The impact of agricultural socialization services on the ecological protection of rice farmland in Jianghan Plain, China

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Article

The Impact of Agricultural Socialization Services on the Ecological Protection of Rice Farmland in Jianghan Plain, China

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Abstract: The ecological protection of cultivated land is crucial for advancing high-quality agricultural development. This study analyzes the impact of agricultural socialization services on the ecological conservation of farmland, focusing on the reduction of chemical fertilizers and pesticides among rice farmers in the Jianghan Plain area. Utilizing data from 743 farmer household surveys conducted in 2023, the findings reveal that agricultural socialization services significantly encourage farmers to reduce chemical input usage. Specifically, a 1% increase in the level of agricultural socialization services correlates with a 14% decrease in chemical fertilizers and a 16.4% decrease in pesticides per mu. The study identifies scale operation, factor substitution, and alleviation of capital constraints as mediating factors enhancing the efficacy of these services. Furthermore, heterogeneity analysis indicates that these services are more effective in reducing chemical inputs among large-scale and newer-generation farmers compared to their small-scale and older counterparts. Additionally, technology-intensive socialized services exhibit a stronger impact on reducing chemical inputs than labor-intensive services.

Keywords: agricultural social services; cultivated land ecological protection; chemical fertilizer reduction; pesticide reduction

1. Introduction

Historically, there has been a lack of awareness among farmers about the importance of protecting cultivated land. This, coupled with the excessive use of chemical fertilizers and pesticides, inappropriate waste disposal, and land utilization practices that prioritize use over sustainability, has led to a significant decline in the quality of cultivated land in China. As of 2019, medium and low-grade cultivated lands comprised 70.5% of the total cultivated area, with the quality of these lands being 30% lower than that in developed regions of Europe and the United States. The situation is exacerbated by industrial pollution, the practice of using superior lands to offset the inferior ones, and flaws in land management systems. This decline in land quality poses a substantial threat to the security of agricultural products and food in China. Recognizing the urgency of the situation, the Chinese government has prioritized the ecological protection of cultivated land. Recent directives, notably the No. 1 Central Documents of 2021, 2022, and 2023, have outlined measures for straw utilization, recycling of agricultural materials, and stringent protection policies for at-risk lands. These initiatives underscore the government's commitment to enhancing land quality and ensuring the safe use of contaminated areas. The development of agricultural social services has provided a new avenue to bolster ecological protection. These services are crucial for implementing sustainable practices, encapsulated in the principle of "hoarding food in the land and storing food in technology." Despite their importance, there is a notable scarcity of research on the impact of these services on land ecological protection. This gap underscores the need for further investigation to optimize and expand the implementation of agricultural social services.

Current research on agricultural social services and cultivated land protection primarily examines three areas: the impact of agricultural social services on farmers' green production, food

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production, and the reduction of chemical fertilizer use. Firstly, agricultural socialization services facilitate green production among farmers. Studies indicate these services significantly enhance farmers' willingness to engage in green production (Zeng Fusheng and Shi Fang, 2021), encourage green production behaviors (Shi Zhiheng and Fu Yue, 2022; Qing et al., 2023), and reduce agricultural carbon emissions (Luo Mingzhong and Wei Binhui, 2023). Consequently, these services support the transition towards sustainable agricultural practices (Zhang Yingnan et al., 2023). Secondly, agricultural socialization services contribute to enhanced food production. Research shows that these services discourage farmers from abandoning their fields (Chen Jingshuai and Han Qing, 2021), facilitate land transfers (Liu et al., 2022), and improve grain productivity (Zhang Zhongjun and Yi Zhongyi, 2015; Zhang Huanan et al., 2023). These services also increase grain yield per unit area (Lu Hua et al., 2023) and secure farmers' income from grain cultivation (Qiu Hailan and Tang Chao, 2019; Luan Jian et al., 2022; Lin and Hu, 2022). Thirdly, there is ongoing debate regarding the effectiveness of agricultural socialization services in reducing chemical fertilizer use. Some studies assert that these services considerably decrease the use of chemical fertilizers in rice and wheat cultivation, with varying impacts across different service types (Liu Hao et al., 2022; Zhang Mengling et al., 2023). Gao Enkai et al. (2023) noted a significant reduction in both the total and per unit area usage of chemical fertilizers, with a 1% increase in service expenditure leading to reductions of 0.055% and 0.443%, respectively. Conversely, other studies argue that these services do not reduce the fertilizer used in wheat but merely lessen the disparity in fertilizer application among farmers (Wan Lingxiao and Yang Guo, 2023). Additionally, these services reportedly have negligible effects on fertilizer reduction among part-time farmers (Zheng Xuyuan et al., 2023).

This study builds on previous literature while addressing identified gaps in research on the impact of agricultural socialization services on the reduction of chemical fertilizers and pesticides. The shortcomings of existing studies include: (1) Most prior analyses of the mechanisms through which agricultural socialization services influence the reduction of chemical fertilizers and pesticides have remained theoretical and lack empirical validation. (2) While previous research has generally explored the overall effects of agricultural socialization services on the reduction of these substances, there has been limited investigation into their heterogeneous impacts. The contributions of this article are threefold. Firstly, it evaluates the overall impact of agricultural socialization services on reducing farmers' use of chemical fertilizers and pesticides. Secondly, it provides both theoretical analysis and empirical testing to explore the mechanisms by which these services affect such reductions. Lastly, it examines the impacts from diverse perspectives, including different scales of planting, generational differences among farmers, and variations in service delivery, thereby offering a detailed assessment of how agricultural socialization services contribute to the reduction of chemical fertilizers and pesticides.

2. Theoretical Analysis

2.1. The Direct Impact of Agricultural Socialization Services on the Ecological Protection of Farmers' Farmland

The ecological protection of farmers' cultivated land can be implemented in two primary ways: self-execution and indirect execution. Self-execution involves farmers independently purchasing and utilizing green production factors, managing all stages of cultivation—from land preparation and sowing to pest control and harvesting—without external assistance. Here, the farmers themselves are the principal agents of ecological protection. Indirect execution, on the other hand, occurs when farmers engage agricultural socialization services. These organizations invest in green production factors and may handle various farming activities, including sowing, pest control, and harvesting. In this model, agricultural socialization service organizations act as the agents of ecological protection (Yang Gaodi and Zhang Lu, 2022). Indirect execution offers three primary advantages over self-execution: reduced costs of green production factors, enhanced adoption of green production technologies, and more efficient operation and management. Agricultural socialization service organizations, due to their large-scale purchases, have significant bargaining power which allows them to procure inputs at costs below market prices, thereby lowering production costs for farmers.

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Furthermore, as leaders in adopting new agricultural technologies, these organizations have access to sufficient capital, government support, and expert resources to advance the use of green technologies. Finally, their modern organizational structures and management practices enable them to deliver comprehensive, high-quality services efficiently, fostering more effective ecological protection of cultivated land. Based on this analysis, the following hypothesis is proposed:

Hypothesis 1: *Agricultural social services significantly enhance the ecological protection of farmers' cultivated land.*

2.2. The Mechanism of Agricultural Socialization Services in Ecological Protection of Farmers' Cultivated Land

Financial constraints significantly hinder the participation of small farmers in agricultural modernization. Due to limited resources, low returns, and high risks, these farmers often lack the funds necessary for adopting modern agricultural practices (Lu Cailan and Zhang Yu, 2020). The highly specific nature of agricultural machinery and equipment across different stages of production exacerbates this issue, making it challenging for small farmers to afford necessary machinery for all activities, thereby reinforcing their financial limitations (Yang Zi et al., 2020). Agricultural social service organizations can mitigate these financial barriers by providing agricultural machinery services at reduced costs. This support not only enables small farmers to access essential machinery without the need for large capital investments but also decreases the cost and risk associated with such purchases. Furthermore, by alleviating the capital constraints associated with the specificity of agricultural machinery and equipment, these organizations facilitate small farmers' investments in funds and the adoption of agricultural technologies. This support not only enhances agricultural production efficiency but also increases the likelihood of farmers adopting technologies for the ecological protection of cultivated land, thereby promoting sustainable agricultural practices. Based on these considerations, the following hypothesis is proposed:

Hypothesis 2: *Agricultural social services enhance the ecological protection of farmers' cultivated land by easing financial constraints.*

The promotion of factor substitution mechanisms is crucial in advancing the ecological protection of cultivated land. This mechanism can be broken down into two primary categories: agricultural labor substitution and technological substitution. First, agricultural labor substitution addresses the severe shortage of agricultural labor, which has been exacerbated by the rapid urbanization and industrial migration of young and middle-aged rural workers. Agricultural socialization services facilitate the mechanization of key farming processes such as plowing, sowing, pest control, and harvesting. This mechanization not only compensates for the lack of human labor but also ensures the standardized application of agricultural production inputs like fertilizers and pesticides, thereby reducing the likelihood of their excessive use and mitigating the adverse effects of labor shortages on cultivated land ecological protection. Second, technological substitution is pivotal for enhancing cultivated land ecological protection. Despite the critical role of agricultural science and technology in this regard, limited financial resources among farmers and scarce governmental support for agricultural technology extension often hinder access to advanced agricultural technologies. Agricultural socialization services bridge this gap by introducing advanced technologies and additional high-value funds into the agricultural sector. This facilitates easier access for farmers to cutting-edge cultivated land ecological protection technologies, subsequently encouraging the adoption of environmentally sustainable practices. Based on the analysis, the following hypothesis is proposed:

Hypothesis 3: *Agricultural socialization services enhance the ecological protection of farmers' cultivated land by promoting factor substitution.*

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The mechanism for expanding business scale through agricultural socialization services plays a pivotal role in the ecological protection of cultivated land. This approach operates through two main avenues: mitigating land abandonment and facilitating land transfers. On one hand, agricultural socialization services counteract the abandonment of cultivated land. In our country, the small and highly fragmented nature of per capita cultivated land complicates agricultural production. This challenge is exacerbated by the significant loss of agricultural laborers and the serious aging of the rural workforce, resulting in a shortage of labor and substantial abandonment of cultivated land. By mechanizing the entire process of plowing, sowing, pest control, and harvesting, agricultural socialization services compensate for the lack of family labor, boost farmers' enthusiasm for grain cultivation, and help mitigate the abandonment of cultivated land (Zhang Qi and Zhang Yanrong, 2023). On the other hand, these services promote land transfers. Agricultural socialization services alleviate capital, labor, and technological constraints faced by farmers. Those with planting experience and financial capability are encouraged to seek economies of scale by transferring more land, thereby expanding their operations. As farmers' business scales grow, the efficiency of agricultural social services improves. This efficiency leads to a significant reduction in the use of chemical fertilizers and pesticides per unit area, lowers farming costs, and further incentivizes farmers to engage in ecological protection of their cultivated land (Cheng Changming et al., 2023). Based on this analysis, the following hypothesis is proposed:

Hypothesis 4: *Agricultural social services enhance the ecological protection of farmers' cultivated land by promoting the expansion of business operations.*

3. Research Design

3.1. Data Sources

The data for this study were obtained through a questionnaire survey conducted among rice farmers in the Jianghan Plain during August and September 2023. The Jianghan Plain was selected for several reasons: it is a major rice-producing region in the country, it has seen significant development in agricultural socialized services, and it has been the focus of extensive pilot projects in this area. Additionally, the Jianghan Plain boasts unique advantages in terms of cultivated land resources and is a focal point of agricultural production, highly prioritized by the government. It also plays a critical role in the rural revitalization efforts in Hubei Province. The sampling strategy involved a combination of stratified and random sampling methods to select representative farmers for household surveys. Based on the development level of agricultural socialization services and the characteristics of cultivated land resources in the region, eight counties and cities within the Jianghan Plain were chosen. From each county, 3-4 towns were randomly selected, and from each town, 2-3 villages were chosen. Within each village, 20-25 farmers were identified as sampling points. Ultimately, approximately 860 farmers were randomly selected as subjects for this study. Of these, 743 valid questionnaires were returned, yielding a questionnaire validity rate of 86.39%.

3.2. Model Construction

To assess the influence of agricultural socialization services on the ecological protection of farmers' cultivated land, this study builds on existing literature and employs the ordered logit (ologit) model. The model is structured as follows:

$$Ecological_i = \beta + \beta_1 Service_i + z_k X_i + \varepsilon_i \quad (1)$$

In formula (1), the variable $Ecological_i$ represents the ecological protection of cultivated land for the i-th farmer, quantified by the average fertilizer application rate (expressed in jin per mu) and the average pesticide application rate per mu. The variable $Service_i$ denotes the level of engagement with agricultural socialization services, measured by the number of service links utilized by the farmer. The model includes X_k, a set of control variables, which account for demographic and socio-economic factors such as age, gender, educational level, health status, size of the agricultural labor force,

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whether the individual holds a cadre position, and whether they are a member of a cooperative. Lastly, ε_i represents the random error term.

To examine the influence of agricultural socialization services on the ecological protection of farmers' cultivated land, this study employs a mediating effect model. This model is based on the methodologies proposed by Baron and Kenny (1986) and further refined by Wen Zhonglin and colleagues (2004) , as follows:

$$M_i = \alpha + \alpha_1 Service_i + z_k X_i + \varepsilon_i \quad (2)$$

$$Ecological_i = \gamma + + \gamma_2 Service_i + \gamma_2 M_i + z_k X_i + \varepsilon_i \quad (3)$$

Among them, formula (1) β_1 is the total effect of agricultural socialization services on the ecological protection of farmers' cultivated land (amount of chemical fertilizers and pesticides applied), formula (3) γ_1 is the direct effect of agricultural socialization services on the ecological protection of farmers' cultivated land, $\alpha_1\gamma_2$ is the agricultural The relative size of the intermediary effect of socialized services on the ecological protection of farmers' cultivated land is the ratio of the intermediary effect to the total effect. M_{it} is the intermediary variable, which mainly includes capital constraints, factor substitution, and business scale. The remaining dependent variables, independent variables, and control variables are the same as before.

3.3. Variable Setting

Dependent Variable. The dependent variable in this study is the ecological protection of cultivated land, which focuses on maintaining the ecological balance of such land. This encompasses efforts to prevent soil pollution—specifically from chemical fertilizers, pesticides, and heavy metals—as well as combating land degradation phenomena including salinization, desertification, and soil erosion. Excessive use of chemical fertilizers and pesticides has been identified as a primary cause of soil pollution. Consequently, reducing the application of these substances is considered a critical strategy for enhancing the ecological protection of cultivated land (Zu Jian et al., 2018). Drawing on the research by Zhao Jianying (2020) and Zheng Linyi (2023), this study uses the amount of fertilizer and pesticide applied by farmers as indicators to assess the impact of agricultural socialization services on the ecological protection of cultivated land.

Core Explanatory Variables. Agricultural socialization services constitute the core explanatory variables in this study. These services encompass a range of activities provided by agricultural socialization service organizations, designed to support farmers throughout the agricultural production process. The services include land preparation, sowing, seedling transplanting, fertilization, pest and disease control, irrigation, harvesting, transportation, and drying, among other production-related tasks. The adoption of agricultural socialization services, as well as the extent to which farmers utilize various service links, significantly impacts the ecological protection of cultivated land. To quantify this impact, this article, informed by the research of Zhang Mengling et al. (2023) and Cheng Changming et al. (2023), selects seven critical service links: land preparation, sowing, raising and transplanting, fertilization, pest control, irrigation, and harvesting. The level of engagement with agricultural socialization services is measured by the number of service links utilized by farmers, with a possible range from 0 to 7.

Control Variables. In order to account for potential confounders that may influence the effectiveness of agricultural socialization services and the ecological protection of cultivated land, this study incorporates several control variables based on insights gleaned from existing research. These variables include the farmers' age, gender, education level, health status, size of the agricultural labor force, cadre status, and membership in cooperatives. The selection of these variables is aimed at isolating the specific effects of agricultural socialization services on ecological outcomes by controlling for demographic and socio-economic factors that could also impact these results. The detailed measurement methods for each of these variables are presented in Table 1.

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Table 1. Descriptive statistical analysis of variables.

Variable	Measurement and assignment
Agricultural social services	The number of production links that farmers adopt socialized services, the value ranges from 0-7
Fertilizer application amount	Amount of chemical fertilizer applied per acre (catties)
Pesticide application amount	Quantity of pesticides and fertilizers per mu (jin)
Changes in fertilizer application rates	Changes in the amount of chemical fertilizer applied per acre: 1=significantly reduced, 2=reduced, 3=no change, 4=increased, 5=significantly increased
Changes in pesticide application rates	Changes in pesticide application rate per acre: 1=significantly reduced, 2=reduced, 3=no change, 4=increased, 5=significantly increased
Agricultural socialization service expenditures	Total service cost per mu in all links (unit: thousand yuan/mu)
Fertilization services	Purchase service fee per mu during fertilization (unit: thousand yuan/mu)
Pest and disease control services	Purchase service cost per mu for pest control (unit: thousand yuan/mu)
Business scale	Whether the farmer transferred the land: 1=yes, 0=no
Financial constraints	Whether farmers purchase agricultural machinery: 1=yes, 0=no
Element substitution	Can agricultural socialization services alleviate family labor shortage? 1=can, 0=cannot
Whether to adopt agricultural socialization services	1=yes, 0=no
Whether to adopt fertilization services	1=yes, 0=no
Whether to adopt pest control services	1=yes, 0=no
Does your village provide agricultural socialization services? 1=provided; 0=not provided	1=yes, 0=no
Is it convenient for you to obtain agricultural socialization services?	1=yes, 0=no
Age	Actual age
Gender	1=male, 0=female
Culture	1=Primary school and below, 2=Junior high school, 3=High school, 4=College and above
Healthy	1=very poor, 2=poor, 3=average, 4=good, 5=good
Agricultural labor	Number of family agricultural laborers
Is it a cadre?	1=yes, 0=no
Total household income	actual income
Cultivated area	actual area
Soil fertility	1=very poor, 2=poor, 3=average, 4=better, 5=very good
Whether to join a cooperative	1=yes, 0=no
Is it agricultural technology training?	1=yes, 0=no
Disaster frequency	1=hardly ever, 2=occasionally, 3=frequently
Whether to buy agricultural insurance	1=yes, 0=no

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4. Empirical Results Analysis

4.1. Baseline Regression Results

Table 2 presents the effects of agricultural socialization services on the usage of chemical fertilizers and pesticides by farmers. The table is divided into four columns: Columns (1) and (2) display the estimation results without control variables, while Columns (3) and (4) include control variables in the estimations. The findings indicate a significantly negative coefficient for agricultural socialization services in Columns (1) and (2), with statistical significance at the 1% level. This suggests that agricultural socialization services lead to a substantial reduction in the application of chemical fertilizers and pesticides. Upon incorporating control variables in Columns (3) and (4), the magnitude of the coefficient decreases but remains significantly negative at the 1% level, reinforcing the initial findings. Specifically, a 1% increase in the level of agricultural socialization services is associated with a 14% decrease in chemical fertilizer usage and a 16.4% decrease in pesticide usage per mu. These results confirm that agricultural socialization services contribute positively to the ecological protection of farmers' cultivated land, as evidenced by the validation of Hypothesis 1 of this study. Compared to traditional methods of manual fertilization and pesticide application, agricultural socialization service organizations employ advanced reduction technologies and equipment. This specialized, intensified, and scaled approach enhances the precision, speed, and efficiency of applications, improving the utilization rate of chemical inputs and effectively reducing their overall usage.

Table 2. The impact of agricultural socialization services on the amount of chemical fertilizers and pesticides used by farmers.

	(1) Fertilizer application amount	(2) Pesticide application amount	(3) Fertilizer application amount	(4) Pesticide application amount
Agricultural social services	-0.144***	-0.177***	-0.140***	-0.164***
	(-4.38)	(-5.41)	(-4.00)	(-4.72)
Gender			-0.0803	0.0632
			(-0.52)	(0.41)
Age			0.00454	-0.00654
			(0.62)	(-0.90)
Culture			0.0169	-0.0120
			(0.75)	(-0.50)
Healthy			-0.105	-0.0258
			(-1.52)	(-0.37)
Agricultural labor			0.0469	-0.122
			(0.63)	(-1.64)
Is it a village cadre?			-0.266**	-0.113
			(-2.14)	(-0.84)
Total household income			-0.0121	-0.0420*
			(-0.52)	(-1.79)
Cultivated area			-0.000512	-0.000945
			(-0.18)	(-0.35)
Soil fertility			-0.113*	0.00307

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			(-1.89)	(0.09)
Whether to join a cooperative			0.371***	0.0311
			(2.69)	(0.22)
Is it agricultural technology training?			-0.208	-0.144
			(-1.62)	(-1.08)
Disaster frequency			0.0398	0.129
			(0.43)	(1.41)
Whether to buy agricultural insurance			0.0186	-0.117
			(0.22)	(-1.36)
N	743	744	736	737

4.2. Endogeneity Analysis

Considering potential issues of bidirectional causality and omitted variables, this study addresses the problem of endogeneity. The bidirectional causality could manifest as follows: on one hand, excessive fertilization and pesticide application by farmers can lead to soil pollution and a deteriorating ecological environment, prompting increased governmental efforts to protect and manage the agricultural ecosystem and encourage the adoption of agricultural social services. On the other hand, given the high costs and low efficiency of manual fertilization and pesticide application, farmers, acting as rational economic agents, may opt for agricultural social services to reduce costs and enhance production efficiency. To address the bias resulting from endogeneity, this study employs an instrumental variable approach, as suggested by Zhang Anran et al. (2023). The instrumental variable chosen is the accessibility of agricultural socialization services. It is posited that farmers with easier access to these services are more likely to adopt them compared to those for whom access is difficult. However, ease of access to agricultural socialization services does not necessarily correlate with a reduction in the use of chemical fertilizers and pesticides. Therefore, while the convenience of obtaining agricultural socialization services may directly influence the adoption of such services, it does not directly affect the volume of fertilizers and pesticides used.

Table 3 presents the results of the endogeneity test for the impact of agricultural socialization services on the usage of chemical fertilizers and pesticides. The first-stage regression results in Columns (1) and (3) of Table 3 reveal that the coefficient of the instrumental variable ("Is it convenient for you to obtain agricultural socialization services?") is significantly positive at the 1% level, aligning with expectations. This significant relationship indicates a strong correlation between the instrumental variable and the endogenous explanatory variables. The Cragg-Donald Wald F statistic exceeds the 10% critical value of 16.38, effectively addressing concerns regarding the weakness of the instrumental variable. Furthermore, the p-value of the Anderson canon. corr. LM statistic is 0.0000, leading to the rejection of the hypothesis of insufficient instrumental variables, thereby validating the appropriateness of the instrumental variable selected for this analysis. The second-stage regression results, displayed in Columns (2) and (4) of Table 3, show that the coefficient of agricultural socialization services is significantly negative at the 10% level, confirming that agricultural socialization services substantially reduce the application of chemical fertilizers and pesticides. Additionally, when comparing these results with those in Table 2, the absolute value of the coefficient for agricultural socialization services in the instrumental variable estimation (Columns (2) and (4) of Table 3) is notably larger. This suggests that the negative impacts of agricultural socialization services on chemical fertilizer and pesticide usage are underestimated when endogeneity issues are not considered.

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Table 3. Endogeneity test.

	(1) Stage 1	(2) Stage 2	(3) Stage 1	(4) Stage 2
	Agricultural social services	Fertilizer application amount	Agricultural social services	Pesticide application amount
Agricultural social services		-0.2252*		-0.2667*
		(0.1331)		(0.1564)
Instrumental variable	0.7690***		0.7896***	
	(0.1859)		(0.1855)	
Gender	0.1878	-0.1343	0.1835	0.0095
	(0.1661)	(0.0953)	(0.1662)	(0.1148)
Age	0.0142*	-0.0001	0.0142*	-0.0053
	(0.0077)	(0.0047)	(0.0077)	(0.0057)
Culture	0.0410	0.0024	0.0414	-0.0099
	(0.0256)	(0.0148)	(0.0256)	(0.0179)
Healthy	-0.0877	-0.0370	-0.0871	0.0085
	(0.0748)	(0.0430)	(0.0748)	(0.0518)
Agricultural labor	0.0853	0.0197	0.0861	-0.0971*
	(0.0800)	(0.0445)	(0.0801)	(0.0538)
Is it a village cadre?	0.0874	-0.1757**	0.0890	-0.0998
	(0.1393)	(0.0785)	(0.1394)	(0.0950)
Total household income	-0.0137	-0.0053	-0.0139	-0.0305*
	(0.0253)	(0.0140)	(0.0254)	(0.0169)
Cultivated area	0.0008	-0.0010	0.0008	-0.0009
	(0.0031)	(0.0017)	(0.0031)	(0.0021)
Soil fertility	0.0172	-0.0487**	0.0182	-0.0023
	(0.0409)	(0.0227)	(0.0409)	(0.0275)
Whether to join a cooperative	0.1100	0.1928**	0.0960	-0.0118
	(0.1517)	(0.0856)	(0.1514)	(0.1027)
Is it agricultural technology training?	0.1901	-0.1588*	0.2004	-0.1214
	(0.1412)	(0.0821)	(0.1411)	(0.0997)
Disaster frequency	0.3116***	-0.0088	0.3051***	0.0087
	(0.0913)	(0.0636)	(0.0912)	(0.0753)
Whether to buy agricultural insurance	-0.6548***	0.0981	-0.6511***	0.0262
	(0.0888)	(0.0988)	(0.0888)	(0.1163)
Cragg-Donald Wald F-statistic	20.699		41.572	
Anderson canon. corr. LM statistics	29.475 (p=0.0000)		36.685 (p=0.0000)	

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N	731	731	732	732

4.3. Robustness Check

To evaluate the robustness of the baseline regression results, this study implements several robustness tests, each employing different methodologies: substituting the dependent variable, altering the core explanatory variable, and excluding specific samples. These approaches are detailed as follows: ①Substituting the Dependent Variable: The study substitutes the initial dependent variables—amounts of chemical fertilizer and pesticide application—with their respective changes over time. The robustness of these substitutions is assessed, with the results presented in Columns (1) and (2) of Table 4. ②Altering the Core Explanatory Variables: Following the methodology of Sun Dingqiang et al. (2016), this study uses expenditure on agricultural socialization services as a proxy for agricultural socialization services to test the robustness of the results. Additionally, inspired by Zhang Mengling et al. (2023), the study considers the adoption of agricultural socialization services as another proxy variable. The outcomes of these substitutions are documented in Columns (3) to (6) of Table 4. ③Excluding Samples: Considering that farmers over 65 years old may have diminished capacity for agricultural labor and potentially less enthusiasm for ecological protection, samples from this age group are excluded to verify the stability of the findings. The re-estimated results are shown in Columns (7) and (8) of Table 4.

The estimation results presented in Columns (1)-(8) of Table 4 consistently demonstrate that regardless of the robustness test employed, agricultural socialization services exert a significant negative impact on both the amount and change in chemical fertilizer and pesticide applications. This finding indicates that agricultural socialization services effectively promote the reduction of chemical fertilizer and pesticide usage, corroborating the baseline regression results. These outcomes affirm that the conclusions of this study possess a considerable degree of robustness, underscoring the reliability of the research findings across different analytical scenarios.

Table 4. Robustness check.

	(1) Changes in fertilizer application rates	(2) Changes in pesticide application rates	(3) Fertilizer application amount	(4) Pesticide application amount	(5) Fertilizer application amount	(6) Pesticide application amount	(7) Cut out samples	(8) Cut out samples
Agricultural social services	-0.558***	-0.658***					-0.517***	-0.641***
	(-14.38)	(-16.86)					(-6.68)	(-8.49)
Agricultural socialization service expenditures			-0.319**	-0.494***				
			(-1.98)	(-3.10)				
Whether to adopt agricultur					-0.847***	-1.719***		
					(-5.53)	(-10.75)		

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al socialization services								
Gender	0.0419	-0.114	-0.0875	0.0606	-0.00889	-0.0972	-0.0324	-0.207
	(0.28)	(-0.76)	(-0.57)	(0.39)	(-0.06)	(-0.65)	(-0.09)	(-0.54)
Age	-0.0100	0.00800	0.00590	-0.00623	-0.0120*	0.00508	0.0182	0.00886
	(-1.49)	(1.15)	(0.81)	(-0.85)	(-1.77)	(0.74)	(0.54)	(0.24)
Culture	-0.0406*	0.00447	0.0195	-0.00893	-0.0495**	-0.00197	0.140	-0.0634
	(-1.90)	(0.21)	(0.85)	(-0.36)	(-2.15)	(-0.10)	(0.67)	(-0.31)
Healthy	-0.107	0.0824	-0.115*	-0.0433	-0.0431	0.113*	-0.00431	0.0962
	(-1.58)	(1.20)	(-1.66)	(-0.62)	(-0.64)	(1.67)	(-0.03)	(0.76)
Family labor	-0.0338	0.0253	0.0493	-0.122	-0.0513	0.00745	0.158	0.138
	(-0.47)	(0.36)	(0.66)	(-1.64)	(-0.71)	(0.11)	(1.20)	(1.08)
Is it a village cadre?	0.142	-0.117	-0.246**	-0.115	0.174	-0.0910	0.727	-0.922*
	(0.95)	(-0.95)	(-1.96)	(-0.87)	(1.16)	(-0.69)	(1.54)	(-1.96)
Total household income	-0.0572***	-0.0177	-0.0103	-0.0379	-0.0577**	-0.0304	-0.120**	0.00546
	(-2.61)	(-0.81)	(-0.44)	(-1.60)	(-2.42)	(-1.39)	(-2.41)	(0.11)
Cultivated area	0.00305	0.00608**	-0.000409	-0.000876	0.00188	0.00551*	0.00190	0.0108**
	(1.16)	(2.25)	(-0.15)	(-0.33)	(0.74)	(1.96)	(0.47)	(2.57)
Soil fertility	-0.0248	0.0503	-0.113*	0.00825	-0.0320	0.0288	-0.207	-0.347**
	(-0.78)	(1.44)	(-1.81)	(0.25)	(-0.98)	(0.88)	(-1.19)	(-2.14)
Whether to join a cooperative	-0.117	0.111	0.387***	0.0518	-0.135	-0.0216	-0.317	-0.224
	(-0.86)	(0.81)	(2.80)	(0.37)	(-0.99)	(-0.16)	(-1.12)	(-0.79)
Agricultural technology training	0.0108	-0.104	-0.179	-0.0954	-0.114	-0.209*	-0.0983	-0.338
	(0.08)	(-0.84)	(-1.39)	(-0.72)	(-0.89)	(-1.69)	(-0.39)	(-1.46)
Disaster frequency	-0.173**	-0.00922	0.0732	0.166*	-0.250***	-0.154*	-0.115	-0.182
	(-2.20)	(-0.11)	(0.78)	(1.81)	(-3.12)	(-1.79)	(-0.90)	(-1.42)

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Whether to buy agricultural insurance	0.00181	-0.0629	-0.0329	-0.162*	0.220***	0.0723	0.0110	-0.0259
	(0.02)	(-0.77)	(-0.39)	(-1.90)	(2.67)	(0.89)	(0.07)	(-0.17)
N	737	737	736	737	737	737	502	502

4.4. Mechanism Inspection

Previous research has demonstrated that agricultural social services contribute to the reduction in farmers' use of chemical fertilizers and pesticides. Building on these findings, this section delves into the specific mechanisms through which agricultural socialization services facilitate this reduction. Drawing from earlier theoretical analyses, the investigation will proceed by examining three distinct mechanisms: business scale, financial constraints, and factor substitution.

Columns (1)-(3) of Table 5 explore the mechanism of operation scale in relation to agricultural socialization services. Column (1) shows a significantly positive coefficient for agricultural social services, suggesting that these services effectively encourage farmers to expand their business operations. Columns (2) and (3) reveal that the coefficients for business scale are significantly negative, while the coefficients for agricultural socialization services are significantly and insignificantly positive, respectively. These results indicate that business scale significantly mediates the relationship between agricultural socialization services and the reduction in chemical fertilizer and pesticide usage. The mediation effect is such that agricultural socialization services reduce pesticide and fertilizer applications by facilitating the expansion of operational scale. This finding confirms Hypothesis 4 of this study. The primary reason for this effect is that agricultural socialization services boost farmers' enthusiasm for crop production, which leads to an expansion in production scale. This expansion, in turn, enhances the efficiency of chemical fertilizer and pesticide utilization, thereby reducing their overall consumption.

Columns (4)-(6) of Table 5 assess the role of financial constraints as mediated by agricultural socialization services. In column (4), the significantly negative coefficient associated with agricultural socialization services suggests that these services effectively alleviate farmers' financial constraints. The coefficients in columns (5) and (6) for both capital constraints and agricultural socialization services are significantly negative, demonstrating that capital constraints function as a mediator in the relationship between agricultural socialization services and the reduction in chemical fertilizer and pesticide use. Specifically, agricultural socialization services facilitate this reduction by mitigating financial barriers, thereby validating Hypothesis 3. The underlying mechanism is that agricultural social services not only lower production costs for farmers but also diminish the substantial financial requirements for purchasing agricultural machinery, thereby motivating farmers to decrease their usage of chemical inputs.

Columns (7)-(9) of Table 5 delve into the mechanism of factor substitution facilitated by agricultural socialization services. In column (7), the coefficient associated with agricultural socialization services is significantly positive, indicating that these services effectively promote factor substitution among farmers. In columns (8) and (9), both the factor substitution coefficient and the agricultural socialization service coefficient are significantly negative, demonstrating that factor substitution acts as a mediator between agricultural socialization services and the reduction in the use of chemical fertilizers and pesticides. This mediation suggests that agricultural socialization services contribute to the decreased application of these chemicals by enhancing factor substitution. Consequently, Hypothesis 2 of this study is supported. The primary mechanism is that agricultural social services can effectively replace traditional agricultural labor, allowing for more precise application of fertilizers and pesticides.

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Table 5. Mechanism of action test.

	(1) Business scale	(2) Fertilizer application amount	(3) Pesticide application amount	(4) financial constraints	(5) Fertilizer application amount	(6) Pesticide application amount	(7) element substitution	(8) Fertilizer application amount	(9) Pesticide application amount
Business scale		-0.434***	-0.134**						
		(-2.62)	(-1.92)						
Financial constraints					-0.219*	-0.101**			
					(-1.78)	(-2.62)			
Element substitution								-0.714***	-0.204**
								(-3.46)	(-2.26)
Agricultural social services	0.216***	-0.137*	-0.1439	-0.122**	-0.138***	-0.160***	0.148***	-0.142***	-0.168***
	(2.84)	(-1.69)	(-0.43)	(2.54)	(-3.92)	(-4.58)	(3.22)	(-4.03)	(-4.81)
Gender	0.293	-0.392	-0.387	0.325	-0.0725	0.0707	0.131	-0.0799	0.0636
	(0.84)	(-1.02)	(-1.04)	(1.51)	(-0.47)	(0.46)	(0.62)	(-0.52)	(0.41)
Age	-0.0416**	0.0146	-0.00532	-0.0244**	0.00359	-0.00681	-0.0108	0.00443	-0.00662
	(-2.38)	(0.79)	(-0.30)	(-2.52)	(0.49)	(-0.93)	(-1.10)	(0.61)	(-0.91)
Culture	0.504**	0.345	-0.197	-0.0872	0.0145	-0.0131	-0.0160	0.0167	-0.0120
	(2.21)	(1.44)	(-0.81)	(-1.35)	(0.64)	(-0.54)	(-0.48)	(0.74)	(-0.50)
Healthy	0.202	0.0837	-0.0887	0.0718	-0.102	-0.0252	-0.165*	-0.106	-0.0303
	(1.33)	(0.53)	(-0.58)	(0.74)	(-1.47)	(-0.36)	(-1.75)	(-1.53)	(-0.43)
Labor force	0.101	0.445**	-0.113	0.196**	0.0531	-0.118	0.0920	0.0486	-0.118
	(0.66)	(2.49)	(-0.67)	(1.98)	(0.71)	(-1.58)	(0.91)	(0.65)	(-1.59)
	-0.427	-0.144	0.306	-0.115	-0.273**	-0.117	-0.133	-0.267**	-0.116

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Is it a village cadre?	(-1.32)	(-0.40)	(0.93)	(-0.58)	(-2.20)	(-0.87)	(-0.73)	(-2.15)	(-0.86)
Household income	0.0367	-0.0355	-0.0191	0.00933	-0.0115	-0.0416*	0.0139	-0.0121	-0.0407*
	(0.90)	(-0.83)	(-0.46)	(0.30)	(-0.50)	(-1.77)	(0.45)	(-0.52)	(-1.73)
Cultivated area	0.233***	0.586	0.369	0.941**	-0.137	-0.0753	0.155***	-0.275	-0.426
	(5.92)	(1.60)	(0.11)	(2.37)	(-0.00)	(-0.28)	(3.45)	(-0.10)	(-0.16)
Soil fertility	-0.322	-0.998***	-0.380	0.0442	-0.114*	0.00379	-0.0218	-0.113*	0.00264
	(-1.31)	(-4.34)	(-1.62)	(0.98)	(-1.84)	(0.11)	(-0.36)	(-1.90)	(0.08)
Whether to join a cooperative	0.485	0.327	-0.308	0.374**	0.383***	0.0492	-0.132	0.369***	0.0258
	(1.50)	(0.96)	(-0.91)	(2.03)	(2.77)	(0.35)	(-0.66)	(2.67)	(0.18)
Agricultural technology training	-0.157	-0.777**	0.0755	-0.0118	-0.209	-0.152	-0.0319	-0.208	-0.144
	(-0.50)	(-2.45)	(0.24)	(-0.06)	(-1.63)	(-1.15)	(-0.18)	(-1.61)	(-1.09)
Disaster frequency	0.513*	0.555*	0.573*	-0.0984	0.0382	0.137	-0.206	0.0367	0.125
	(1.85)	(1.92)	(1.94)	(-0.68)	(0.41)	(1.50)	(-1.40)	(0.39)	(1.37)
Whether to buy agricultural insurance	-0.394**	-0.386*	-0.400*	-0.123	0.0187	-0.125	-0.143	0.0185	-0.122
	(-1.99)	(-1.85)	(-1.92)	(-1.01)	(0.22)	(-1.45)	(-1.19)	(0.21)	(-1.41)
N	150	150	150	736	736	736	(3)	736	737

4.5. Heterogeneity Analysis

To further investigate the potential heterogeneity in the impact of agricultural social services on the reduction of chemical fertilizers and pesticides among farmers, this study examines several dimensions: farm scale, generational differences, and variation in service linkages. The research specifically aims to determine whether agricultural socialization services are more effective in reducing chemical inputs for large-scale and new generation farmers compared to their smaller-scale and older counterparts. The study will explore these effects across different operational scales, generational cohorts, and the specific services utilized in the agricultural process.

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Table 6 assesses the impact of agricultural socialization services on the reduction of chemical fertilizers and pesticides among farmers of varying sizes. Following the classification method used by Liu Sha and Liu Ming (2021) and Zhu Mande (2011), farmers are categorized based on cultivated land area into three groups: small-scale (less than 10.5 acres), medium-scale (10.5-49.55 acres), and large-scale (49.55 acres or more). The results in Table 6 reveal that the coefficients for agricultural socialization services across columns (1)-(6) are consistently and significantly negative for all size groups, indicating that agricultural socialization services have substantially facilitated the reduction of chemical fertilizers and pesticides among small, medium, and large-scale farmers. A comparative analysis of the absolute values of the coefficients suggests notable differences in the effectiveness of these services across different farm sizes. The impact is most pronounced for large-scale farmers, followed by medium-scale, with small-scale farmers experiencing the least impact. This pattern suggests that the effectiveness of agricultural socialization services in reducing chemical input use increases with the scale of farming operations. Furthermore, the coefficient magnitude for large-scale farmers is approximately twice that observed for medium- and small-scale farmers. This indicates that for farms exceeding 49.55 acres, the efficacy of agricultural socialization services in reducing chemical inputs is notably enhanced, achieving the most substantial reduction in chemical fertilizer and pesticide usage.

Table 6. The impact of agricultural socialization services on fertilizer and pesticide variables: based on different scale perspectives.

	Small scale farmers		Medium-sized farmers		Large-scale farmers	
	(1)	(2)	(3)	(4)	(5)	(6)
	Fertilizer usage	Pesticide usage	Fertilizer usage	Pesticide usage	Fertilizer usage	Pesticide usage
Agricultural social services	-0.120**	-0.137***	-0.140***	-0.164***	-0.309**	-0.342*
	(-2.53)	(-2.89)	(-4.00)	(-4.72)	(-2.17)	(-1.82)
Gender	-0.0735	-0.117	-0.0803	0.0632	-0.655	6.703***
	(-0.36)	(-0.56)	(-0.52)	(0.41)	(-0.52)	(2.91)
Age	-0.00615	-0.0107	0.00454	-0.00654	0.105	0.0156
	(-0.63)	(-1.08)	(0.62)	(-0.90)	(1.55)	(0.19)
Culture	-0.0233	-0.0654	0.0169	-0.0120	-0.502	-0.237
	(-0.69)	(-1.38)	(0.75)	(-0.50)	(-0.71)	(-0.30)
Healthy	-0.195**	0.105	-0.105	-0.0258	0.354	0.484
	(-2.05)	(1.08)	(-1.52)	(-0.37)	(0.65)	(0.73)
Labor force	0.0133	-0.178*	0.0469	-0.122	0.296	0.589
	(0.13)	(-1.67)	(0.63)	(-1.64)	(0.42)	(0.75)
Is it a village cadre?	-0.203	-0.180	-0.266**	-0.113	2.403	0.783
	(-1.38)	(-1.08)	(-2.14)	(-0.84)	(1.43)	(0.33)
Household income	-0.0513	-0.108***	-0.0121	-0.0420*	-0.0158	-0.0266
	(-1.39)	(-2.91)	(-0.52)	(-1.79)	(-0.14)	(-0.21)
Cultivated area	0.0106	0.120***	-0.000512	-0.000945	-0.00852	0.0102
	(0.28)	(3.05)	(-0.18)	(-0.35)	(-1.16)	(1.02)
Soil fertility	-0.0923	-0.00666	-0.113*	0.00307	-1.191*	0.221
	(-1.64)	(-0.19)	(-1.89)	(0.09)	(-1.78)	(0.25)
	0.506***	0.0849	0.371***	0.0311	0.0716	1.102

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Whether to join a cooperative	(2.94)	(0.48)	(2.69)	(0.22)	(0.07)	(0.82)
Agricultural technology training	-0.171	-0.144	-0.208	-0.144	-2.264	26.47
	(-0.98)	(-0.79)	(-1.62)	(-1.08)	(-1.21)	(0.01)
Disaster frequency	0.00451	0.0338	0.0398	0.129	0.827	-5.179***
	(0.04)	(0.32)	(0.43)	(1.41)	(1.04)	(-2.73)
Whether to buy agricultural insurance	0.0717	-0.0354	0.0186	-0.117	-0.299	-0.111
	(0.63)	(-0.31)	(0.22)	(-1.36)	(-0.54)	(-0.17)
N	416	416	736	737	31	31

Table 7 assesses the impact of agricultural socialization services on the reduction of chemical fertilizers and pesticides among farmers, differentiated by generational cohorts. Following the methodologies used by He Ke and Zhang Junbiao (2014) and Wei Jian et al. (2023), this study classifies farmers into two groups based on their year of birth: those born before 1980 are categorized as first-generation or older generation farmers, while those born after 1980 are considered new generation farmers. The results displayed in Table 7 indicate that the coefficients of agricultural socialization services across columns (1)-(4) are significantly negative for both new and old generation farmers, suggesting that agricultural socialization services have effectively facilitated the reduction of chemical fertilizers and pesticides across generational lines. A comparison of the absolute values of the coefficients in columns (1)-(2) with those in columns (3)-(4) reveals that the impact is more pronounced among new generation farmers than among their older counterparts. This suggests a stronger marginal impact of agricultural socialization services on chemical input reduction within the newer generation. The greater responsiveness of new generation farmers can be attributed to their higher receptivity to advanced agricultural technologies and a deeper understanding of agricultural socialization services. They are more likely to embrace these services, whereas older generation farmers, who often have a stronger attachment to traditional farming practices and the land itself, may prefer to manage their operations independently if capable. Consequently, the adoption of agricultural socialization services is considerably more limited among older farmers compared to those of the newer generation. This generational difference underscores the need for tailored approaches in promoting agricultural socialization services that accommodate the specific preferences and capacities of different farmer groups.

Table 7. The impact of agricultural socialization services on fertilizer and pesticide variables: based on the perspective of intergenerational differences.

	New generation farmers		Old generation farmers	
	(1)	(2)	(3)	(4)
	Fertilizer usage	Pesticide usage	Fertilizer usage	Pesticide usage
Agricultural social services	-0.196***	-0.392***	-0.128***	-0.140***
	(-3.30)	(-2.64)	(-3.45)	(-3.81)
Gender	0.512	0.487	-0.128	0.0284
	(0.84)	(0.84)	(-0.78)	(0.17)
Age	-0.0105	0.0263	0.00814	-0.00285
	(-0.20)	(0.53)	(0.84)	(-0.30)
Culture	-0.0531	0.0204	-0.0291	-0.134

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	(-0.94)	(0.40)	(-0.28)	(-1.24)
Healthy	-0.704*	0.352	-0.0948	-0.0274
	(-1.71)	(0.93)	(-1.33)	(-0.38)
Labor force	0.566*	0.252	0.0167	-0.162**
	(1.76)	(0.90)	(0.21)	(-2.04)
Is it a village cadre?	0.558	-0.0463	-0.290**	-0.0841
	(1.12)	(-0.10)	(-2.22)	(-0.58)
Household income	-0.00791	-0.0150	-0.0234	-0.0414
	(-0.14)	(-0.26)	(-0.89)	(-1.58)
Cultivated area	-0.0141	-0.0117	-0.000108	-0.000578
	(-1.45)	(-1.07)	(-0.04)	(-0.20)
Soil fertility	-0.547	-0.187	-0.0993*	0.0111
	(-1.24)	(-0.43)	(-1.79)	(0.32)
Whether to join a cooperative	1.926***	0.00695	0.265*	-0.0243
	(2.67)	(0.01)	(1.81)	(-0.16)
Agricultural technology training	-0.920	-0.865	-0.168	-0.117
	(-1.26)	(-1.23)	(-1.25)	(-0.84)
Disaster frequency	-0.0378	-0.311	0.0585	0.153
	(-0.08)	(-0.54)	(0.59)	(1.63)
Whether to buy agricultural insurance	-0.258	-0.910*	0.0134	-0.0994
	(-0.48)	(-1.75)	(0.15)	(-1.13)
N	58	58	666	667

Table 8 explores the impact of agricultural socialization services on farmers' reduction of chemical fertilizers and pesticides, analyzing the effects associated with different service links. Drawing from the research of Zhang Mengling et al. (2023), this study categorizes agricultural socialization services into seven distinct links, dividing them based on their reliance on agricultural production factors into technology-intensive socialized services (including seedling cultivation, fertilization, prevention, and control) and labor-intensive socialized services (such as land preparation, sowing, harvesting, and irrigation). The results in Table 8 reveal that technology-intensive socialized services show a positive and significant coefficient at the 1% level in columns (1) and (2), indicating a substantial contribution to the reduction of chemical fertilizers and pesticides. Similarly, labor-intensive socialized services also demonstrate a positive and significant impact at the 1% level in columns (3) and (4), contributing to the reduction of these chemical inputs. However, when comparing the absolute values of the coefficients between technology-intensive and labor-intensive services, the coefficients for technology-intensive services in columns (1)-(2) exceed those for labor-intensive services in columns (3)-(4), suggesting that technology-intensive services have a more pronounced marginal impact on the reduction of fertilizers and pesticides. The primary reason for these differences is that labor-intensive services primarily substitute agricultural labor with mechanization, focusing on enhancing production speed with less emphasis on the application of fertilizers and pesticides during the service process. Consequently, the impact of labor-intensive services on reducing chemical inputs is relatively smaller. On the other hand, technology-intensive

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services, which replace manual labor with biochemical technologies, are geared towards increasing crop yields and ensuring crop health. These services typically involve more intensive fertilization and pesticide application strategies, thereby exerting a greater influence on the reduction of chemical inputs.

Table 8. The impact of agricultural socialization services on fertilizer and pesticide variables: based on the perspectives of different links.

	(1) Fertilizer usage	(2) Pesticide usage	(3) Fertilizer usage	(4) Pesticide usage
Technology-intensive social services	-0.958***	-1.409***		
	(-14.19)	(-18.51)		
Labor-intensive social services			-0.894***	-0.825***
			(-12.27)	(-11.92)
Gender	0.0163	-0.131	0.0451	-0.127
	(0.11)	(-0.88)	(0.30)	(-0.84)
Age	-0.0111*	0.00845	-0.0108	0.00395
	(-1.65)	(1.23)	(-1.60)	(0.57)
Culture	-0.0357	0.0136	-0.0496**	-0.00684
	(-1.57)	(0.67)	(-2.34)	(-0.33)
Healthy	-0.104	0.0795	-0.0861	0.0906
	(-1.54)	(1.16)	(-1.28)	(1.33)
Labor force	-0.00706	0.0877	-0.0650	-0.0175
	(-0.10)	(1.26)	(-0.90)	(-0.25)
Is it a village cadre?	0.147	-0.143	0.126	-0.123
	(0.98)	(-1.16)	(0.85)	(-0.99)
Household income	-0.0607***	-0.0304	-0.0483**	-0.00713
	(-2.77)	(-1.38)	(-2.20)	(-0.33)
Cultivated area	0.00289	0.00633**	0.00253	0.00562**
	(1.10)	(2.37)	(0.99)	(2.08)
Soil fertility	-0.0368	0.0438	-0.0152	0.0473
	(-1.14)	(1.29)	(-0.48)	(1.41)
Whether to join a cooperative	-0.182	-0.000390	-0.0514	0.140
	(-1.33)	(-0.00)	(-0.38)	(1.02)
Agricultural technology training	-0.00442	-0.0911	-0.0180	-0.149
	(-0.03)	(-0.73)	(-0.14)	(-1.21)
Disaster frequency	-0.159**	0.0190	-0.203***	-0.0867
	(-2.02)	(0.23)	(-2.63)	(-0.99)
Whether to buy agricultural insurance	0.0802	-0.0114	0.0294	0.00689
	(0.98)	(-0.14)	(0.35)	(0.08)
N	737	737	737	737

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5. Research Conclusions and Policy Recommendations

5.1. Research Conclusion

This article analyzes data from 743 household surveys conducted among rice farmers in Hubei Province in 2023, focusing on the role of agricultural socialization services in reducing the use of chemical fertilizers and pesticides, and thereby enhancing the ecological protection of cultivated land. The study confirms that agricultural socialization services substantially decrease the application of chemical inputs. Specifically, it was found that a 1% increase in the level of agricultural socialization services leads to a reduction of 14% and 16.4% in the application rates of chemical fertilizers and pesticides per mu, respectively. The mechanisms driving this impact include scale operation, factor substitution, and financial constraints, which serve as intermediaries in the relationship between agricultural socialization services and the reduction in chemical input use. Through expanding operational scales, enhancing factor substitution, and easing financial constraints, these services effectively reduce the use of chemical fertilizers and pesticides. Furthermore, heterogeneity analysis reveals that agricultural socialization services have a marked impact across all farm sizes, with the most significant reductions observed among large-scale farmers. When comparing generational differences, the services significantly lower chemical input use among both new and old generation farmers, with a notably stronger effect on the newer generation. Both technology-intensive and labor-intensive socialized services contribute significantly to the reduction of chemical inputs; however, technology-intensive services have a more pronounced effect.

5.2. Policy Recommendations

The policy recommendations derived from this article are as follows:Promote the Expansion of Farming Scale and Develop High-Standard Farmland: The research findings indicate that the larger the farming scale, the more effective the ecological protection of farmland facilitated by agricultural socialization services. Notably, once the planting scale exceeds 49.55 acres, the effectiveness of agricultural socialization services in reducing chemical fertilizer and pesticide use doubles. Future initiatives should therefore focus on enhancing the farmland of small and medium-sized farmers. This can be achieved by encouraging the consolidation of farmland through mergers and replacements, promoting the development of large-scale and high-standard farmland. Such strategies will maximize the benefits of agricultural socialization services in reducing chemical inputs. Increase Financial Support and Enhance Social Service Levels: Currently, the cost for farmers to adopt agricultural socialization services remains prohibitive, significantly diminishing planting income and hindering the widespread adoption and application of these services. To address this, it is recommended that the government increases subsidies for farmers who engage in agricultural socialization services. Modifying the subsidy framework from one based on cultivated land area to one based on service adoption levels could encourage farmers to utilize multiple aspects of agricultural socialization services, thereby advancing agricultural modernization.

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References

1. Zeng Fusheng, Shi Fang. How agricultural social services promote the organic connection between small farmers and modern agriculture - a theoretical analysis framework [J]. Journal of Jishou University (Social Science Edition), 2021, 42(03):92- 100.
2. Shi Zhiheng, Fu Yue. Discrepancy between agricultural socialized service organizations, land scale, and farmers' green production intentions and behaviors [J]. Journal of China Agricultural University, 2022, 27(03): 240-254.
3. Qing, C. and W. Zhou, et al. (2023). "Impact of outsourced machinery services on farmers' green production behavior: Evidence from Chinese rice farmers." Journal of Environmental Management 327: 116843.
4. Lin, Y. and R. Hu, et al. (2022). "The role of public agricultural extension services in driving fertilizer use in rice production in China." Ecological Economics 200: 107513.
5. Luo Mingzhong, Wei Binhui. Carbon emission reduction effect of agricultural producer services: effects and mechanisms [J]. Economic Jingwei, 2023, 40(04): 58-68.
6. Zhang Yingnan, Yin Yanshu, Zhang Kangjie, etc. Can agricultural social services promote the green production transformation of wheat farmers? ——Based on farmer household survey evidence in Henan, Shandong, and Shanxi [J]. China Population·Resources and Environment, 2023, 33(06): 172-181.
7. Zhang Zhongjun, Yi Zhongyi. Research on the impact of agricultural productive service outsourcing on rice productivity - an empirical analysis based on 358 farmers [J]. Agricultural Economic Issues, 2015, 36(10): 69-76.
8. Liu, Y. and N. Heerink, et al. (2022). "Do agricultural machinery services promote village farmland rental markets? Theory and evidence from a case study in the North China plain." Land Use Policy 122: 106388 .
9. Chen Jingshuai, Han Qing. The inhibitory effect of agricultural producer services on agricultural land abandonment [J]. Journal of South China Agricultural University (Social Science Edition), 2021, 20(06): 23-34.