessments. Cotteleer et al. [47] believed that market forces based on the subjective affected the price of farmland. On the whole, the land rental market is conducive to the redistribution of farmland resources and the

improvement of farmers' income [48]. The Chinese scholars found that social, economic, location, and other factors had an impact on farmland circulation pricing mechanisms. Tian et al. [49] analyzed land rent from a sociological perspective, emphasizing that land rent was a dual problem of economy and society, and social factors had a deeper impact on land rent. Zhang [50] recognized that there are problems in China's land circulation pricing mechanism, and pointed out that factors such as economy, location, and cultivation willingness were related to land circulation prices. The research of Du et al. [51] showed that there are regional differences in the land circulation prices of China. With the development of the land circulation market, the role of natural factors was decreasing, while the influence of location economy and human-land resource endowment were further enhanced. In recent years, China's land circulation system and circulation price mechanism have been continuously improved. Land markets are critical not only for non-agricultural growth but, by allowing more effective use of potentially idle land, this can contribute to significant productivity gains [52].

Based on the above analysis, we found that there are irregularities in farmland circulation in the plains and mountainous areas of Zhangye City and suggest that government departments should focus on regulating the behavior of farmland circulation and reduce the potential risks brought about by farmland circulation. Through the in-depth analysis of the factors of "farmland circulation price", it is proposed that the dynamic supervision mechanism should be used to meet market demand, and encourage the exploration of various interest linkage mechanisms, to realize the rationalization of farmland circulation price. In view of the phenomenon of the "fragmentation of farmland", integrating farmland resources to reduce the degree of farmland fragmentation is an effective way to promote the circulation of farmland, and is also the key to realizing large-scale agricultural operations. For the difference in water resources between plains and mountainous areas, the local government should encourage the planting of crops according to local conditions, to realize the rational and efficient use of farmland resources.

6. Conclusions

The farmland circulation features in plains and mountainous areas of Zhangye City were compared and analyzed, and the binary logistic regression model was used to analyze the influencing factors of farmland circulation. We further provided differentiated management suggestions of farmland circulation to support the scientific basis for related research.

The differences in farmland circulation features between plains and mountainous areas were manifested in the circulation rate, modes, destinations, scale, and period. This indicated that differences in geographical environment can affect the characteristics of farmland circulation. In terms of influencing factors, farmland features mainly affected circulation behaviors through "farmland circulation price" and the "degree of farmland fragmentation". They had varying degrees of influence on farmland circulation in plains and mountainous areas. Irrigation conditions were most obviously different in these two areas and were also the main influencing factors of farmland circulation. As an internal driving force, natural conditions determined the regional geographical environment and planting conditions, and affected the features of farmland circulation. Thus, decision makers should practice management measures such as regulating farmland circulation behavior, formulating reasonable farmland circulation pricing models, and integrating farmland to promote the circulation and efficient use of farmland, and the sustainable development of agriculture.

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