land

MDPI

Article

Does Farmland Scale Management Promote Rural Collective Action? An Empirical Study of Canal Irrigation Systems in China

Liangzhen Zang [1], Yahua Wang [2,3,*] and Yiqing Su [4]

[1] Institute of Agricultural Economics and Development, Chinese Academy of Agricultural Sciences, Beijing 100081, China; zangliangzhen@caas.cn
[2] School of Public Policy and Management, Tsinghua University, Beijing 100084, China
[3] China Institute for Rural Studies, Tsinghua University, Beijing 100084, China
[4] School of Public Policy and Management, Guangxi University, Nanning 530004, China; suyiqing@gxu.edu.cn
* Correspondence: wangyahua@tsinghua.edu.cn; Tel.: +86-010-6278-3923

Abstract: Farmland scale management represents an inevitable trend toward global modern agriculture. In the new development context, the key to solving the tough problem of the insufficient supply of rural public goods is to effectively improve the enthusiasm of farming households to participate in rural collective action in countries with a small arable area per capita, such as India, China and countries in Eastern Europe. This paper adopts the Institutional Analysis and Development (IAD) framework in the context of a land system with Chinese characteristics, and uses sample data of 3663 rural households in 17 provinces to study the impact of farmland scale and various relevant systems on farming households' participation in rural collective action. We found that the advantages of collective action, such as reduced production costs, enhanced risk resistance and improved production efficiency, can offset the disadvantages incurred by free-riding behavior, and the expansion of farmland scale can significantly facilitate rural collective action. Additionally, as the farmland scale expands, stable farmland tenure and reasonable farmland tenure transfer can help to optimize the allocation of arable land resources, increase investment, and reduce free-riding behavior, thus effectively stimulating farming households to actively participate in collective action. However, since socialized agricultural services lead to the separation of the suppliers and the users of rural public goods, the expansion of farmland scale shows a negative effect. Therefore, in the context of the continuous migration of the rural population to cities, a stable farmland tenure adjustment mechanism should be established, while the balance between farmland tenure transfer and socialized agricultural services, in pushing forward rural collective action, should be emphasized, so as to ensure the effective supply of rural public goods in propelling farmland scale management. Especially in promoting the development of socialized agricultural services, more attention should be paid to specifying the responsibilities and obligations of the main provider of commercialized services in the supply of rural public goods.

Keywords: farmland scale management; collective action; farmland tenure stability; farmland tenure transfer; socialized agricultural services; Institutional Analysis and Development (IAD) framework

Citation: Zang, L.; Wang, Y.; Su, Y. Does Farmland Scale Management Promote Rural Collective Action? An Empirical Study of Canal Irrigation Systems in China. *Land* **2021**, *10*, 1263. https://doi.org/10.3390/land10111263

Academic Editor: Rohan Bennett

Received: 20 October 2021
Accepted: 18 November 2021
Published: 19 November 2021

1. Introduction

As typical natural resources, farmland resources play a key role in agricultural production. Agricultural development patterns can vary largely in countries with different land systems. With respect to the supply of public goods in agricultural production, in particular, the difference in land systems is bound to affect the ability of farming households to cooperate in the supply of public goods [1,2]. Existing studies on developed countries indicate that the scale expansion of farmland operations can compromise farmers' willingness to participate in the cooperative supply of public goods [3]. Correspondingly, it remains to be further discussed whether the expansion of the scale of farmland operations in developing countries with a small arable area per capita, such as India, China and

other countries in Eastern Europe, will affect farmers' ability to cooperate in supplying public goods. In countries with private land ownership such as the United States and Japan, the mechanism of farming households' cooperation in the supply of rural public goods must be different from that in China and other developing countries that adopt collective ownership of cultivated land [4,5]. Therefore, in the context of the peculiar rural land system of developing countries, the discussion of the supply of rural public goods, clarification of the logical relationship between farmland scale management (representing agricultural development) and the cooperative supply of public goods (representing rural development) can provide a new understanding for the comprehensive and coordinated development of agriculture and rural areas in countries or regions with a small arable area per capita.

As the world's largest developing country, China has long presented a paradox of development in rural areas. Despite the growing total area of agricultural arable land and the output of agricultural products, the supply of public goods such as rural infrastructure and ecological environment is declining, with no organization and a low degree of participation. The governance of the commons in rural areas is facing severe challenges [6]. In China, a large country with a large population of smallholders, the top priority in solving the problems of the insufficient supply of public goods and supply–demand imbalance in rural areas lies in effectively increasing the enthusiasm of farming households to participate in the governance of the rural public goods supply [7,8].

Historically, China's rural land system and rural collective action are closely related. From 1953 to 1978, most of the farmland was in the ownership of production teams in rural China, with only small plots of land, which could not be sold or subleased, freely left to farming households for personal use. During this period, China's rural economy was primarily manifested as a collective economy, supplemented by the common ownership of the agricultural means of production by all commune members. Hence, farming households were almost free-riders in agricultural production. However, the supply of rural public goods mainly depended on the farming households' cooperation under political forces. Taking farmland irrigation facilities as an example, the construction and maintenance of facilities mainly rely on farming households' cooperation under political mobilization. In 1978, China began to implement the Household Contract Responsibility System that allowed farming households to manage agricultural production on their own initiatives, while the farmland remained under the ownership of the rural collective [9]. Since then, China's agricultural production has been in a decentralized state with smallholders as the mainstay. At this stage, with the implementation of "entrusting the farmland owned by the village collective to individual households", the state authority gradually faded from the village, and the ability of rural organizations to integrate farming households continued to decline. However, the system of compulsory labor and accumulated labor for public undertakings in rural areas guaranteed the supply of rural public goods during this period. In terms of the irrigation and water conservancy of farmland, the village community could still organize farming households to build water conservancy facilities [10].

Starting from 2003, China issued a number of policies to further activate the rural land market and focused on supporting the transfer of rural land-use rights from the legal level [11]. The No. 1 Central Document for 2016 proposed the implementation of the system for separating the ownership rights, contract rights, and management rights for contracted rural land. The No. 1 Central Document for 2017 proposed the vigorous development of diversified, agricultural, professional organizations and promoted the development of a commercialized rural service system. As a result, China entered a new stage of farmland scale management, gradually transforming from scaled-up land operations based on land tenure transfer to scaled-up service operations based on agricultural productive services [12]. In addition, the report at the 19th CPC National Congress in 2017 proposed the implementation of concrete steps to extend the farmland tenure contracts for another 30 years, at which point they expire, further consolidating the foundation for farming households to engage in production and operation. However, China's capacity for the

governance of the commons in rural areas saw a declining trend during this period. In 2003, China cancelled the system of compulsory labor and accumulated labor for public undertakings in rural areas, making it increasingly difficult to carry out farmland and water conservancy projects, with rural communities as the basic organizational units. A growing number of farming households chose to solve irrigation needs independently. Furthermore, rural tax reform led to a loss of motivation of the township government to become involved in the governance. As a consequence, the government gradually fell into a state of failure in the governance of the commons in rural areas. The voluntary cooperation of farming households was highlighted in rural public affairs. However, due to the lack of mutual trust and supervision among farming households, it was difficult for them to achieve spontaneous cooperation, which led to the dilemma of rural collective action [13].

On the whole, from the 1950s to 2003, the basic unit of China's agricultural production gradually shifted from the initial cooperative production to individualized production, with the farmland scale changing from a scaled mode to a fragmented mode. Meanwhile, the basic unit participating in the governance of the commons in China changed from the initial people's communes to villages, and, in recent years, further narrowed to a number of farming households or even a single farming household, and the governance of the commons in rural areas gradually shifted from collectivization to individualization. Starting in 2003, China began to shift to farmland scale management with family farms, cooperatives, and agricultural enterprises as production units. The emergence of formal systems that promoted farmland scale management, such as farmland tenure transfer and socialized agricultural services, greatly promoted the economies of scale in agricultural production. In the meantime, changes in informal systems, such as farmland tenure adjustment within the collective organizations in rural China, also had a significant impact on the decision making regarding farming households' participation in farmland scale management [14]. Given the vigorous implementation of farmland scale management in China, what impact will the ever-expanding farmland area have on collective action in rural areas? In realizing farmland scale management, can institutional changes strengthen the impact of such operations on rural collective action? Solving these problems is of great significance for eradicating the conflicts between the transformation of China's agricultural production and operation units from individualized ones to collective ones, and the transformation of rural public affairs governance units from collective ones to individualized ones.

This paper is innovative in two aspects. First, it uses the Institutional Analysis and Development (IAD) framework in public governance theory to analyze the specific agricultural conditions in China's rural areas, and contributes to public governance research, incorporating influencing variables such as the stability of farmland tenure, large-scale farmland tenure transfer, socialized agricultural services, and other variables with Chinese characteristics. This framework realizes the theoretical and empirical application of the generally applicable IAD framework in the Chinese context, thereby contributing Chinese cases and experience to the research on governing the commons. Second, this paper focuses on the crisis of rural cooperation in public governance, namely the issue of collective action in rural areas, as well as representative farmland irrigation facilities. By delving into the problem of collective action among people, this paper seeks a new solution, responding the crisis of rural cooperation in developing countries.

2. Literature Review

There are a large number of documents describing and analyzing the important influencing factors and mechanisms, with respect to promoting rural irrigation collective action. Scholars' analysis on the governance of the rural irrigation system is mainly based on the IAD framework, which was described earlier. The existing research on the important influencing factors of rural irrigation collective action is mainly based on three attributes: biophysical conditions (e.g., water scarcity [15–17], village topography [18]), attributes of community (e.g., village size [19], income heterogeneity [20]), and rules-in-use (such as

institutional structure [21]). Among biophysical conditions, farmland resources, as the basic resources of agricultural production, are closely related to rural irrigation collective action. In general, the research on the relationship between farmland resources and rural irrigation collective action mainly centers around such factors as farmland scale, farmland location, and farmland fragmentation.

2.1. Relationship between Farmland Scale and Irrigation Collective Action

2.1.1. Larger Scale of Farmland Helps Facilitate Irrigation Collective Action

According to existing research findings, the scale of farmland has a significant positive impact on rural irrigation collective action. Specifically, the larger the farmland area of a farmer household is, the more willing the farming household is to participate in the rural irrigation collective action, which can be observed in countries or regions such as India and Southern Africa [22,23]. Mao, Wang, and Zhang confirmed the above views by analyzing survey data of large-sample farming households in various provinces of China [24–26], as did Zhao's research on the Hetao Irrigation District in Inner Mongolia [27] and Xu's research on Pishihang Irrigation District [10]. Yuan and Luo also confirmed the positive impact of farmland scale on rural irrigation collective action after investigating and analyzing farming households in China's functional grain production areas and important agricultural production protection areas, such as Anhui, Henan, and Hubei [28,29].

In addition, scholars further measured the specific extent of the positive impact of the scale of farmland on irrigation collective action. For instance, Liu found, based on an analysis of survey data of farming households in Shaanxi, China, that, among all respondents, the proportion of "less than 0.2 ha, 0.2–0.4 ha, 0.4–0.6 ha and over 0.6 ha" farmland areas was 21.5%, 41.2%, 29.5% and 7.8%, respectively, with the proportion of farming households' willingness to participate in rural irrigation collective action being 77.4%, 77.7%, 82.4% and 94.0%, respectively. It can be said that the larger the farmland area of the farming households is, the stronger their willingness to participate in rural irrigation collective action [30]. Zhou analyzed the survey data of farming households in Jiangxi, China, finding that, among households with irrigated paddy fields of "under 0.33 ha, 0.33–0.67 ha, and over 0.67 ha", their willingness to participate in the management of collective farmland irrigation facilities was 61.18%, 73.9% and 85.1%, respectively, showing an upward trend [31].

The main reasons for the positive impact of the farmland scale on the rural irrigation collective action are as follows:

First, the larger the farmland scale is, the more dependent the farmer household is on agricultural income [32]. Since farmland irrigation facilities are the most basic facilities that ensure agricultural production, they are crucial to ensuring farming households' timely access to water sources for irrigation and a stable income from growing grain [33]. Therefore, the larger the farmland area is, the greater the farmer households' demand for irrigation facilities, and the stronger the degree of farming households' participation in rural irrigation collective action [34].

Second, the larger the farmland area of a farmer household is, the greater the agricultural risk it will bear. In order to avoid economic losses, farming households can improve their ability to cope with risks by participating in infrastructure construction [35]. Under the conditions of the same disaster intensity, the larger the area of farmland owned by the household, the more economic losses it will suffer [36]. Therefore, compared with farming households with smaller-scale farmland, farming households with larger-scale farmland are more in need of well-functioning farmland irrigation facilities to avoid the risk of grain yield reduction [29], and are therefore more likely to participate in rural irrigation collective action.

Third, the larger the farmland area is, the less likely the farmer household is to commit free-riding, which is conducive to the realization of rural irrigation collective action. Free-riding usually occurs in the use of water conservancy facilities for farmland by farming households with a small farmland scale [36], and the free-riding effect of members

in collective action may offset the incentive effect of other members, which ultimately makes it difficult for farming households to reach cooperation agreements [37]. Therefore, compared with farming households with smaller farmland scales, farming households with larger farmland scales are more likely to overcome the free-riding dilemma, thus contributing to the success of collective action.

Fourth, the farmland scale is a typical feature of farmer household heterogeneity, which is an important factor for promoting collective action. According to the theory of collective action, heterogeneous groups are more likely to promote the success of collective action than homogeneous groups [38,39]. This implies that farmland scale is a key dimension for measuring the heterogeneity of members, and heterogeneous members have stronger incentives to participate in collective action [40].

2.1.2. Larger-Scale Farmland Is Not Conducive to Facilitating Irrigation Collective Action

Although most scholars believe that the farmland scale of a farmer household has a significant positive effect on the rural irrigation collective action, some scholars found that the larger the farmland area is, the less likely the farmer household will be to participate in rural irrigation collective action. In other words, there is a reverse relationship between the area of farmland and rural irrigation collective action [41]. There are two main reasons for this: First, from the cost–benefit perspective, farming households with more farmland are more inclined to use their own irrigation facilities instead of cooperating with others to reduce costs (such as purchasing or leasing small water conservancy facilities to meet irrigation needs), in order to improve land marginal revenue and maximize benefits, ultimately realizing economies of scale [42,43]. Therefore, households with larger farmland may resort to other independent irrigation methods instead of collective irrigation methods, thereby reducing the possibility of participating in collective action [44]. Second, the investment and commissioning of rural collective irrigation facilities usually depend on the water consumption of farming households, and the farming households with larger farmland will inevitably contribute more input. However, the free-riding behavior of farming households with a smaller farmland scale always exists, which indirectly leads to the need for more input by farming households with larger farmland area. Therefore, farming households with a larger farmland area are more inclined to invest in the construction of irrigation facilities themselves rather than cooperate with others, thus reducing both costs and disputes [45].

2.1.3. Unclear Relationship between Farmland Scale and Irrigation Collective Action

In addition to the above two views, some scholars believe that the relationship between the farmland scale and rural irrigation collective action is unclear. For example, Cai and Huang's studies on provinces in the Yellow River irrigation area in China [46,47], Xu's research on key counties of national small irrigation and water conservancy in China [48], and Dong's research on South China [49] all found no correlation between farmland scale and farming households' participation in maintenance, demand, investment and other aspects of collective irrigation facilities. The existing literature fails to fully explain why there is no direct relationship between the farmland scale and rural irrigation collective action. Only Zhu gave an explanation when studying the willingness of farming households to participate in farmland and water conservancy projects in Jiangxi Province, China. Most of the land currently operated by farming households is transferred. Since the farmland tenure transfer is mainly carried out in oral form and no fixed and legal contract form is established, the farmland tenure transfer relationship remains unstable [50]. Ultimately, the uncertainty of farming households' farmland scale makes it difficult for farming households to obtain the corresponding water conservancy services when they participate in farmland and water conservancy projects, resulting in an insignificant impact of the operation scale on farming households' involvement in collective irrigation action.

2.2. Relationship between Farmland Location and Irrigation Collective Action

Overall, the location of farmland is primarily represented by two aspects, the first of which is the topography of the farmland. Existing studies suggest that farmland topography has a significant impact on irrigation collective action. Some scholars argue that if the farmland is in areas such as plains, the input cost of collective irrigation facility construction and maintenance is relatively low [51]; therefore, the degree of farming households' participation in collective action will be higher. Some scholars believe that if the farmland is in mountainous or hilly areas, despite the high construction and maintenance costs of collective irrigation facilities compared with the construction or maintenance of irrigation facilities by farming households themselves, the cost of collective cooperation will be relatively low; therefore, farming households would be more inclined to take collective action.

The second aspect is the distance between farmland and riverways. Existing studies suggested that the distance between farmland and riverways shows an inverted U-shaped effect on irrigation collective action. When the distance between farmland and riverways is relatively short, farming households are less willing to participate in collective irrigation action due to abundant water resources; this is mainly because abundant water resources weaken farming households' participation in irrigation facility construction in order to expand water supply [52,53]. Therefore, as the distance between farmland and riverways increases and water resources conditions worsen, farming households' willingness to participate in collective irrigation action increases. However, when the distance reaches a certain level, their willingness to participate in collective irrigation action is lower. This is because large distances lead to water scarcity and correspondingly high investment costs [15,16].

2.3. Relationship between Farmland Fragmentation and Irrigation Collective Action

Farmland fragmentation refers to the fact that a farmer household holds multiple non-adjacent and small plots of farmland [54,55]. Farmland fragmentation is common in East Asia, and Central and Eastern Europe [56]. In China, with household contracts as the basic production and management means, the stratification evolution of farming households induced by farmland fragmentation is significantly enhanced due to many external factors [57]. Generally speaking, smallholders with different degrees of farmland fragmentation usually present clear individual behavior preferences and demand preferences, and their demands for the rural production of public goods also show different preferences [58]. Existing studies show that farmland fragmentation compromises the enthusiasm of farming households to participate in rural irrigation collective action. In other words, the smaller the farmland area and the greater the number of plots, the lower the degree of participation for smallholders in collective action [32]. In addition, farmland fragmentation affects the formation of rural collective action in many ways. For example, farmland fragmentation reduces the dependence of smallholders on agricultural production, increases the pressure on farming households to participate in rural collective action, and expands the differences between different smallholders, which weakens the ability of the rural collective action [23,59].

Based on the existing research literature, most scholars believe that there is a positive relationship between the farmland scale of farming households and the rural irrigation collective action, for which the reasons are diverse. For example, the larger the scale of farmland is, the more dependent the farming households are on agricultural income, the greater the risk of farmland suffering disasters, the stronger the ability to overcome free-riding behavior, and the stronger the heterogeneity of farming households. These factors together contribute to the success of rural irrigation collective action. There is also a different view, namely that the scale expansion of farmland is not conducive to the success of rural collective action. However, regardless of the conclusion, farmland scale management represents an inevitable trend in future agricultural development [60]. "A large country with a large population of smallholders" is a manifestation of the basic national conditions and agricultural conditions of China. Given the small-sized farmland per

household, will stabilizing farmland tenure affect the formation of rural irrigation collective action? In addition, will farmland tenure transfer and socialized agricultural services, two different measures for promoting farmland scale management, impose different impacts on rural irrigation collective action? Will the three measures on farmland in China have different impacts on the relationship between land scale and rural irrigation collective action? These problems have not been discussed and analyzed in previous studies. Based on the basic characteristics of small-scale farmland in rural China, this paper further reveals the specific mechanism of farmland tenure stability, farmland tenure transfer and socialized agricultural services in the relationship between farmland scale and rural irrigation collective action. This paper will deepen the existing research on the relationship between farmland scale and rural irrigation collective action; on the other hand, it will compare and discuss the effects of the three different measures, so as to provide a scientific basis for the subsequent policy formulation to promote rural irrigation collective action.

3. Framework and Hypotheses

3.1. Framework

The IAD framework developed by Elinor Ostrom aims to explain how exogenous variables such as rules impact the autonomous governance of common pool resources, in order to provide resource users with a range of institutional design schemes and evaluation standards that can enhance trust and cooperation (see Figure 1) [61]. The unified model established under the IAD framework serves as the "grammar" for describing the relationship between the system, human society and the utilization of natural resources, providing a basic concept for analyzing diversity issues.

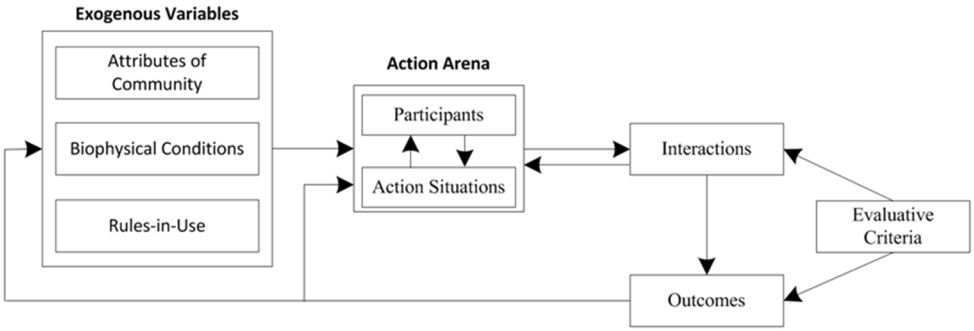

Figure 1. Institutional analysis and development framework.

The IAD framework comprises exogenous variables, an action arena and evaluation results. The action arena contains two variables: the participants and the action situations. The participants are considered as a single individuals or a group that functions as a joint action. Participants have certain "resources" and different levels of "information", and they choose the "decision-making process" of a certain action by "processing" such resources and information. Action situations refer to the structure that directly affects the behavior process of the research object, namely: a "participant" with a specific "status" may produce different types of "information" based on the "result" of the action, and complete its "action" through a certain "control" method. Within the action arena, participants interact according to the incentives they face. Given the exogenous variables that affect the structure of the action arena, the IAD framework helps confirm the action arena, the mode and the outcome of the interaction, as well as evaluating the outcome [62].

Farmland is the foundation of agricultural production. The scale of farmland is bound to affect all links of agricultural production. As an element of biophysical conditions, the scale of farmland is proven to have a close relationship with rural irrigation collective action. The gist of the IAD framework is that the decision making of participants is not only subject to biophysical conditions and attributes of community in the external environment, but also subject to rules-in-use (see Figure 2). At present, many rural collective irrigation facilities

are falling into decline shortly after they are completed, which is due to the lack of effective institutional arrangements. Rules-in-use shape the action situation, thus further influencing the incentive structure and choice logic used by the actor. Generally, the preliminary system and rules of rural irrigation infrastructure projects are relatively complete, but the formulation and implementation of subsequent management and protection rules often fail to be guaranteed. This increases the transaction cost of management and protection, causing free-riding behavior by farming households, and discouraging farming households from participating in management and protection. Overall, the existing literature on rural irrigation collective action focuses more on the role of irrigation-related rules and systems, and less on the impact of other rules and systems. Therefore, it is necessary to delve into the relationship between relevant land systems and rural irrigation collective action in the context of farmland scale management, so as to discover the influence of different systems. This research is built upon the three aspects of farmland tenure stability, farmland tenure transfer, and socialized agricultural services, as well as systems concerning scaled-up operations of farmland.

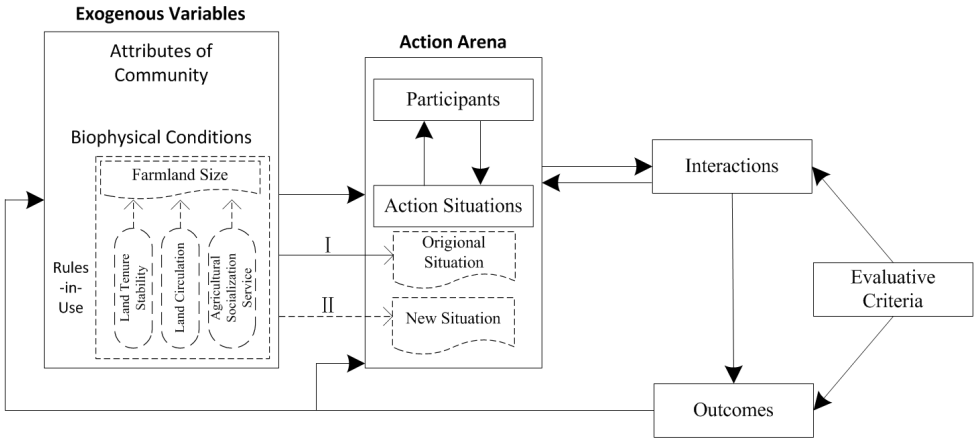

Figure 2. Framework for analyzing the relationship between farmland scale management and irrigation collective action.

3.2. Hypotheses

Existing studies revealed that, with the farmland scale expansion of farming households, factors such as increased dependence on agriculture, greater demand for agricultural risk alleviation and increased farmer household heterogeneity can motivate farming households to participate in rural irrigation collective action. The free-riding factor does not weaken the farming households' demand for public irrigation facilities in the process of farmland expansion. Particularly, due to the small farmland area per capita in China, the farmland scale expansion of farming households remains at a slow pace, and has not reached the inflection point where the rapid land expansion weakens farming households' willingness to participate in rural irrigation collective action. Thus, we propose the following hypothesis:

Hypothesis 1. *The scale of farmland has a significant positive effect on rural irrigation collective action.*

In general, stable farmland tenure can help to increase farming households' motivation in the supply of rural public goods. This is particularly true in rural irrigation facilities featuring large capital investment and a long payback period, which require more stable farmland tenure as a guarantee. On the contrary, in case of the high frequency of farmland tenure adjustment, it will be more difficult for farming households to cooperate in the agricultural production, especially in rural irrigation facilities with large investment and slow return. Therefore, with increased farmland area, stable farmland tenure can help

facilitate farming households' participation in collective irrigation action, and thus we propose the following hypothesis:

Hypothesis 2. *Stable farmland tenure policy can further promote the impact of farmland scale on rural irrigation collective action.*

As the rural population moves to cities, the implementation of the farmland tenure transfer policy further expands the farmland area of farming households, realizing an optimal allocation of land resources. With increasingly reasonable farmland use planning, a large amount of social funds are invested in agricultural production, which can greatly cater to the funding needs in the construction and maintenance of rural public irrigation facilities. Therefore, under the adjustment of the farmland tenure transfer policy, the continuous expansion of the scale of farmland can continuously affect the extent of farming households' participation in rural irrigation collective action, and thus we propose the following hypothesis:

Hypothesis 3. *The farmland tenure transfer policy can further enlarge the influence of the scale of farmland on rural irrigation collective action.*

Socialized agricultural services serve as an important means of supplementing and solving the inability of achieving farmland scale management through farmland tenure transfer. The introduction of socialized agricultural services altered the fact that the supplier and the user of rural irrigation facilities are independent of each other. The involvement of third-party socialized agricultural service providers further aggravates the difficulty of farming households' cooperation in the supply of rural public goods. Therefore, with the expansion of farmland area, the implementation of socialized agricultural service policy may weaken farming households' motivation to participate in rural irrigation collective action, and thus we propose the following hypothesis:

Hypothesis 4. *Socialized agricultural services may weaken the influence of farmland scale on rural irrigation collective action.*

4. Methods and Materials

4.1. Data

The data used in this paper are from the Hundred Villages and Thousand Households survey organized by the China Institute for Rural Studies (CIRS), Tsinghua University. CIRS organizes students from colleges and universities nationwide to conduct data tracking surveys on agricultural and rural development every year. The questionnaires in 2017 were divided into two parts: a questionnaire for farming households and a questionnaire for villages. The questionnaire for farming households contained the contents of respondents' farmland, living environment, water conservancy and irrigation, new industries, governance participation, etc.; while the questionnaire for villages involved infrastructure and public services, village-level economy and public investment, farmland water conservancy and water environment, village governance, poverty and poverty alleviation, etc. In April and May 2017, CIRS recruited at least 900 university students nationwide to participate in the survey activities, and divided them into 150 groups. In June, CIRS offered training for participants in the activities, including the selection of sample points, communication methods, questionnaire explanation, case presentation, etc. From July to September, more than 900 researchers carried out field surveys and collected data across the country. Finally, a total of 17,949 households from 865 villages in 21 provinces were randomly selected as the survey objects.

Agricultural irrigation varies largely across various regions of China. There are generally four irrigation methods: canal irrigation (including reservoirs, lakes, dams, pipelines, artificial reservoirs, etc.); motor-pumped well irrigation (including well digging

by the farming households, collective well digging and drip irrigation); pumping irrigation (for which a water pump is used to pump water from rivers, streams, gully water, and pond water, as well as lifting irrigation, spray irrigation, etc.); natural rain (used for fields without the need for irrigation). Since this research focused on canal irrigation, 3663 households in 17 provinces were finally selected as the research objects.

4.2. Variables

Based on the IAD framework, we selected the relevant variables of rural irrigation collective action in China. The explanatory variables were divided into four types: rules-in-use, biophysical conditions, attributes of community and attributes of household. The classification and definition of these variables are shown in Table 1.

4.2.1. Dependent Variable

According to the existing research literature, rural irrigation collective actions are rich in content, including the supply of rural collective irrigation facilities (such as the construction [40,63,64], investment [7,49,53] and commissioning [65]), the management of rural collective irrigation facilities (such as facility management and protection [4,66,67], performance evaluation of collective farmland irrigation system [68–70] and irrigation management reform [10,27]), and future demand analysis of rural collective irrigation facilities (such as demand willingness) [48,49]. According to the basic theory of economics, exclusivity and competitiveness are two important criteria used to classify the attributes of goods. Canal irrigation is deemed as a common pool resource because of its non-exclusive use and competitive access to resources. These two features define that the problem of collective action exists for canal irrigation, that is, how to overcome the free-riding behavior in the construction and maintenance of canal irrigation facilities. Thus, to measure the degree of rural irrigation collective action, the key is to evaluate the degree of solving the problem of free-riding in common pool resources. Therefore, we selected "the degree of farmer household participation in the preparation and maintenance of irrigation facilities in the village" as a variable to measure the rural irrigation collective action.

4.2.2. Independent Variables

(1) Farmland Scale

The core independent variable is the area of a single plot of farmland. There are two main reasons why we selected the average plot size of the farmland in a household instead of the total area of farmland. First, the variable of the area of a single plot is more applicable to a study of the correlation with policies of farmland tenure stability, farmland tenure transfer, and socialized agricultural services. Farmland tenure transfer and socialized agricultural services are vital to solving the problem of a small area of a single plot. By introducing the variable of the average plot size of the farmland in a household, the correlation can be better found in subsequent studies. Second, the variable of the average plot size of the farmland in a household better reflects the unique phenomenon of farmland fragmentation in China. Farmland fragmentation is usually characterized by small farmland area and a large number of farmland plots. The average plot size of the farmland in a household can be employed to interpret the degree of farmland fragmentation to a certain extent. We also selected the total area of farmland as a variable for further stability testing.

(2) Rules-in-Use

Rules-in-use involve three variables: farmland tenure stability, farmland tenure transfer, and socialized agricultural services. The farmland tenure stability is measured by whether the village has made farmland tenure adjustments in the past ten years. In the case of no adjustments, it indicates that the tenure is relatively stable. Farmland tenure transfer is measured by whether the proportion of the farmland transferred in the whole village accounts for more than 36.97% of the total farmland; in 2017, the farmland tenure transfer

rate averaged 36.97% in China. If it is higher than the national average, this indicates that the local farmland tenure transfer system functions well. Socialized agricultural services are measured by whether farmland trusteeship, joint tillage and planting, and farmland entrusted to individuals is adopted in the village. Socialized agricultural services, especially farmland trusteeship, joint tillage and planting, and farmland entrusted to individuals, are in their infancy. If socialized agricultural services use the above services, it indicates that the system has begun to be promoted locally.

Irrigation facilities are managed in two forms: collective management and individual management. Collective management is more binding than individual management. It features overall planning and standardization in terms of funds and manpower used in the maintenance of irrigation facilities, and thus can motivate smallholders to participate in collective action [71].

The failure of village governance reflects the poor functioning of a village's system and rules of irrigation management. For example, a lack of punitive measures for stealing water is not conducive to the solidarity and cooperation of villagers, making collective action more difficult [15]. Therefore, we selected this index as a key variable to measure the degree of village governance.

(3) Biophysical Conditions

The biophysical conditions mainly include four variables: the distance from the village to the nearest city, the natural conditions of village water resources, the location of farmland in the source of irrigation water and the farmland water scarcity.

There is controversy pertaining to the impact of the distance of the village to the nearest city on collective action. Some scholars believe that the closer the village is to the city, the more opportunities there are for farming households to engage in market activities and withdraw from agriculture, which will reduce the dependence among farming households and is not conducive to promoting collective action [18,72]. However, some scholars argue that the closer the village is to the city, the closer it is to the market, which reduces the cost of communication with the government and the market and makes it easier to meet the needs of farming households, and may therefore enhance collective action capability [73].

The natural conditions of village water resources are mainly used to measure the impact of resource scarcity on collective action. An inverted U-shaped relationship was found between this factor and collective action, that is, in the cases of sufficient water supply and severe water shortage, farming households have no incentive to increase water supply or save water through collective cooperation [15,74].

The location of farmland in the source of irrigation water is mainly used to measure the cost of farming households. In normal cases, the upstream farming households have a stronger incentive to be a free-rider in the irrigation collective action, while the downstream farming households bear more costs in irrigation collective action. Therefore, both are less willing to participate in irrigation collective action, while the farming households whose farmland is in the middle reaches of the canal have a strong willingness to participate in the collective action [18].

Farmland water scarcity is mainly used to measure the resource shortage degree of individual farming households. In the case of farming households, their farmland often has a shortage of irrigation water, which may reduce the possibility of farming households' participation in rural irrigation collective action [52].

(4) Attributes of Community

The group size of the village (number of households) has a certain impact on the rural irrigation collective action, but the impact relationship is uncertain. According to Olson's collective action theory, if a village has a large population, the free-riding problem will lead to the decline of collective action [75]. However, Poteete believes that there exists a certain correlation between group size and other elements, so group size does not have a unilateral relationship with collective action [19].

The higher the collective income of the village is, the higher the investment will be in the construction and maintenance of rural irrigation infrastructure, and the more conducive it is to the cooperation between farming households. According to the Hierarchical Theory of Needs, farming households will pursue higher-level needs only after their basic needs are met. Therefore, the higher the collective income of the village is, the lighter the burden of the villagers, and the easier it is to achieve collective action [76,77].

(5) Attributes of Household

The number of family members is mainly used to measure the supply status of family labor resources. If the number is small, the scarcity of labor resources causes farming households to invest in the fields with relatively high personal benefits in labor distribution, reducing labor input in the construction and maintenance of irrigation facilities [78]. Therefore, a small household size may be detrimental to the success of rural irrigation collective action.

The importance of agricultural income mainly determines farming households' dependence on agriculture. If farming households' agricultural income accounts for a higher proportion of total income, they will be more dependent on farmland and irrigation. Therefore, farming households are more likely to invest more capital and labor in agricultural development, which helps promote collective action among farming households [59].

The education and age of the family head are also key variables that affect the rural irrigation collective action. More educated household heads are more likely to recognize the advantages of obtaining benefits through cooperation, so they are more inclined to participate in collective action [79]. Older household heads are likely to work less frequently in cities and have a single source of income, thus reducing investment in the construction and maintenance of irrigation facilities [80].

(6) Regional Control Variable

We selected "whether the village is in a plain area" as the regional control variable. Plain areas differ greatly from mountainous or hilly areas in terrain, transportation convenience, and the construction and maintenance cost of irrigation facilities; therefore, plain areas can fully reflect the differences between regions.

Based on the IAD framework, we selected the above variables as independent variables. In the impacting factors of rural irrigation collective action, there are also many other variables not mentioned in our analysis, such as the relationship among the participants. Unfortunately, since such questions are not set in our questionnaire, the studies on these variables cannot be added to the econometric analysis. However, the above selected variables can represent rules-in-use, biological conditions, attributes of community and attributes of household. Therefore, although several variables are missing, it does not affect the results, to a large extent, of agricultural scale management and relevant policies on farming households' participation in rural irrigation collective action.

Table 1. Definition of variables.

Variables	Definition
Dependent Variables	
Irrigation collective action	The degree of farmer household participation in the construction and maintenance of irrigation facilities in the village: 1 = never; 2 = seldom; 3 = sometimes; 4 = often; 5 = usually
Independent Variables	
Key variable	
Farmland scale	The average plot size of the farmland in a household (ha)
Rules-in-use	
Farmland tenure stability	Whether the village has made farmland tenure adjustments in the past ten years: 1 = no; 0 = yes
Farmland tenure transfer	Whether the proportion of the farmland transferred in the whole village accounts for more than 36.97% of the total farmland: 1 = yes; 0 = no
Socialized agricultural services	Whether farmland trusteeship, joint tillage and planting, and farmland entrusted to individuals are adopted in the village: 1 = yes; 0 = no

Table 1. *Cont.*

Variables	Definition
Methods of management	Whether collective management is adopted in managing village irrigation facilities: 1 = yes; 0 = no
Governance failure	Whether water disputes often occur in the village: 1 = yes; 0 = no
Biophysical Conditions	
Distance to city	Distance from the village to the nearest city (km)
Village water resources	Abundance of water resources in the village: 1 = medium; 0 = other
Farmland location	Whether the farming household's farmland is located in the middle reaches of the irrigation channel: 1 = yes; 0 = no
Farmland water scarcity	Whether water shortage is severe for farming: 1 = extremely not severe; 2 = not severe; 3 = general; 4 = severe; 5 = very severe
Attributes of Community	
Group size	Number of farming households in the village
Collective income	Village collective income (USD)
Attributes of Household	
Family members	Number of household members
Agricultural income importance	Whether the agricultural income of the farmer household accounts for more than 50%: 1 = yes; 0 = no
Education	Education of family head: 1 = no school; 2 = primary school; 3 = junior high school; 4 = senior high school; 5 = college; 6 = graduate
Age	Age of family head
Regional Control Variable	Whether the village is in a plain area: 1 = yes; 0 = no

4.3. Method

Since the dependent variables are discrete data, the standard regression model cannot be used for empirical research. In this paper, since the data reflecting the irrigation collective action are mainly discrete data, the ideal estimation method is to analyze the problem of discrete choice by using a probabilistic model. Because the dependent variable involves five types of discrete values, the ordered probit model should be used in this paper. An ordered probit model can deal with many kinds of discrete data. It is a method used to study the changing regularity of unobservable latent variables by establishing a model and using observable ordered data. Therefore, the ordered probit method was selected to estimate the impact of farmland scale on farming households' participation in collective action, expressed as follows:

$$\begin{gathered} Y_i^* = X_i\alpha + \varepsilon,\ \varepsilon_i \sim N(0, \sigma^2) \\ Y_i = \begin{cases} 1,\ \text{if } Y_i^* \in (-\infty, \mu_1) \\ 2, \text{if } Y_i^* \in (\mu_1, \mu_2) \\ 3, \text{if } Y_i^* \in (\mu_2, \mu_3) \\ 4, \text{if } Y_i^* \in (\mu_3, \mu_4) \\ 5, \text{if } Y_i^* \in (\mu_4, +\infty) \end{cases} \end{gathered} \tag{1}$$

where Y_i^* represents whether farmer household i participates in the rural irrigation collective action, specifically "the degree to which a farmer household participates in the construction and maintenance of irrigation facilities in the village"; X represents an explanatory variable; α represents the parameter to be estimated; ε represents the random error term; and μ is the threshold. It can be concluded that:

$$\begin{gathered} P(Y_i = 1) = P(Y_i{*} < \mu_1) = \Phi(\mu_1 - x_i\alpha) \\ P(Y_i = 2) = P(\mu_1 \le Y_i{*} < \mu_2) = \Phi(\mu_2 - x_i\alpha) - \Phi(\mu_1 - x_i\alpha) \\ P(Y_i = 3) = P(\mu_2 \le Y_i{*} < \mu_3) = \Phi(\mu_3 - x_i\alpha) - \Phi(\mu_2 - x_i\alpha) \\ P(Y_i = 4) = P(\mu_3 \le Y_i{*} < \mu_4) = \Phi(\mu_4 - x_i\alpha) - \Phi(\mu_3 - x_i\alpha) \\ P(Y_i = 5) = P(\mu_4 \le Y_i{*}) = 1 - \Phi(\mu_4 - x_i\alpha) \end{gathered} \tag{2}$$

where $\Phi(\cdot)$ represents the cumulative density function of the standard normal distribution of ε_i.

5. Results and Discussion

5.1. Results

5.1.1. Descriptive Analysis

Table 2 shows that farming households' participation in rural irrigation collective action averages 3.171, which is at a medium level. The area of a single plot of farmland averages 0.086 ha, which is small and consistent with the overall situation of China's rural farmland.

Table 2. Results of descriptive analysis.

Variables	Mean	Std. Dev.	Min	Max
Irrigation collective action	3.171	1.067	1.000	5.000
Farmland scale	0.086	0.188	0.001	8.533
Farmland tenure stability	0.223	0.417	0.000	1.000
Farmland tenure transfer	0.157	0.364	0.000	1.000
Socialized agricultural services	0.399	0.490	0.000	1.000
Methods of management	0.691	0.462	0.000	1.000
Governance failure	0.066	0.249	0.000	1.000
Distance to city	22.443	15.266	1.000	105.000
Village water resources	0.164	0.371	0.000	1.000
Farmland location	0.212	0.409	0.000	1.000
Farmland water scarcity	2.893	1.150	1.000	5.000
Group size	725.739	652.461	25.000	4687.000
Collective income	9.839	70.996	0.000	752.751
Family members	3.213	1.359	1.000	10.000
Agricultural income	0.571	0.495	0.000	1.000
Education	2.683	0.927	1.000	6.000
Age	52.174	12.851	20.000	105.000
Regional control variable	0.509	0.500	0.000	1.000

In terms of rules-in-use, the farmland tenure stability averages 0.223, indicating that most of the surveyed villages have a relatively stable farmland tenure. The farmland tenure transfer averages 0.157, i.e., the number of farming households whose farmland tenure transfer rate is higher than the national average accounts for only 15.7%. The mode of socialized agricultural services averages 0.399, indicating that nearly 40% of farming households adopted socialized agricultural services for agricultural production. The mode of collective management irrigation facilities averages 0.691, i.e., collective management became the main method of irrigation facilities management in most rural areas. The village governance failure averages 0.066, indicating that the governance in most rural areas is successful.

In terms of biophysical conditions, the distance from the village to the city averages 22.443 km; the village water resource averages 0.164; the farmland location averages 0.212; and the farmland water scarcity averages 2.893, indicating that 30% of the surveyed farming households' farmland is often short on water.

In terms of attributes of community, the group size averaged 726 households, in line with the current average level of the number of households in Chinese villages; the collective income of the village averages USD 98,390, with a large difference between the minimum and maximum values, indicating that rural wealth varies largely in different regions.

In terms of attributes of households, the number of family members averages 3.213, that is, most rural households have three or four members. The importance degree of agricultural income averages 0.571, indicating that more than half of farming households still regard agricultural income as an important source of family income. The educational level of the head of the household averages 2.683, that is, most household heads received junior high school education; and the average age of the household heads was 52.174.

The regional control variable averages 0.509, indicating that, in the selected sample, half of the farming households live in plain areas, and the other half are in mountainous or hilly areas.

5.1.2. Analysis of Direct Effect

First, with Stata software, the ordered Probit model was used to estimate the direct impact of farmland scale on farming households' participation in rural irrigation collective action. The estimated results are shown in Table 3. Model 1 shows the result of the impact of the area of a single plot (independent variable) on farming households' participation in rural irrigation collective action. Model 2 shows the result after adding related variables and control variables, such as farmland tenure stability, farmland tenure transfer, socialized agricultural services and other systems that promote farmland scale management. Model 3 shows the result after the variable of "the average plot size of the farmland in a household" is replaced by "total area of farmland", mainly used to test the stability of the model.

Table 3. Results of direct effect.

Variables	Model 1	Model 2	Model 3
Average plot size of the farmland	0.112 *** (0.020)	0.119 *** (0.024)	
Total area of farmland			0.071 *** (0.024)
Farmland tenure stability		0.085 * (0.047)	0.080 * (0.047)
Farmland tenure transfer		0.188 *** (0.052)	0.155 *** (0.051)
Socialized agricultural services		0.079 * (0.041)	0.089 ** (0.041)
Methods of management		0.130 *** (0.042)	0.157 *** (0.041)
Governance failure		−0.677 *** (0.080)	−0.676 *** (0.080)
Distance to city		0.094 *** (0.026)	0.075 *** (0.026)
Village water resources		0.033 (0.05)	0.027 (0.05)
Farmland location		0.070 (0.044)	0.060 (0.043)
Farmland water scarcity		0.142 *** (0.016)	0.142 *** (0.016)
Group size		−0.016 (0.025)	−0.033 (0.024)
Collective income		0.006 (0.005)	0.007 (0.005)

Table 3. *Cont.*

Variables	Model 1	Model 2	Model 3
Family members		0.009 (0.013)	0.003 (0.013)
Agricultural income		0.159 *** (0.037)	0.158 *** (0.037)
Education		0.018 (0.022)	0.022 (0.022)
Age		−0.005 *** (0.002)	−0.005 *** (0.002)
Regional control variable		−0.050 (0.042)	−0.012 (0.041)
N	3,663	3,663	3,663
Log likelihood	−5296.2932	−5154.7822	−5162.7237
Pseudo R^2	0.0030	0.0296	0.0281
P	0.0000	0.0000	0.0000

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

It can be seen, from the result of Model 1, that the farmland area has a significant positive effect on farming households' participation in rural irrigation collective action. This is significant at the level of 1%. That is, as the average farmland area of farming households increase, the incentive of farming households to participate in rural irrigation collective action becomes stronger. This research result is the same as those of previous scholars, revealing that, despite the small area of farmland per household in rural China, there remains a positive relationship between farmland resources and collective action.

After adding the related system variables and all the control variables that promote farmland scale management, such as the farmland tenure stability, farmland tenure transfer and socialized agricultural services, Model 2 shows that there remains a significant positive relationship between farmland scale and farming households' participation in rural irrigation collective action. In addition, the results of the three variables that measure the institutional factors also display their positive impact on farming households' participation in rural irrigation collective action. Specifically, farmland tenure stability has a significant impact on farming households' participation in rural irrigation collective action at the level of 10%, that is, the more stable the farmland tenure, the more motivated farming households are to participate in rural irrigation collective action. The degree of farmland tenure transfer has a significant impact on farming households' participation in rural irrigation collective action at the level of 1%, that is, the higher the degree of village farmland tenure transfer, the stronger the ability of farming households to participate in rural irrigation collective action. The utilization degree of socialized agricultural services has a significant impact on farming households' participation in rural irrigation collective action at the level of 10%, that is, the higher the utilization degree of socialized agricultural services, the stronger the ability of farming households to participate in rural irrigation collective action.

In terms of control variables, distance from village to city, village water resources, methods of management and agricultural income importance have a significant positive impact on farming households' participation in rural irrigation collective action, while village governance failure and age of household head have a negative effect, and other factors have no significant effect.

Model 3 tests the stability of the variable "farmland scale", namely, the measurement result after replacing the variable "the average plot size of the farmland" with "total area of farmland." The results show that the total area of farmland has a significant positive effect on rural irrigation collective action, being significant at the 1% level. In terms of control variables, the influence direction and significance degree of all control variables are the

same as the results of Model 2. This fully demonstrates the stable influence of farmland scale on farming households' participation in rural irrigation collective action.

5.1.3. Analysis of Moderating Effect

Aside from paying attention to the direct effect of farmland scale on farming households' participation in rural irrigation collective action, this paper also focuses on the role of three institutions and rules promoting farmland scale management, namely farmland tenure stability, farmland tenure transfer and socialized agricultural services and their influence on farming households' participation in rural irrigation collective action. For this, this paper added the cross terms between the above three factors and the farmland scale into the models, so as to verify whether there was a moderating effect relationship between the three different institutional factors. Table 4 shows the measurement results. Model 4, Model 5 and Model 6 reflect the results after separately adding the cross terms of the farmland tenure stability, farmland tenure transfer, socialized agricultural services and the farmland scale, respectively. Model 7 shows the result after adding the three cross terms simultaneously.

Table 4. Results of moderating effect.

Variables	Model 4	Model 5	Model 6	Model 7
Farmland scale	0.078 *** (0.026)	0.058 ** (0.027)	0.173 *** (0.029)	0.062 * (0.034)
Farmland tenure stability	0.774 *** (0.184)	0.067 (0.047)	0.075 (0.047)	0.721 *** (0.184)
Farmland tenure transfer	0.179 *** (0.052)	1.198 *** (0.190)	0.187 *** (0.052)	1.101 *** (0.193)
Socialized agricultural services	0.081 ** (0.041)	0.100 ** (0.041)	−0.382 *** (0.136)	−0.221 (0.139)
Methods of management	0.145 *** (0.042)	0.144 *** (0.042)	0.146 *** (0.042)	0.168 *** (0.043)
Governance failure	−0.669 *** (0.080)	−0.720 *** (0.080)	−0.696 *** (0.008)	−0.721 *** (0.080)
Distance to city	0.102 *** (0.027)	0.081 *** (0.027)	0.109 *** (0.027)	0.100 *** (0.027)
Village water resources	0.025 (0.051)	0.042 (0.051)	0.022 (0.051)	0.026 (0.051)
Farmland location	0.068 (0.044)	0.057 (0.044)	0.058 (0.044)	0.048 (0.044)
Farmland water scarcity	0.147 *** (0.016)	0.143 *** (0.016)	0.140 *** (0.016)	0.147 *** (0.016)
Group size	−0.022 (0.025)	−0.021 (0.025)	−0.022 (0.025)	−0.030 (0.025)
Collective income	0.007 (0.005)	0.004 (0.005)	0.004 (0.005)	0.003 (0.005)
Family members	0.006 (0.013)	0.008 (0.013)	0.008 (0.013)	0.005 (0.013)
Agricultural income	0.163 *** (0.037)	0.166 *** (0.037)	0.163 *** (0.037)	0.171 *** (0.037)

Table 4. *Cont.*

Variables	Model 4	Model 5	Model 6	Model 7
Education	0.016 (0.022)	0.013 (0.022)	0.018 (0.022)	0.012 (0.022)
Age	−0.005 *** (0.002)	−0.005 *** (0.002)	−0.005 *** (0.002)	−0.005 *** (0.002)
Regional control variable	−0.036 (0.042)	−0.040 (0.042)	−0.043 (0.042)	−0.022 (0.043)
N	3,663	3,663	3,663	3,663
Log likelihood	−5147.2324	−5139.3905	−5148.4988	−5129.1424
Pseudo R^2	0.0310	0.0325	0.0308	0.0344
P	0.0000	0.0000	0.0000	0.0000

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

It can be seen from Model 4 that, with other variables controlled, after adding the cross terms of farmland scale and farmland tenure stability, the impact of farmland scale on farming households' participation in rural irrigation collective action is significant at the 1% level, and the cross term is also significant at the 1% level. This fully shows that farmland tenure stability has a positive moderating effect on the impact of farmland scale on farming households' participation in rural irrigation collective action, that is, the stronger the tenure stability is, the more motivated farming households become to participate in rural irrigation collective action.

The result of Model 5 shows that, after adding the control variables, the two variables of the farmland scale, namely the cross term of farmland scale and farmland transfer system, are significant at the levels of 5% and 1%, respectively. This indicates that the farmland tenure transfer policy has a positive moderating effect on the impact of farmland scale on farming households' participation in rural irrigation collective action, that is, the higher the farmland tenure transfer rate, the more motivated are farming households, with larger land areas to participate in rural irrigation collective action.

Differing from the results of Model 4 and Model 5, the result of Model 6 shows that after adding the cross terms of farmland scale and farming households' participation in socialized agricultural services, the variable of farmland scale is significant at the 1% level and shows a positive relationship, but the cross term of farmland scale and farming households' participation in social services is significant at the 1% level and shows a negative relationship. This shows that, although the larger the scale of farmland, the stronger the motivation of farming households to participate in rural irrigation collective action. If socialized agricultural services are promoted at a high level, the positive impact of the scale of farmland on farming households' participation in rural irrigation collective action can be reduced.

5.2. Discussion

5.2.1. Farmland Tenure Stability and Irrigation Collective Action

In the context of stable farmland tenure, the expansion of the farmland scale is conducive to the success of rural irrigation collective action. Fundamentally, the stability of farmland tenure can enhance the expected income of agricultural production and encourage farming households to increase their investment in agricultural production [81]. The key to the impact of farmland tenure stability on agricultural production investment lies in whether the farmland tenure stability has significant incentives for farming households' productive investment. Clearly, the incentive of farmland tenure on farming households' investment is influenced by many factors such as the historical dynamic process, the effect of individual differences, and the interaction of various policies [82]. In terms of specific reasons, stable farmland tenure can regulate the relationship between farmland scale and rural irrigation collective action for two main reasons.

The first reason is that stable farmland tenure can increase farming households' investment in production [83], especially stimulating their willingness toward long-term investment in agricultural production facilities [84]. Agricultural irrigation facilities are public goods requiring long-term investment. They feature a long investment time, a large level of investment and a slow return cycle, due to which the construction and maintenance of rural irrigation facilities must be primarily invested in by groups engaged in agricultural production and management in the long term. Therefore, in the context of farmland policy emphasizing stable farmland tenure, with the expansion of farmland scale, farming households can be stimulated to participate in the construction and maintenance of rural public irrigation facilities through collective action.

The second reason is that stable farmland tenure is conducive to reducing the free-riding behaviors of farming households participating in rural irrigation collective action. In the process of agricultural production, in the case of too many adjustments to the farmland tenure, free-riding behavior frequently occurs, which leads to a decline in the level of farming households' cooperation in supplying goods [85]. Stable farmland tenure can help reduce free-riding behavior, especially with the scale expansion of farmland. The standardization and clarification of the tenure transaction process help reduce the occurrence of unstable factors and ensure that farming households reach agreements in collective action in the construction and maintenance of rural public irrigation facilities.

5.2.2. Farmland Tenure Transfer and Irrigation Collective Action

Farmland tenure transfer is a key factor for adjusting the farmland scale and rural irrigation collective action and can significantly promote its success. The reasons why farmland tenure transfer can show a significant moderating effect between the two are summarized below.

First, farmland tenure transfer greatly optimized the reasonable allocation of farmland resources. China is fundamentally "a large country with a large population of smallholders". For example, the area of a single plot of a farming household in this study averages a mere 0.086 ha. In this case, the promotion of a farmland transfer policy can boost the orderly transfer of the farmland tenure, so as to realize farmland scale management. Farmland tenure transfer facilitates the flow of farmland resources between agricultural producers and operators. With the scale expansion of the farmland of farming households, in order to further improve the farmland utilization rate and input–output efficiency, agricultural producers and operators made increasingly reasonable plans concerning the utilization of farmland [86], and gradually realized an optimal allocation in the construction of farmland irrigation infrastructure. Therefore, with respect to rural public irrigation facilities, orderly farmland tenure transfer also helps foster agreement among farming households regarding irrigation collective action.

Second, farmland tenure transfer can lead to more capital flow into agricultural production. With the continuously improved farmland tenure transfer policy, the farmland tenure transfer market system is gradually established to standardize the whole farmland tenure transaction market and help to promote the transfer of social funds to agricultural production [87]. With the scale expansion of farmland, the demand for construction and maintenance of irrigation facilities, the most basic infrastructure for agricultural production, further increases. Therefore, the capital brought by the development of the farmland tenure transfer market helps promote the formation of rural irrigation collective action.

Third, the promotion of new technologies and new varieties brought by farmland tenure transfer can indirectly increase the demand for the construction and maintenance of irrigation and other infrastructure. With the continuous advancement of farmland tenure transfer, the farmland area of farming households for agricultural production is expanding, and new technologies and new varieties of agricultural production are being promoted, providing a sound platform for the development and promotion of high-efficiency cash crops [88]. In light of the widespread application of these technologies or varieties, higher

requirements for agricultural irrigation facilities and other basic conditions are bound to emerge, and thus indirectly promote the benefits of collective irrigation facilities.

5.2.3. Socialized Agricultural Services and Irrigation Collective Action

Although socialized agricultural services can greatly promote the realization of agricultural economies of scale, research reveals that, in the process of farmland scale affecting the rural irrigation collective action, socialized agricultural services significantly reduce the positive impact of farmland scale. It is found through analysis that the main reasons for this are the following.

First of all, socialized agricultural services led to a change of the supplier and the user of public goods, which, to some extent, reduced the motivation of farming households to participate in irrigation collective action. The nature of socialized agricultural services lies in the division of the labor system and the market system reconstruction of agriculture. With the improvement of agricultural productivity and the commercialization of agricultural products, agricultural production links that used to be directly undertaken by farming households diverged from the agricultural production process indifferent forms, such as farmland trusteeship, joint tillage and planting, and farmland entrusted to individuals [89,90]. After farming households purchase socialized agricultural services, they only need to focus on the results after purchasing, and the services are fully provided by the service provider. In terms of socialized agricultural services, the main supplier of public irrigation facilities changed from farming households to providers of socialized services; hence, the introduction of socialized agricultural services leads to a decline in farming households' ability to participate in collective action.

Second, households with a small farmland area are more dependent on socialized agricultural services. In case of a small farmland area, farming households devote more energy to non-agricultural industries with higher returns. In order to avoid the abandonment of farmland and alleviate the shortage of family labor, most farming households with small farmland seek socialized agricultural services for agricultural production [91]. Since the construction and maintenance of rural public irrigation facilities are long-term, while the socialized agricultural services purchased by smallholders are short-term, it is difficult to rely on socialized service subjects for the construction and maintenance of public irrigation facilities; thus, the introduction of socialized agricultural services reduces the enthusiasm of farming households to participate in rural irrigation collective action. In addition, with the scale expansion of farmland, farming households will focus more on the cost-saving and efficiency-increasing effects of socialized agricultural services; that is, with the increase in the specialization, scale, and commercialization in the process of socialized agricultural services, farming households will pay more attention to economic benefits, which increase the demand for socialized agricultural services and further aggravates the difficulty for farming households to participate in irrigation collective action [92].

Third, market-oriented socialized agricultural services have weakened the extent to which farming households participate in the supply of rural public irrigation facilities. According to the survey results, the supply of rural public goods is principally undertaken by non-profit social service entities such as cooperatives, and it is difficult to rely on for-profit social service entities such as enterprises, family farms, professional large households, and specialized social service organizations for the effective supplying of goods [93]. With the scale expansion of the farmland of farming households, the demand for public irrigation facilities has gradually increased, but there is no effective motivation for market-oriented socialized service subjects to invest in the construction of rural public facilities [94]. Therefore, with the increase in the scale of household land, socialized agricultural services have further aggravated the contradiction between the supply and demand of public irrigation facilities, resulting in a further reduction in the motivation of farming households to participate in rural irrigation collective action.

6. Conclusions

This paper takes rural irrigation collective action as the research object, and by constructing an IAD framework in the context of a farmland system with Chinese characteristics, it studies the impact of farmland scale on rural collective action in China, and further analyzes the main role of farmland systems (farmland tenure stability, farmland tenure transfer and socialized agricultural services) that promote farmland scale management. The major findings are shown as below: first, China is fundamentally "a large country with a large population of smallholders". Considering the context of China's scale of farmland being much lower than the world average, as the scale of farmland expands, the advantages of collective action, such as reduced production costs, enhanced risk resistance and improved production efficiency, can completely offset the disadvantages incurred by free-riding. Therefore, the scale expansion of farming households' farmland in China's rural areas can significantly propel the success of rural collective action. Second, with the scale expansion of farming households' farmland, stable farmland tenure plays a significant role in promoting rural collective action because of its advantages of increasing investment in the supply of rural public goods and reducing free-riding behavior in collective action. Third, the farmland tenure transfer policy can continuously optimize the reasonable allocation of farmland resources and guide the investment of funds into the rural public infrastructure. These advantages can significantly encourage farming households to actively participate in rural collective action. Fourth, the impact of socialized agricultural services is different from that of the above factors. As socialized agricultural services have led to the supplier–user separation of rural public goods, and the market-oriented operation has weakened the supply of rural public goods, with the scale expansion of farmland, socialized agricultural services have shown a negative effect.

In general, the dilemma of rural collective action is an important problem faced by many countries in the world, and agricultural scale management is also an inevitable trend in developing countries. Taking China as an example, this study, which focused on rural collective action in the context of agricultural scale management, is conducive to solving the common problems faced by developing countries in governing the rural commons. This paper studies rural collective action by taking the irrigation system as an example, and its conclusion is also applicable to the solution for the collective action dilemma in other fields of agricultural production, such as farmland road supply. This paper is enlightening and greatly significant for the policy formulation of agricultural scale management and rural public governance, especially for the policies on the provision of rural public goods through collective action in agricultural production.

On the one hand, for rural areas with a relatively small scale of farmland, the first priority is to stabilize the farmland tenure. Especially in the context of the continuous migration of rural population to cities, a stable farmland tenure adjustment mechanism should be established to protect the basic interests of farming households and fundamentally enhance farming households' confidence in the investment and construction of public infrastructure in the field of rural production. It is then possible to improve the degree of farming households' participation in rural collective action and provide a good basis and optimum conditions for the governance of the commons in rural areas.

On the other hand, in promoting farmland tenure transfer and socialized agricultural services, it is necessary to measure the balance between the two in promoting rural collective action. With respect to farmland tenure transfer, farmland scale management is further realized by expanding the scale of farmland, which can provide more incentives for the construction of public infrastructure in agricultural production. Therefore, it is necessary to further improve the farmland tenure transfer market and continuously promote the positive role of farmland tenure transfer in rural collective action. However, socialized agricultural services promote the farmland scale management from the perspective of service. Although these services greatly improve the agricultural production efficiency, a great weakness is exposed in the effective organization of farming households for participating in the provision of the rural public infrastructure in the fields of agricultural production.

Therefore, in the future policy formulation, when it comes to promoting the development of socialized agricultural service organizations, the responsibilities and obligations of the socialized services provider in the supply of rural public goods should be clarified to ensure the effective supply of rural public goods in promoting farmland scale management.

In addition, under the conditions of agricultural production with small farmland scales, farming households should actively use the policy advantages of the farmland tenure transfer policy to realize agricultural scale management and reduce the cost of supplying rural public goods by using the scale effect. Furthermore, in the process of using socialized agricultural services, farming households should not only pay attention to their own interests, but also to the supply of public infrastructure by the supplier of socialized agricultural services, focusing on the importance of public infrastructure in agricultural production from a long-term perspective.

This research also has certain limitations. For example, the research method can be improved to study the intermediate mechanism, especially the complex relationships among farmers, which could play an important role in the impact of agricultural scale management on rural collective action. In addition, it was not considered whether different agricultural scale management policies had U-shaped or inverted U-shaped relationships with rural collective action, and the impact of different types of socialized agricultural services on collective action in rural areas were not examined. However, this article makes a preliminary judgment on the relationship between agricultural scale management and rural collective action, and the above problems can be fixed in the future.

Author Contributions: Conceptualization, L.Z. and Y.W.; methodology, L.Z. and Y.S.; formal analysis, L.Z. and Y.S.; resources, L.Z. and Y.W.; writing—original draft preparation, L.Z. and Y.S.; writing—review and editing, Y.W. and Y.S.; supervision, Y.W.; project administration, Y.W.; funding acquisition, L.Z. and Y.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Natural Science Foundation of China, grant numbers 71573151 and 71721002; the National High-end Think-tank Project of Tsinghua University, grant number 2020ZZBF0112; the Fundamental Research Funds for the Central Public Interest Scientific Institute of China, grant number 161005202118; the Major Statistical Program of the China National Bureau of Statistics, grant number 2021ZX13; and the Agricultural Science and Technology Innovation Program of China, grant number ASTIP-IAED-2021-08.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author. The data are not publicly available due to the national law on the restriction of privacy.

Acknowledgments: The authors would like to thank the editors and anonymous reviewers. Special gratitude is given to the students and peasants who took part in the Hundred Villages and Thousand Households survey organized by the China Institute for Rural Studies of Tsinghua University for providing us the data.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Gebremedhin, B.; Pender, J.; Tesfay, G. Collective action for grazing land management in crop–livestock mixed systems in the highlands of northern Ethiopia. *Agric. Syst.* **2004**, *82*, 273–290. [CrossRef]
2. Gong, Y.; Tan, R. Emergence of local collective action for land adjustment in land consolidation in China: An archetype analysis. *Landsc. Urban Plan.* **2021**, *214*, 104160. [CrossRef]
3. Mirra, L.; de Gennaro, B.C.; Giannoccaro, G. Farmer evaluation of irrigation services. Collective or self-supplied? *Land* **2021**, *10*, 415. [CrossRef]
4. Takayama, T.; Matsuda, H.; Nakatani, T. The determinants of collective action in irrigation management systems: Evidence from rural communities in Japan. *Agric. Water Manag.* **2018**, *206*, 113–123. [CrossRef]
5. Shrestha, D.; Brown, J.F.; Benedict, T.D.; Howard, D.M. Exploring the regional dynamics of U.S. irrigated agriculture from 2002 to 2017. *Land* **2021**, *10*, 394. [CrossRef]
6. Wang, Y.; Gao, R.; Meng, Q. Crisis and response of Chinese rural public affair governance. *J. Tsinghua Univ. Philos. Soc. Sci.* **2016**, *31*, 23–29.

7. Cai, Q.; Zhu, Y. The influence of relational networks on farmers' participation in village collective action: Based on farmers' participation in the investment of small irrigation system. *J. Nanjing Agri. Univ. Soc. Sci. Ed.* **2017**, *17*, 108–118.
8. Qiao, D.; Lu, Q.; Xu, T. Analysis on influencing factors of cooperative supply willingness of rural small water conservancy facilities: Based on multi group structural equation model. *Rural Econ.* **2016**, *3*, 99–104.
9. Zhou, Y.; Li, X.; Liu, Y. Rural land system reforms in China: History, issues, measures and prospects. *Land Use Policy* **2020**, *91*, 104330. [CrossRef]
10. Xu, L.; Luo, D.; Liu, A. Effects of social capital on farmers' willingness to participate in irrigation management reform. *Resour. Sci.* **2015**, *37*, 1287–1294.
11. Wang, C.; Siriwardana, M.; Meng, S. Effects of the Chinese arable land fallow system and land-use change on agricultural production and on the economy. *Econ. Model.* **2019**, *79*, 186–197. [CrossRef]
12. Gao, J.; Liu, Y.; Chen, J. China's initiatives towards rural land system reform. *Land Use Policy* **2020**, *94*, 104567. [CrossRef]
13. Wang, Y. Diagnosing the complex situation in social ecological system: Understanding the self-governance in old China's irrigation. *J. Tsinghua Univ. Philos. Soc. Sci.* **2018**, *33*, 178–191.
14. Cao, Y.; Zhang, X.; He, L. Collective Action in maintaining rural infrastructures: Cadre-farmer relationship, institution rules and their interaction terms. *Land Use Policy* **2020**, *99*, 105043. [CrossRef]
15. Araral, E. What explains collective action in the commons? Theory and evidence from the Philippines. *World Dev.* **2009**, *37*, 687–697. [CrossRef]
16. Agrawal, A. Common property institutions and sustainable governance of resources. *World Dev.* **2001**, *29*, 1649–1672. [CrossRef]
17. Ippolito, T.A.; Herrick, J.E.; Dossa, E.L.; Garba, M.; Ouattara, M.; Singh, U.; Stewart, Z.P.; Prasad, P.V.V.; Oumarou, I.A.; Neff, J.C. A comparison of approaches to regional land-use capability analysis for agricultural land-planning. *Land* **2021**, *10*, 458. [CrossRef]
18. Meinzen-Dick, R.; Raju, K.V.; Gulati, A. What affects organization and collective action for managing resources? Evidence from canal irrigation systems in India. *World Dev.* **2002**, *30*, 649–666. [CrossRef]
19. Poteete, A.R.; Ostrom, E. Heterogeneity, group size and collective action: The role of institutions in forest management. *Dev. Chang.* **2004**, *35*, 435–461. [CrossRef]
20. Agrawal, A.; Gibson, C.C. Enchantment and disenchantment: The role of community in natural resource conservation. *World Dev.* **1999**, *27*, 629–649. [CrossRef]
21. Ostrom, E.; Calvert, R.; Eggertsson, T. Governing the commons the evolution of institutions for collective action. *Am. Polit. Sci. Rev.* **1993**, *86*, 249–279.
22. Bjornlund, H.; Zuo, A.; Wheeler, S.A.; Parry, K.; Pittock, J.; Mdemu, M.; Moyo, M. The dynamics of the relationship between household decision-making and farm household income in small-scale irrigation schemes in southern Africa. *Agric. Water Manag.* **2019**, *213*, 135–145. [CrossRef]
23. Manjunatha, A.V.; Anik, A.R.; Speelman, S.; Nuppenau, E.A. Impact of land fragmentation, farm size, land ownership and crop diversity on profit and efficiency of irrigated farms in India. *Land Use Policy* **2013**, *31*, 397–405. [CrossRef]
24. Mao, M.; Zhang, H. An analysis of the influence factors of farmers' participation willingness to small irrigation system's constructing and management: Based on 3552 questionnaire samples' data from 21 provinces. *Chin. Rural Water Hydropower* **2016**, *10*, 44–48.
25. Wang, X.; Lu, Q. Empractical analysis of willingness to cooperative supply of small water conservancy facilities in rural community. *Chin. Popul. Resour. Environ.* **2012**, *22*, 115–119.
26. Zhang, H. Factors affecting farmers' willingness to participate in construction and management of small irrigation and water conservancy: Based on 3552 questionnaires of 21 provinces in China. *Acta Agric. Jiangxi* **2016**, *28*, 114–119.
27. Zhao, L.; Shi, J. Factors influencing the peasant household's willingness to participate in irrigation management reform: Based on the survey of farmers in Inner Mongolia. *J. Arid Land Resour. Environ.* **2014**, *28*, 20–26.
28. Yuan, J. An empirical analysis of farmers' willingness to participate in the management and protection of small farmland water conservancy facilities. *Water Res. Dev. Res.* **2016**, *4*, 21–27.
29. Luo, X. Peasant household's willingness to participate construction of agricultural infrastructure and influencing factors: Based on the survey data of 556 peasant households in Hubei Province. *J. Zhongnan Univ. Econ. Law* **2012**, *192*, 29–34.
30. Liu, B.; Lu, Q. Farmer willingness for small-scale irrigation facilities in Jingyang County. *Resour. Sci.* **2013**, *35*, 1159–1166.
31. Zhou, L.; Su, H.; Deng, Q. An empirical analysis of farmers' willingness to participate in irrigation management: Based on the survey of farmers in Jiangxi Province. *Jiangxi Soc. Sci.* **2014**, *34*, 215–219.
32. Zang, L.; Araral, E.; Wang, Y. Effects of land fragmentation on the governance of the commons: Theory and evidence from 284 villages and 17 provinces in China. *Land Use Policy* **2019**, *82*, 518–527. [CrossRef]
33. Rosegrant, M.W. The impact of irrigation on production and income variability: Simulation of diversion irrigation in the Philippines. *Agric. Syst.* **1992**, *40*, 283–302. [CrossRef]
34. Bobojonov, I.; Berg, E.; Franz-Vasdeki, J.; Martius, C.; Lamers, J.P.A. Income and irrigation water use efficiency under climate change: An application of spatial stochastic crop and water allocation model to Western Uzbekistan. *Clim. Risk Manag.* **2016**, *13*, 19–30. [CrossRef]
35. Cai, R.; Cai, S. Village scale, income inequality and collective action: An empirical analysis of 102 irrigated villages in Anhui Province. *Econ. Rev.* **2014**, *185*, 48–57.

36. Cai, R.; Ma, W.; Guo, X. Farmer willingness towards micro irrigation facilities management during irrigation canal reconstruction. *Res. Sci.* **2014**, *36*, 2594–2603.
37. Kung, J.K. Transaction costs and peasants′ choice of institutions: Did the right to exit really solve the free rider problem in Chinese collective agriculture. *J. Comp. Econ.* **1993**, *17*, 485–503. [CrossRef]
38. Adhikari, B.; Lovett, J.C. Institutions and collective action: Does heterogeneity matter in community-based resource management? *J. Dev. Stud.* **2006**, *42*, 426–445. [CrossRef]
39. Janssen, M.A.; Anderies, J.M. A multi-method approach to study robustness of social-ecological systems: The case of small-scale irrigation systems. *J. Inst. Econ.* **2013**, *9*, 427–447. [CrossRef]
40. Cai, R.; Cai, S. Rice farmers' attitudes towards farmland irrigation facilities in Anhui Province. *Resour. Sci.* **2013**, *35*, 1661–1667.
41. Wang, G.; Lu, Q. The paradox between willingness and behavior: Factors influencing farmers' willingness to cooperation and real payment behavior on small-scale irrigation facilities in rural communities. *J. Huazhong Univ. Sci. Technol. Soc. Sci. Ed.* **2013**, *27*, 68–75.
42. Hosni, H.; El-gafy, I.K.; Ibrahim, A.H.; Abowarda, A.S. Maximizing the economic value of irrigation water and achieving self sufficiency of main crops. *Ain Shams Eng. J.* **2014**, *5*, 1005–1017. [CrossRef]
43. Jordan, C.; Donoso, G.; Speelman, S. Measuring the effect of improved irrigation technologies on irrigated agriculture. A study case in Central Chile. *Agric. Water Manag.* **2021**, *257*, 107160. [CrossRef]
44. Miao, S. Farmers' small-scale irrigation facilities participative behavior under multi-dimensional social capital perspective. *Chin. Popul. Resour. Environ.* **2014**, *24*, 46–54.
45. Gao, X.; Tan, Z.; Yang, S. An empirical analysis on farmer households' willingness to participate in the small-scale irrigation and water conservancy construction: Based on a survey on farmers in Jiangxi Province. *Chin. Rural Water Hydropower* **2015**, *12*, 53–56.
46. Cai, Q.; Zhu, Y. Influence of social capital and income inequality on village collective action: Based on farmers' participation in the maintenance of small irrigation systems in three provinces. *J. Public Manag.* **2016**, *13*, 89–100.
47. Huang, L.; Zhu, Y. Study on the impact of heterogeneity on farmers' participation in village collective action: Taking the construction of small farmland and water conservancy facilities as an example. *J. Agro-Tech. Econ.* **2017**, *11*, 61–71.
48. Xu, L.; Liu, T.; Yang, J. Study on demand and influencing factors of small farmland water conservancy facilities: A case study of Rudong County, Jiangsu Province. *Chin. Rural Water Hydropower* **2014**, *7*, 10–13.
49. Dong, H.; He, Z.; Wang, H. Farmers' demand to agricultural rural small water conservancy and influence factors of investment: Based on 120 farmers research in Boluo County. *Guangdong Agric. Sci.* **2013**, *40*, 220–223.
50. Zhu, H.; Weng, Z.; Kang, L. Theoretical and empirical analysis of the factors influencing the willingness of farmers' participation in construction of water conservancy works: Based on the survey of 619 major rice-planting farmers in Jiangxi Province. *J. Nat. Resour.* **2010**, *25*, 539–546.
51. Panagopoulos, Y.; Makropoulos, C.; Gkiokas, A.; Kossidaa, M.; Evangelou, L.; Lourmas, G.; Michas, S.; Tsadilas, C.; Papageorgiou, S.; Perleros, V.; et al. Assessing the cost-effectiveness of irrigation water management practices in water stressed agricultural catchments The case of Pinios. *Agric. Water Manag.* **2014**, *139*, 31–42. [CrossRef]
52. Nakano, Y.; Otsuka, K. Determinants of household contributions to collective irrigation management: The case of the Doho Rice Scheme in Uganda. *Environ. Dev. Econ.* **2011**, *16*, 527–551. [CrossRef]
53. Perez-Quesada, G.; Hendricks, N.P. Lessons from local governance and collective action efforts to manage irrigation withdrawals in Kansas. *Agric. Water Manag.* **2021**, *247*, 106736. [CrossRef]
54. King, R.; Burton, S. Land fragmentation: Notes on a fundamental rural social problem. *Prog. Hum. Geog.* **1982**, *6*, 475–494. [CrossRef]
55. Sabates-Wheeler, R. Farm strategy, self-selection and productivity: Can small farming groups offer production benefits to farmers in post-socialist Romania? *World Dev.* **2002**, *30*, 1737–1753. [CrossRef]
56. Sklenicka, P.; Janovska, V.; Salek, M.; Vlasak, J.; Molnarova, K. The farmland rental paradox: Extreme land ownership fragmentation as a new form of land degradation. *Land Use Policy* **2014**, *38*, 587–593. [CrossRef]
57. Ye, C.; Xu, Q.; Xu, Z. Land fragmentation: Historical and economics analysis. *Issues Agric. Econ.* **2008**, *9*, 9–15.
58. Lv, X.; Huang, X.; Zhong, T.; Zhao, Y. Review on the research of farmland fragmentation in China. *J. Nat. Resour.* **2011**, *26*, 530–539.
59. Wang, Y.; Zang, L.; Araral, E. The impacts of land fragmentation on irrigation collective action: Empirical test of the social-ecological system framework in China. *J. Rural Stud.* **2020**, *78*, 234–244. [CrossRef]
60. Su, Y.; Araral, E.; Wang, Y. The effects of farmland use rights trading and labor outmigration on the governance of the irrigation commons: Evidence from China. *Land Use Policy* **2020**, *91*, 104378. [CrossRef]
61. Ostrom, E. *Understanding Institutional Diversity*; Princeton University Press: Princeton, NJ, USA, 2005.
62. Ostrom, E. Background on the institutional analysis and development framework. *Policy Stud. J.* **2011**, *39*, 7–27. [CrossRef]
63. Nagrah, A.; Chaudhry, A.M.; Giordano, M. Collective action in decentralized irrigation systems: Evidence from Pakistan. *World Dev.* **2016**, *84*, 282–298. [CrossRef]
64. García-Mollá, M.; Ortega-Reig, M.; Boelens, R.; Sanchis-Ibor, C. Hybridizing the commons. Privatizing and outsourcing collective irrigation management after technological change in Spain. *World Dev.* **2020**, *132*, 104983. [CrossRef]
65. Wang, B.; Wan, J.; Zhu, Y. Analysis of the influence of institutional capacity on farmers' cooperative supply of farmland irrigation system: Based on survey data from 6 provinces in the Yellow River Irrigation District. *J. Agro-Tech. Econ.* **2020**, *2*, 32–44.

66. Theesfeld, I. Constraints on collective action in a transitional economy: The case of Bulgaria's irrigation sector. *World Dev.* **2004**, *32*, 251–271. [CrossRef]
67. Yuan, J.; Du, W. Influence factors for peasant households' behaviors to participate in management of small-scale irrigation facilities based on investigation of farmers in Fangcheng County of Henan Province. *J. Econ. Water Resour.* **2016**, *34*, 69–74.
68. Chaudhry, A.M. Improving on-farm water use efficiency: Role of collective action in irrigation management. *Water Resour. Econ.* **2018**, *22*, 4–18. [CrossRef]
69. Mushtaq, S.; Dawe, D.; Lin, H.; Moya, P. An assessment of collective action for pond management in Zhanghe Irrigation System (ZIS), China. *Agric. Syst.* **2007**, *92*, 140–156. [CrossRef]
70. Wang, B.; Wang, H.; Zhu, Y. Influence of institutional capacity on the governance performance of irrigation systems: A study based on the survey data from six provinces of Yellow River Irrigation Area. *Chin. Popul. Resour. Environ.* **2019**, *29*, 122–129.
71. Wang, Y.; Zang, L. Logic of collective action for small-scale peasant. *Issues Agri. Econ.* **2020**, *1*, 59–67.
72. Mattoussi, W.; Seabright, P. Cooperation against theft: A test of incentives for water management In Tunisia. *Am. J. Agric. Econ.* **2014**, *96*, 124–153. [CrossRef]
73. Wang, Y.; Chen, S.; Araral, E. The mediated effects of urban proximity on collective action in the commons: Theory and evidence from China. *World Dev.* **2021**, *142*, 105444. [CrossRef]
74. Zewdie, M.C.; Moretti, M.; Tenessa, D.B.; Ayele, Z.A.; Nyssen, J.; Tsegaye, E.A.; Minale, A.S.; Van Passel, S. Agricultural technical efficiency of smallholder farmers in Ethiopia: A stochastic frontier approach. *Land* **2021**, *10*, 246. [CrossRef]
75. Olson, M., Jr. *Logic of Collective Action: Public Goods and the Theory of Groups*; Harvard University Press: Boston, MA, USA, 1965.
76. Bardhan, P. Irrigation and cooperation: An empirical analysis of 48 irrigation communities in South India. *Econ. Dev. Cult. Chang.* **2000**, *48*, 847–865. [CrossRef]
77. Ito, J. Collective action for local commons management in rural Yunnan, China: Empirical evidence and hypotheses using evolutionary game theory. *Land Econ.* **2012**, *88*, 181–200. [CrossRef]
78. Khalkheili, T.A.; Zamani, G.H. Farmer participation in irrigation management: The case of Doroodzan Dam Irrigation Network, Iran. *Agric. Water Manag.* **2009**, *96*, 859–865. [CrossRef]
79. Zarafshani, K.; Alibaygi, A.H.; Afshar, N. The utility of discriminant analysis for predicting farmers' intentions to participate in farmer-managed irrigation systems in Iran. *J. Appl. Sci.* **2008**, *8*, 697–701. [CrossRef]
80. Fujiie, M.; Hayami, Y.; Kikuchi, M. The conditions of collective action for local commons management: The case of irrigation in the Philippines. *Agric. Econ-Blackwell* **2005**, *33*, 179–189. [CrossRef]
81. Atwood, D.A. Land registration in Africa the impact on agricultural production. *World Dev.* **1990**, *18*, 659–671. [CrossRef]
82. Hu, W.; Zhang, J.; Chen, Z. Small farmer and large scale production: Farmland scale and agricultural capital deepening—Taking agricultural machinery operation service as example. *J. Agro-Tech. Econ.* **2019**, *8*, 2–96.
83. Deininger, K.; Jin, S. Tenure security and land-related investment: Evidence from Ethiopia. *Eur. Econ. Rev.* **2006**, *50*, 1245–1277. [CrossRef]
84. Huang, J.; Ji, X. The verification of the right to use farmland and farmers' long-term investment in farmland. *Manag. World* **2012**, *9*, 76–81.
85. Cai, Q. Research on the cooperative supply of rural irrigation infrastructure from the perspective of social trusty. *Xinjiang State Farms Econ.* **2020**, *2*, 57–63.
86. Miceli, T.J.; Sirmans, C.F. The economics of land transfer and title insurance. *J. Real Estate Financ. Econ.* **1995**, *10*, 81–88. [CrossRef]
87. Jia, R.; Lu, Q. Land transfer, collective action and the adoption of soil and water conservation measures in the Loess Plateau of China. *Nat. Hazards (Dordrecht)* **2020**, *102*, 1279–1304. [CrossRef]
88. Shao, J.A.; Zhang, S.; Li, X. Effectiveness of farmland transfer in alleviating farmland abandonment in mountain regions. *J. Geogr. Sci.* **2016**, *26*, 203–218. [CrossRef]
89. Danso-Abbeam, G.; Ehiakpor, D.S.; Aidoo, R. Agricultural extension and its effects on farm productivity and income: Insight from Northern Ghana. *Agric. Food Secur.* **2018**, *7*, 1–10. [CrossRef]
90. Hao, A. Research of agricultural producer services' effect on agricultural technology progress. *J. South Chin. Agric. Univ. Soc. Sci. Ed.* **2015**, *14*, 8–15.
91. Qu, M.; Zhao, K. Impact of operation scale expansion on farmers' investment behavior of agricultural socialized services under different land transfer scenarios. *Chin. Land Sci.* **2021**, *35*, 37–45.
92. Tian, H.; Feng, X. Land fragmentation and technological efficiency of rice production. *J. South Chin. Agric. Univ. Soc. Sci. Ed.* **2019**, *18*, 68–79.
93. Elahi, E.; Abid, M.; Zhang, L.; Ul Haq, S.; Sahito, J.G.M. Agricultural advisory and financial services; farm level access, outreach and impact in a mixed cropping district of Punjab, Pakistan. *Land Use Policy* **2018**, *71*, 249–260. [CrossRef]
94. Peng, L.; Wu, C.; Zhang, Y.; Zhang, Z.; Wang, Y. Food production efficiency: Does agricultural productive service have regulation effect to aging agricultural labor force? Based on the investigation of 500 farmers in Jiangxi Province. *Chin. J. Agric. Resour. Reg. Plan.* **2018**, *39*, 7–13.