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Original Research

Study on the Impact of Climate Change Information Sources on Farmers' Decisions on Adaptive Farming Behavior: Based on 1200 Questionnaires in Shaanxi Province, China

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Abstract

Adaptive farming behavior is a key strategy for farmers to cope with climate change. This paper aims to explore the potential impacts of climate change information sources on farmers' adaptive farming behavior. This paper clarifies the internal mechanism of three typical information sources, namely government departments, scientific research institutions and neighborhood communication, affecting farmers' adaptive farming behavior. Based on the sample data of 1200 farmers in the main wheat producing areas of Shaanxi Province, the theoretical conjecture is empirically tested. The results showed that the climate change information from government departments and scientific research institutions has a significant positive impact on farmers' adaptive farming behavior, but in the case of considering the three sources of information at the same time, the information source of scientific research institutions has the strongest positive impact on farmers' adaptive farming behavior. After farmers have access to climate change information exchanged by government departments, scientific research institutions and neighbors, their differences in climate change adaptive farming behavior mainly depend on their climate change cognition rather than subject trust factors. Formally organized climate change information represented by government departments and scientific research institutions has a more significant positive impact on farmers' adaptive farming behavior, but this impact depends largely on whether the information obtained by farmers can improve their climate change awareness.

Keywords: information source, climate change cognition, subject trust, adaptive farming behavior, China

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Introduction

Climate change is a serious challenge facing the international community, which significantly affects the economic development and national security of each country [1]. Agriculture is a sensitive and vulnerable sector affected by climate change [2]. Global warming and frequent extreme weather have increased the risk of agricultural production and posed a direct threat to food security [3]. China is a typical country that is negatively affected by climate change [4]. On the one hand, warming has led to a reduction in wheat production in parts of northern China [5]. On the other hand, frequent extreme climate disasters continue to increase the loss of agricultural production [6]. According to the data, from 1952 to 2019, the average annual crop drought and flood disaster areas in China increased by about 84.9 % and 139.4 % respectively. Actively responding to climate change and resisting climate risks to ensure food security has become a basic consensus of academia and government departments [7].

Mitigation and adaptation are two important policy focuses in response to climate change. Mitigating climate change focuses on reducing greenhouse gas emissions or increasing carbon sinks, while adapting to climate change focuses on adjustments based on actual or expected climate scenarios and their impacts. Greenhouse gas emission reduction is global, long-term and arduous. Public sectors such as the government usually play an important role in greenhouse gas emission reduction. At the micro level of farmers, it is more realistic and urgent to explore climate change adaptation closely related to yield and income [8]. Studies in developed countries such as the United States [9], Britain [10], etc., and less developed countries such as Ethiopia [11], Vietnam [12], etc., have shown that adopting climate change adaptive farming measures can significantly improve farmers' climate risk resilience and agricultural production efficiency. In China, more and more studies have also found that the adoption of adaptive farming measures has a positive impact on enhancing farmers' resistance to climate change risks, ensuring food security and increasing farmers' income [13]. Nevertheless, the adoption rate of farmers' adaptive farming measures is still generally low in actual production [14].

Out of concern for climate change risk response and farmers' welfare issues, a large number of studies have attempted to identify the constraints of farmers' adaptive farming behavior decisions, and then draw targeted incentive and guidance strategies. From the existing research, it is generally believed that adoption income [15], credit constraints [16], risk appetite [17], and climate change cognition [18] are the key factors affecting farmers' adaptive farming behavior decisions. Among them, the relationship between climate change cognition and farmers' climate adaptation behavior decision-making has received extensive attention. Behavior change theory believes that cognition is a key factor affecting behavior. Based on social cognitive theory, Bandura further points out that the combination of internal cognition and external environment determines individual behavior [19]. Based on the Theory of Planned Behavior, Ajzen found that individual behavior decision-making follows the 'cognition-stimulation-behavior' model [20]. Based on the above literature, the climate change adaptation model constructed by Grothmann & Patt also regards climate change cognition as one of the determinants of individual adaptation behavior decision-making [21]. However, it should be noted that farmers' cognition of climate change needs to be based on climate and related information, which can be obtained through farmers' own production experience, government departments, scientific research units or other farmers.

However, how climate change information sources affect farmers' adoption decisions has not been fully discussed. In theory, farmers hold different attitudes towards the authenticity and authority of climate change information from different sources, which may lead to differences in farmers' adaptation behavior. On the one hand, due to the differences in the form of publicity of information channels, even for the same climate change knowledge, different information sources are difficult to achieve the same effect in improving farmers' awareness of climate change. More importantly, if farmers cannot form a correct understanding of climate change, it will be difficult to take appropriate adaptation measures. On the other hand, the interest relationship between the subjects behind the information transmission, especially in the context of information asymmetry, the degree of trust between the subjects becomes the key to whether farmers accept a certain climate change information and take action. Therefore, it is logical to judge that the source of climate change information has important genetic significance for climate change adaptation behavior. In thus, this study uses the sample data of 1200 farmers in the main wheat producing areas of Shaanxi Province in 2022 to quantitatively estimate the impact of climate change information sources on farmers' adaptive farming behavior. This study not only helps to deepen our understanding of the decision-making mechanism of farmers' climate change adaptation behavior, but also helps to provide valuable policy reference for further publicity of climate change information. In short, this study aims to accomplish two main objectives:

- To explore the internal mechanism of three typical information sources of government departments, scientific research institutions and neighborhood communication affecting farmers' adaptive farming behavior.
- This study attempts to construct a theoretical framework of climate stimulus-information intervention-adaptive behavior.

Theoretical Framework

Climate Change Information Sources and Adaptive Farming Behavior

Climate change adaptation refers to the adjustment made by farmers according to actual or expected climate stimulation and its impact [22]. Further, farmers choose the corresponding farming methods according to the actual or expected changes in climatic conditions, which is called adaptive farming [23]. The decision-making of farmers' adaptive farming measures is affected by multiple factors [24]. The theory of behavioral change emphasizes the important role of cognitive factors [25]. Individuals' response to disasters depends largely on their risk perception, including the existence of natural disasters and the degree of trust in information sources [26]. Similarly, farmers need to form a correct understanding of climate change before dealing with climate change risks [14]. However, different from other agricultural production information, climate change information, as professional scientific and technological information, usually exceeds farmers' own learning and computing ability, and relies more on the transmission and guidance of external information, so as to improve farmers' awareness of the impact of climate change and adaptation strategies, and ultimately become an important basis for farmers to adopt adaptation measures [27].

Generally speaking, farmers' access to climate change information mainly includes two channels: one is the formal channel, that is, farmers obtain information on climate change from publicity and education activities carried out by government technology promotion departments or scientific research institutions [28]. The second is informal channels, that is, farmers summarize their own production experience, form an experience summary of past climate change rules, a nd predict climate change trends [29]. Further, farmers' cognition of climate change based on experience realizes knowledge sharing through the dissemination of social networks and social learning [30]. This paper explores the impact of different climate change information sources on farmers' adaptive farming behavior from three dimensions: government departments, scientific research institutions and neighborhood communication.

Government departments are the providers and disseminators of climate change information, and the information they release has significant characteristics such as influence, appeal and credibility [31]. In practice, the government disseminates climate change information to farmers mainly through agricultural technology promotion and professional skills training [32]. The specific measures of agricultural technology extension refer to the government's promotion to farmers on how to design and implement specific adaptation measures to adapt to the impact of climate change [33]. Professional technical training is based on the guidance of farmers' planting technology and climate risk identification, and puts forward information and suggestions for adaptation or coping strategies [34]. Combined with the above analysis, climate change information from the government affects the public's perception of climate change to a large extent. According to the theory of behavioral change, farmers are more inclined to adopt adaptive measures after they have the cognition of climate change impact theory and the cognition of the effectiveness of adaptation measures.

Scientific research institutions are the main body of scientific and technological exploration, as well as the main body of the dissemination of advanced science and technology and scientific knowledge [35]. The climate change information they disseminate is systematic, professional and authoritative. In the field of agriculture in China, scientific research institutions engaged in climate change research mainly include universities and agricultural research institutes, which play an important role in the service and promotion of agricultural climate change adaptation technology [36]. More and more facts show that the agricultural technology communication system of scientific research institutions has greatly promoted the transformation and application of new varieties and new technologies [37]. However, in the climate change information scenario, limited by factors such as information transmission and scientific and cultural quality, whether the theoretical and practical information dissemination related to climate change in scientific research institutions can stimulate farmers' adaptation behavior still needs further empirical test [38].

Neighborhood communication is a traditional way of communication for Chinese farmers, which has the characteristics of short transmission path and high efficiency [39]. Due to the information occlusion and narrow communication channels between farmers, agricultural production information is usually transmitted through the social network formed by the interaction of 'relationship circles' formed by blood, kinship and geography under the background of 'acquaintance society' [40]. In a relatively close social network relationship, in addition to obtaining information from services such as agricultural extension, it is an important way for farmers to obtain climate change information from their neighbors [41]. In particular, China's agricultural management pattern is still dominated by scattered small-scale farmers [42]. The information exchange between adjacent farmers effectively reduces the cost of information transmission and information acquisition [43]. As a group with frequent contact in farmers' social network relations, relatives and friends have high frequency of information exchange and are prone to spatial dependence [44]. The dissemination and exchange of climate change information between farmers' neighbors has realized the sharing of information and enhanced the awareness of climate change, which may stimulate farmers' adaptive behavior.

Hypothesis H1. Climate change information sources have a positive impact on farmers' adaptive farming behavior.

Subjective Trust and Climate Change Cognition

Climate change information sources are constructed and disseminated by society. However, at the individual level, differences in world outlook, personal experience, expectations for technology, and trust in the subject will affect the perception and understanding of risks, as well as decisions and behavioral choices to respond. In particular, the social characteristics of low trust and differential pattern are common in rural areas of China. In rural interpersonal communication, there is a cognitive structure judgment of whether it belongs to own people, that is, farmers have different degrees of trust in different subjects [45]. The degree of trust of different subjects determines that farmers are willing to pay trust on a subject or rely on the information and suggestions provided by the subject to take action. In terms of farmers' trust, many studies have found that trust has a significant impact on farmers' behavior choice. Montefrio et al. (2015) study found that social trust has a significant positive impact on farmers' low-carbon production behavior [46]. Bouma et al. (2008) research shows that the higher the farmers' trust in relatives and friends, villagers and village cadres, the more they can promote communication and cooperation and achieve collective action [47]. It can be seen that in the choice of individual behavior, subject trust may indeed be used as a moderating variable to regulate the information source-adaptive farming behavior. Farmers produce adaptive farming behavior on the basis of understanding climate change [48]. Information source is the external condition for farmers to obtain information, and climate change cognition is the internal factor of farmers' behavior choice [49]. In the context of specific climate change risks, rational farmers, based on the harmful consequences of risk perception on agricultural input and output, adopt adaptive behaviors while pursuing the maximization of benefits and combining their own capabilities [50]. Therefore, it can be understood that although the source of climate change information is an important way for farmers to recognize climate change, cognition is the substantive and internal reason for farmers' adaptive farming behavior after obtaining climate change information from different channels. It can be inferred that climate change cognition, as an internal factor, may play a regulatory role between climate change information sources and farmers' adaptive farming behavior.

Hypothesis H2. Subject trust and climate change cognition positively moderates the relationship between climate change information sources and farmers' adaptive farming behavior.

Based on the previous theoretical analysis, this paper constructs a theoretical analysis framework of climate stimulus-information intervention-adaptive behavior (as shown in Fig. 1). In general, under the stimulation of the external environment of climate change, farmers have obtained climate change information from government departments, scientific research institutions and neighbors, and finally stimulated their adaptive farming behavior through the regulation of subject trust and climate change cognition.

Materials and Methods

Data Sources

The data used in this paper are derived from the questionnaire survey of farmers in the main wheat producing areas of Shaanxi Province conducted by the research group in July and September 2022. China is a large country of wheat production and consumption, and wheat is one of the most sensitive crop types and production systems affected by climate change. Therefore, this study focuses on the adaptive farming behavior of farmers in the main wheat producing areas to cope with climate change. In terms of climate change,

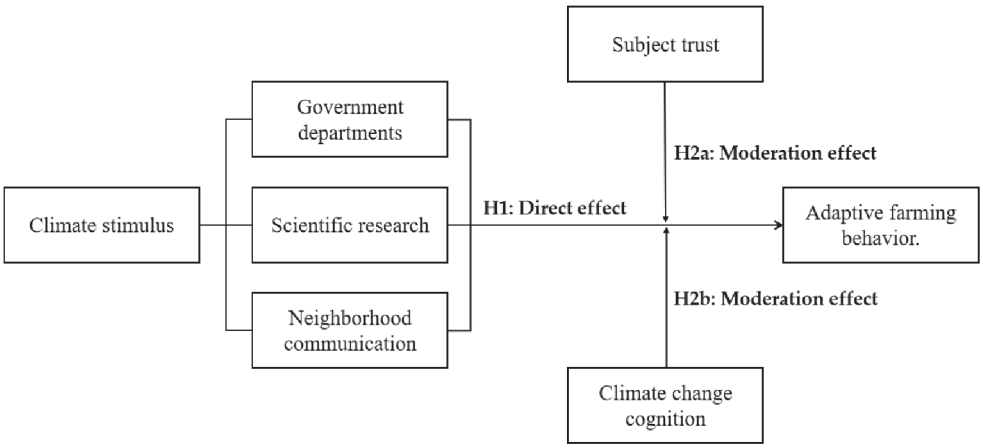

Fig. 1. Research Model.

Shaanxi Province belongs to the subtropical monsoon climate, the climate terrain is complex and diverse, and the summer is hot and rainy. In recent years, climate disasters such as waterlogging and drought have occurred frequently. In terms of geographical factors, Shaanxi Province (105°30'~108°24'E, 32°15'~33°56'N) is located in the Guanzhong Plain. It is the main producing area of wheat in China and is vulnerable to meteorological disasters. It is of practical significance to study the adaptive farming behavior of farmers to ensure food security in China.

Variables Measurement

The survey adopted a multi-stage random sampling method. In the first stage, Weinan, Baoji, Xi'an and Hanzhong were selected as sample collection areas. In the second stage, 1~2 townships were randomly selected in the sample city, a total of 5 townships. In the third stage, 2 to 4 townships were randomly selected in each sample county, a total of 17 townships. In the fourth stage, 1-3 villages were randomly selected in each sample township, a total of 40 villages. Finally, 30~40 farmers were randomly selected from each sample village, and a total of 1500 farmers were surveyed. According to the research content of this paper, a total of 1200 valid questionnaires were obtained after eliminating the blank, missing key information and answering contradictory questionnaires, with an effective rate of 80%.

Benchmark Regression Model

This paper focuses on the impact of climate change information sources on farmers' adaptive farming behavior, as well as the differences in the impact of farmers' trust in different subjects and their awareness of climate change on adaptive farming behavior. Therefore, this paper constructs an interaction model that does not include and includes the degree of trust of the subject and the source of information, climate change cognition and the source of information for empirical test. Since farmers' adaptive farming behavior is a binary dummy variable, this paper uses the Probit model to study the impact of climate change information sources on farmers' adaptive farming behavior. The model expression without interaction terms is as follows:

$$Y_i = \alpha_0 + \alpha_1 Source_{Si} + \alpha_2 \sum_i C_i + D_i + \varepsilon_i \quad (1)$$

In the formula (1), it indicates whether the family Y_i has a binary dummy variable of adaptive farming behavior in the face of climate change risk. In the face of climate change, farmers adopt corresponding water and fertilizer management measures at the appropriate stage of rice growth. $Source_{Si}$ represents different information sources, including three dimensions: government departments, scientific research institutions, and neighborhood communication. C_i represents the control variables, including the individual characteristics of the agricultural production decision-makers of the i th peasant household (gender, age, health level, years of education, years of farming, whether they are members of cooperatives), the family characteristics of the i th peasant household (total income, agricultural income, non-agricultural income ratio, number of agricultural labor force, whether part-time employment, whether the family has a fixed broadband network), and the agricultural production characteristics of the i th peasant household (whether there is land transfer, average distance from home to field, number of plots, land area). D_i represents the virtual variable of the region where the farmer i is located, which is used to control the regional fixed effects such as climate conditions and pests and diseases. α_0 is the intercept term, α_1 and α_2 are the parameters to be estimated.

Introduction of Interaction Term Model

The model expression containing the interaction term is as follows:

$$Y_i = \alpha_0 + \alpha_1 Source_{Si} + \alpha_2 Trust_i + \alpha_3 Source_{Si} \times Trust_i + \alpha_4 \sum_I C_i + D_i + \varepsilon_i \quad (2)$$

$$Y_i = \alpha_0 + \alpha_1 Source_{Si} + \alpha_2 Con_i + \alpha_3 Source_{Si} \times Con_i + \alpha_4 \sum_I C_i + D_i + \varepsilon_i \quad (3)$$

In the formula (2), $Trust_i$ represents the subject trust variable, and $Source_{Si} \times Trust_i$ represents the interaction term between the information source and the subject trust. In the formula (3), Con_i represents the variable of climate change cognition, and $Source_{Si} \times Con_i$ represents the interaction between information source and climate change cognition. The definitions of other variables and parameters are consistent with those in the formula (1). In order to overcome the multicollinearity problem that the interaction term may cause, this paper centralizes the interaction term.

Variable Selection and Description

(1) Explained variables. Farmers' adaptive farming behavior is the explained variable of this study. In the measurement of farmers' adaptive farming behavior, referring to the research of Feola et al. (2015) and combining with the actual situation of farmers in the survey area, the question 'whether you adopt water and fertilizer management measures to adapt to climate change in the growth stage of wheat' is used to measure.

(2) Explanatory variables. The main explanatory variables of this paper are climate change information sources, and the moderating variables are subject trust and climate change cognition. In terms of climate change information sources, according to the research of Mase et al. (2015) and the content of this questionnaire

survey [51], the climate change information sources are divided into three dimensions: the first dimension is the government department, which is characterized by asking whether the climate change information obtained comes from the propaganda of the government department. The second dimension is the representation of scientific research institutions asking whether the climate change information obtained is from the science popularization of universities or agricultural academies. The third dimension is neighborhood communication, which is represented by the question' Do you communicate information about climate change adaptation with your neighbors'.

(3) Control variables. In order to eliminate the interference of other factors, this paper controls the variables of householder's personal characteristics, family characteristics, production characteristics, and incorporates regional dummy variables to control regional fixed effects. The meaning and assignment of all variables are shown in Table 1.

Results

Benchmark Model Estimation Results

Table 2 reports the estimation results without interaction terms. Regressions 1-3 report the impact of three types of climate change information sources, including government departments, scientific research institutions and neighborhood exchanges, on farmers' adaptive farming behavior. Regression 4 also considers the impact of three types of information sources on farmers' adaptive farming behavior.

According to the results of regression 1 in Table 2, the impact of government climate change information sources is significant, and the impact coefficient and marginal effect are positive. This shows that climate change information from government departments can significantly increase the probability of farmers' adoption of adaptive farming behavior. The model estimation results are consistent with the previous theoretical expectations. This shows that the climate change information from government departments has the advantages of transmission channels and modes of transmission. It can timely and effectively transmit new knowledge and new technologies on climate change and adaptive farming measures to farmers, so that farmers have a high degree of adoption of information issued by government departmentsThe estimation results of regression 2 in Table 2 show that the impact of climate change information sources of scientific research institutions is significant, and the impact coefficient and marginal effect are positive. This shows that farmers are more inclined to adopt adaptive farming behavior after obtaining climate change information from scientific research institutions. It is not difficult to understand that scientific research institutions, as the 'main battlefield' for the dissemination of scientific knowledge, provide farmers with professional information and scientific guidance, while farmers have a higher degree of acceptance and adoption of professional information provided by authoritative institutions.

The estimation results of Regression 3 in Table 2 show that the impact of climate change information from neighbors on farmers' adoption of adaptive farming behavior is negative, but it does not pass the significance test. This shows that the climate change information obtained by farmers based on neighborhood communication has no significant impact on their adoption of adaptive farming behavior. The possible reason is that, combined with the atomization of rural society in China, especially in the central region, it can be seen that rural society has gradually disintegrated from the traditional society, and the traditional social communication and information transmission functions may have weakened.

The estimation results of regression 4 in Table 2 show that after the variables of scientific research institutions and neighborhood communication are included, the variables of government institutions are no longer significant, and the results of the variables of scientific research institutions are still significant. This shows that after considering the three main sources of information, the positive impact of climate change information sources of scientific research institutions on farmers' adaptive farming behavior is the strongest.

Interaction Term Model Estimation Results

The interaction of subject trust. As mentioned above, trust factors may have a moderating effect between climate change information sources and farmers' adaptive farming behavior. Based on this, this paper conducts further analysis by incorporating the interaction between subject trust and information sources in the model. Table 3 reports the estimation results of the model with interaction terms. The regression results show that the interaction coefficient of trust between government departments, scientific research institutions and subjects is positive, but it does not pass the significance test; the interaction coefficient between neighborhood communication and subject trust is negative, but it also fails the significance test. This shows that there is no significant moderating effect of subject trust between climate change information sources and farmers' adaptive farming behavior. In other words, whether farmers will adopt adaptive farming behavior for climate change information from different channels does not depend on the trust of the information source.

Interaction Term Model Estimation Results

The interaction of subject trust. As mentioned above, trust factors may have a moderating effect between climate change information sources and farmers' adaptive farming behavior. Based on this,

Table 1. Variable names and descriptive statistics.

Variable Name and Variable Description			Mean	S.D.
Adaptive farming behavior	Water and Fertilizer Management Measures	Whether farmers adopt water and fertilizer management measures to adapt to climate change at the appropriate stage of rice growth: yes = 1; no = 0	0.548	0.498
Information source	Government departments	Whether the obtained climate change information comes from government propaganda: yes = 1; no = 0	0.255	0.436
	Scientific research	Whether the obtained climate change information comes from the popular science of colleges and universities or agricultural academies: yes = 1; no = 0	0.065	0.247
	Neighborhood communication	Whether to exchange information on climate change adaptation with neighbors: yes = 1; no = 0	0.224	0.417
Subject trust	Government trust	Very distrust~very trust = 1~5	3.912	0.891
	Trust in scientific research	Trust in institutions of higher learning and agricultural academies (scientific institutions, scientific research institutions, scientists): Very distrust~very trust = 1~5	3.978	0.891
	Farmers trust	Trust in neighbors: Very distrust~very trust = 1~5	3.937	0.795
Cognitive level	Climate change cognition	The importance of climate change (value): Very low~Very high = 1~5	3.590	1.067
Farmers characteristics	Total household income	Total annual household income / ten thousand yuan	6.609	6.465
	Agricultural income	Household annual agricultural income / ten thousand yuan	1.905	4.099
	Income structure	Non-agricultural income share	0.690	0.344
	Agricultural labour force	Number of people engaged in agricultural production / person	1.864	0.764
	Part-time situation	In 2021, whether the main labor force is also a business worker: yes = 1; no = 0	0.590	0.492
	Information Services	Whether the family installs a fixed broadband network: yes = 1; no = 0	0.604	0.489
Individual characteristics	Gender	Male = 1; female = 0	0.698	0.459
	Age	Actual age	58.327	9.395
	Health level	Very poor~very good = 1~5	3.417	0.907
	Years of education	Farmers , actual years of education / year	7.111	3.222
	Years of farming	Years of farming / year	36.201	13.110
	Cooperative members	Whether the head of household participates in farmers, professional cooperatives: yes = 1; no = 0	0.238	0.426
Production characteristics	Land transfer	With or without land transfer: yes = 1; no = 0	0.376	0.485
	Field distance from home	Average distance from home to field / m	550.827	742.679
	Land quantity	Land quantity / block	9.864	13.552
	Land area	Land area / mu	14.527	27.123
Region dummy variable	Setting regional dummy variables by county	Chang'an County, Xi 'an City = 1, other = 0	0.198	0.399
		Fuping County, Weinan City = 1, others = 0	0.223	0.416
		Dali County, Weinan City = 1, others = 0	0.132	0.338
		Meixian County, Baoji City = 1, others = 0	0.225	0.418
		Chenggu County, Hanzhong City = 1, other = 0	0.223	0.416

Table 2. The model estimation results of the influencing factors of farmers' adaptive farming behavior (no interaction term is introduced).

Variable	Regression (1)		Regression (2)		Regression (3)		Regression (4)	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Government departments	0.231**	0.088**	-	-	-	-	0.163	0.062
	(0.105)	(0.040)	-	-	-	-	(0.110)	(0.042)
Scientific research	-	-	0.502**	0.191**	-	-	0.416**	0.158**
	-	-	(0.197)	(0.074)	-	-	(0.206)	(0.078)
Neighborhood communication	-	-	-	-	-0.038	-0.014	-0.038	-0.014
	-	-	-	-	(0.112)	(0.043)	(0.113)	(0.043)
Gender	0.092	0.035	0.120	0.046	0.096	0.037	0.117	0.044
	(0.098)	(0.037)	(0.098)	(0.037)	(0.098)	(0.037)	(0.099)	(0.037)
Age	-0.004	-0.002	-0.004	-0.001	-0.004	-0.002	-0.004	-0.002
	(0.006)	(0.002)	(0.007)	(0.002)	(0.007)	(0.003)	(0.007)	(0.002)
Health level	0.008	0.003	0.009	0.004	0.008	0.003	0.010	0.004
	(0.051)	(0.019)	(0.051)	(0.019)	(0.051)	(0.019)	(0.051)	(0.019)
Years of education	0.017	0.006	0.018	0.007	0.021	0.008	0.015	0.006
	(0.014)	(0.005)	(0.014)	(0.005)	(0.014)	(0.005)	(0.015)	(0.005)
Years of farming	0.004	0.002	0.004	0.001	0.004	0.002	0.004	0.002
	(0.005)	(0.002)	(0.005)	(0.002)	(0.005)	(0.002)	(0.005)	(0.002)
Cooperative members	0.033	0.013	0.055	0.021	0.097	0.037	0.019	0.007
	(0.115)	(0.044)	(0.111)	(0.042)	(0.110)	(0.042)	(0.115)	(0.044)
Total household income	0.032***	0.012***	0.033***	0.012***	0.033***	0.013***	0.032***	0.012***
	(0.011)	(0.004)	(0.011)	(0.004)	(0.011)	(0.004)	(0.011)	(0.004)
Agricultural income	0.002	0.001	0.001	0.000	0.005	0.002	-0.001	-0.000
	(0.023)	(0.009)	(0.022)	(0.009)	(0.023)	(0.009)	(0.022)	(0.009)
Income structure	0.220	0.084	0.273	0.104	0.251	0.096	0.250	0.095
	(0.174)	(0.066)	(0.173)	(0.065)	(0.174)	(0.066)	(0.174)	(0.066)
Agricultural labour force	0.034	0.013	0.035	0.o13	0.030	0.012	0.036	0.014
	(0.056)	(0.021)	(0.057)	(0.022)	(0.057)	(0.022)	(0.057)	(0.021)
Part-time situation	-0.055	-0.021	-0.058	-0.022	-0.067	-0.026	-0.047	-0.018
	(0.096)	(0.036)	(0.096)	(0.036)	(0.096)	(0.037)	(0.096)	(0.036)
Information Services	0.008	0.003	0.002	0.001	0.017	0.007	-0.002	-0.001
	(0.093)	(0.035)	(0.093)	(0.036)	(0.092)	(0.035)	(0.093)	(0.035)
Land transfer	0.104	0.040	0.119	0.045	0.117	0.045	0.110	0.042
	(0.092)	(0.035)	(0.092)	(0.035)	(0.091)	(0.035)	(0.092)	(0.035)
Field distance from home	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Land quantity	0.001	0.000	0.002	0.001	0.001	0.000	0.002	0.001
	(0.004)	(0.002)	(0.004)	(0.002)	(0.004)	(0.002)	(0.004)	(0.002)
Land area	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)

Table 2. Continued.

Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cons	-0.546		-0.595		-0.553		-0.569	
	(0.435)		(0.436)		(0.437)		(0.436)	
R^2	0.036		0.037		0.032		0.039	
N	1200	1200	1200	1200	1200	1200	1200	1200

Note: 1) ***, ** and * were expressed as significant at 1 %, 5 % and 10 % significance level, respectively; 2) Robust standard error in parentheses

this paper conducts further analysis by incorporating the interaction between subject trust and information sources in the model. Table 3 reports the estimation results of the model with interaction terms. The regression results show that the interaction coefficient of trust between government departments, scientific research institutions and subjects is positive, but it does not pass the significance test; the interaction coefficient between neighborhood communication and subject trust is negative, but it also fails the significance test. This shows that there is no significant moderating effect of subject trust between climate change information sources and farmers' adaptive farming behavior. In other words, whether farmers will adopt adaptive farming behavior for climate change information from different channels does not depend on the trust of the information source.

The moderating effect of climate change cognition. Further, in order to explore the relationship between the impact of information sources and farmers' adaptive farming behavior adoption, this study incorporates the interaction between information sources and climate change cognition into the model. Table 4 reports the estimation results of the interaction term model including climate change cognition. It can be found that the interaction between government departments and climate change cognition is significant, and the coefficient is positive (regression 8), indicating that the higher the degree of farmers' cognition of climate change, the stronger the impact of climate change

Table 3. The model estimation results of the influencing factors of farmers' adaptive farming behavior (no interaction term is introduced).

Variable	Regression (5)		Regression (6)		Regression (7)	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Government departments	0.108	0.041	-	-	-	-
	(0.114)	(0.043)	-	-	-	-
Government trust	0.149***	0.056***	-	-	-	-
	(0.0541)	(0.020)	-	-	-	-
Scientific research	-	-	0.434**	0.160**	-	-
	-	-	(0.203)	(0.074)	-	-
Trust in scientific research	-	-	0.302***	0.111***	-	-
	-	-	(0.054)	(0.019)	-	-
Neighborhood communication	-	-	-	-	-0.047	-0.017
	-	-	-	-	(0.114)	(0.043)
Trust in neighbors	-	-	-	-	0.290***	0.109***
	-	-	-	-	(0.060)	(0.022)
Government departments × Government trust	0.181	0.068		-	-	-
	(0.134)	(0.051)		-	-	-
Scientific research × Trust in scientific research	-	-	0.262	0.097	-	-
	-	-	(0.268)	(0.099)	-	-
Neighborhood communication × Trust in neighbors	-	-	-	-	-0.260	-0.097
	-	-	-	-	(0.170)	(0.063)

Table 3. Continued.

Control variable	Yes	-	Yes	-	Yes	-
Cons	-1.012	-	-1.685	-	-1.727	-
	(0.483)		(0.486)		(0.496)	
R^2	0.047	-	0.067	-	0.051	-
N	1200	1200	1200	1200	1200	1200

Note: 1) ***, ** and * were expressed as significant at 1 %, 5 % and 10 % significance level, respectively; 2) Robust standard error in parentheses

Table 4. Model estimation results of influencing factors of farmers' adaptive farming behavior (interaction between information sources and climate change cognition).

Variable	Regression (8)		Regression (9)		Regression (10)	
	Coefficient	Marginal Effect	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Government departments	0.154	0.058	-	-	-	-
	(0.110)	(0.041)	-	-	-	-
Climate change cognition	0.091**	0.034**	-	-	-	-
	(0.046)	(0.017)	-	-	-	-
Scientific research	-	-	0.395*	0.148*	-	-
	-	-	(0.208)	(0.077)	-	-
Climate change cognition	-	-	0.114***	0.043***	-	-
	-	-	(0.042)	(0.015)	-	-
Neighborhood communication	-	-	-	-	0.001	0.000
	-	-	-	-	(0.115)	(0.043)
Climate change cognition	-	-	-	-	0.101**	0.038**
	-	-	-	-	(0.044)	(0.017)
Government departments × Climate change cognition	0.219**	0.082**	-	-	-	-
	(0.106)	(0.040)	-	-	-	-
Scientific research × Climate change cognition	-	-	0.455**	0.170**	-	-
	-	-	(0.207)	(0.077)	-	-
Neighborhood communication × Climate change cognition	-	-	-	-	0.233**	0.088**
	-	-	-	-	(0.116)	(0.043)
Control variable	Yes	-	Yes	-	Yes	-
Cons	-0.744	-	-0.899	-	-0.707	-
	(0.460)		(0.448)		(0.466)	
R^2	0.047	-	0.050	-	0.045	-
N	1200	1200	1200	1200	1200	1200

Note: 1) ***, ** and * were expressed as significant at 1 %, 5 % and 10 % significance level, respectively; 2) Robust standard error in parentheses

information from government departments on their adaptive farming behavior. The interaction between scientific research institutions and climate change cognition is significant and the coefficient is positive (regression 9). This shows that the higher the degree of farmers' awareness of climate change, the higher

the possibility of farmers adopting adaptive farming behavior after obtaining climate change information from scientific research institutions. The interaction between neighborhood communication and climate change cognition is significant and the coefficient is positive (regression 10). This shows that the higher the farmers' awareness of climate change, the stronger the promotion effect of climate change information exchanged by farmers' neighbors on their adaptive farming behavior.

According to the estimation results of the above interaction term model, climate change cognition has a significant moderating effect between information sources and farmers' adaptive farming behavior, while the moderating effect of subject trust is not significant. This shows that after farmers obtain climate change information from government departments, scientific research institutions and neighbors, their differences in climate change adaptive farming behavior mainly depend on their climate change awareness level. Therefore, it is not difficult to speculate that no matter what kind of climate change information source is faced, if farmers' own awareness of climate change cannot be improved, farmers' adaptive farming behavior adoption decisions cannot be effectively stimulated.

Discussion

In the context of China's specific ecological strategy, climate change information sources can influence farmers' adaptive farming behavior through government departments, scientific research institutions and neighborhood exchanges. Li and Geng (2013) affirmed the impact of climate on adaptive farming behavior [52]. Based on the definition of climate change information sources by Barnes et al. (2013), this paper divides the dimensions of climate change information sources, and comprehensively examines the impact of different dimensions of climate change information sources on farmers' adaptive farming behavior [53]. Based on different research dimensions, we reiterate the positive role of climate change information sources in promoting farmers' adaptive farming behavior. Although farmers' climate change information sources are affected by many factors, the existence of climate change information sources has greatly affected farmers' behavior. Similarly, this result is consistent with Zamasiya et al. (2017) 's conclusion that climate change information sources positively affect farmers' environmental behavior and Liu et al. (2019)'s conclusion that climate change information sources promote farmers' participation in land transfer, indicating that in all areas of pro-environmental behavior, climate change information sources still play a vital role in rural social development [54, 55]. Therefore, it is necessary to solve the comprehensive value of climate change information sources. It is worth noting that in this study, when measuring the influence path of variables such as government departments, scientific research institutions and neighborhood communication, the influence of individual variables is different from the existing research results. On this basis, this paper measures social capital through subject trust and climate change cognition, and expands research. The study found that topic trust and climate change cognition have a significant impact on farmers' adaptive farming behavior. The climate change information from government departments and scientific research institutions has a significant positive impact on farmers' adaptive farming behavior, but in the case of considering the three sources of information at the same time, the information source of scientific research institutions has the strongest positive impact on farmers' adaptive farming behavior. After farmers have access to climate change information exchanged by government departments, scientific research institutions and neighbors, their differences in climate change adaptive farming behavior mainly depend on their climate change cognition rather than subject trust factors. Formally organized climate change information represented by government departments and scientific research institutions has a more significant positive impact on farmers' adaptive farming behavior, but this effect depends largely on whether the information obtained by farmers can improve their climate change awareness.

Conclusions

Due to the abstraction and complexity of climate change issues, farmers need to obtain relevant information from the outside as a basis for adaptive behavior decision-making. This study constructs a theoretical analysis framework of " climate stimulation-information intervention-adaptive behavior," and clarifies the internal mechanism of the three typical information sources of government departments, scientific research institutions and neighborhood communication affecting farmers' adaptive farming behavior. On this basis, this study uses the sample data of 1200 farmers in the main wheat producing areas of Shaanxi Province to empirically test the theoretical conjecture. The results show that: (1) Climate change information from government departments and scientific research institutions has a significant positive impact on farmers' adaptive farming behavior, but in the context of considering three information sources at the same time, the positive impact of scientific research institutions on farmers' adaptive farming behavior is the strongest. (2) After obtaining climate change information from government departments, scientific research institutions and neighbors, farmers' differences in climate change adaptive farming behavior mainly depend on their climate change cognition rather than trust factors.

Suggestions

First, the climate change information of formal organizations represented by governments and scientific research institutions plays an important role in promoting farmers to adopt adaptive farming behavior decisions. Therefore, in terms of climate change information dissemination, governments at all levels should pay full attention to the authenticity, timeliness and effectiveness of information release by authoritative departments, and provide farmers with more professional and systematic climate change information. Secondly, local government departments should further strengthen village information service capabilities and information construction, reduce farmers' information search costs, pay attention to the construction and maintenance of information transmission channels, and ensure that information on meteorological information and climate change adaptive farming measures can be timely disseminated to farmers.

Third, the dissemination of climate change information should focus on improving farmers' awareness of climate change, strengthen the education and training of agricultural technology promotion departments and scientific research institutions, truly improve farmers' awareness of the impact of climate change and adaptive strategies, and promote the transformation of farmers' behavior from 'passive acceptance' to 'active adoption'.

Limitations and Future Research Directions

The research results of this paper are based on the current data of a certain time point, which is static, while the interaction between various factors is a dynamic process. The data of influencing factors and variables will change constantly, and with the change of data, model will also change to some extent. This study is still unable to grasp the development trend of data, which is the limitation of this paper and most experimental articles. When conditions permit, the survey data of different periods should be collected, the model of different data in different periods should be established, and the model and results should be compared and analyzed to make the results more scientific.

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Conflict of Interest

The authors declare no conflict of interest.

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