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Analysis of the Influence of Agricultural Natural Disaster on Farmers' Technology Adoption Decision

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Xinjiang is the main cotton-producing area in China. However, its natural environment is special, and natural disasters frequently occur during the agricultural production process. Fortunately, the application of modern agricultural production technology provides a good tool for cotton farmers to reduce disaster losses. In order to analyze the impact of agricultural natural disasters on farmers' adoption of agricultural production technology, based on the survey data of 216 cotton farmers in the main cotton production areas, this study uses a binary logistic model to analyze the impact of disaster types and stages on cotton farmers' application of drip irrigation water-saving technology. The results show that hail, drought, and disease disasters have a significant impact on the application of drip irrigation water-saving technology, considering that the damage to equipment and technology's control of disasters are the reasons behind; post-disaster remediation in the growth or maturity period also has a significant impact, which can reduce losses; and market price risk for cotton also has a significant impact.

Keywords: agricultural disasters, disaster stages, farmers' willingness to adopt technology, water-saving technology, environment

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1 INTRODUCTION

Technological progress has greatly promoted the development of society and economy, and has had a profound impact on all aspects of the economy (Sun et al., 2021a). In Xinjiang, where natural disasters are frequent, the advancement of agricultural technology has provided a guarantee for agricultural production. In agricultural production, farmers' adoption of agricultural production technology depends not only on technology itself but also on policy incentives and farmers' cognition. From the perspective of relevant research, the focus of farmers' technology adoption behavior decision-making mainly focuses on the impact of factor input and farmers' subjective willingness on agricultural production technology adoption.

Some scholars have focused on the impact of technology application and technological progress on farmers' production activities, and the factors that affect farmers' decision to adopt technology. Wu et al. found that improved upland rice technology has a robust and positive effect on farmers' well-being; however, the impact of technological improvement on producer income is decreasing, and continuous innovation is needed to replace the old technologies that have reached their saturation points (Wu et al., 2010). Vijayasarathy and Ashok analyzed from the perspective of technical efficiency of crop production and concluded that farmers can improve their adaptability to climate change after adopting technology (Vijayasarathy and Ashok 2015). Ainembabazi and others believe that market cost and market income are the main driving forces for farmers to use green production technology; gradual advances in technology development and continuous retraining of farmers are essential for sustainable adoption of agricultural technologies for some crops (Ainembabazi and Mugisha 2014). Perret and Stevens analyzed from the perspective of transaction cost that the adoption of technology depends not only on the willingness of individual farmers but also on property rights of resources and collective community action (Perret and Stevens 2006). Chang and others analyzed the types, methods, causes, and results of technology adopted by farmers. It is found that new technologies such as tractor farming, mechanical planting, irrigation, and the combination of organic fertilizer and commercial fertilizer have resulted in high output of agricultural products and hybrid crops, saving labor, and increasing farmers' income (Chang and Tsai 2015; Baležentis et al., 2021).

In addition to planting technologies that have a direct impact on agricultural production activities, technologies that indirectly affect agricultural production activities such as information and communication technology have also been the focus of scholars. Wang, Geling, and others believe that social networks and extension services can improve the efficiency of farmers' agricultural technology adoption. Farmers obtain technical information through social interaction, determine the expected return of technology, and make adoption decisions. Social networks have the functions of providing information, reducing risks, and making up for the defects of formal systems (Wang et al. 2020). Maredia, mywish K, and others believe that with the rapid spread of communication technology (ICT) in developing countries, mobile phones have great potential in spreading agricultural information technology to farmers. Through the field experiment in Burkina Faso, it is found that the animation video transmitted by mobile phones can help farmers with low literacy rates to learn and improve the adoption of science and technology (Maredia et al., 2018). Salik, Muzaffar Hussain, and others believe that farmers can help them adopt the latest agricultural information and modern agricultural technology by listening to more radio agricultural programs. Majority of the farmers reported that radio communication is helpful "to some extent" because of the information for the preparation of soil, crop varieties, suitable fertilizers, sowing time, and improved inputs (regarding drip irrigation, tunnel farming, hydroponic agriculture, etc.) (Salik et al., 2021).

As a guiding agency, the policies issued by the government and the environment created have a greater impact on economic activities (Sun et al., 2021b), including agricultural production. Ike et al. analyzed the reasons why farmers did not continue to adopt technology from the perspective of financial support. The study found that farmers did not have enough funds to maintain their small ponds and buy necessary feed and other aquaculture necessities. By providing credit facilities to farmers, the level of aquaculture technology in Nigeria can be improved (Ike and Roseline 2007). Suvedi and others believe that the wide use of new technologies requires a favorable social and institutional environment. Because contexts vary by country or region, extension service providers should create institutions favorable for innovation adoption within a social system (Suvedi et al. 2017). Omotilewa, Oluwatoba J, and others found that government subsidies can enable farmers to test the technology and learn from experience before investment, through a one-time use of subsidy to build awareness and reduce risk which, in turn, can help generate demand for the new technology and thus crowd-in commercial demand for it (Omotilewa et al. 2019).

As the leader of agricultural production activities, studying the influence of farmers' personal characteristics on agricultural production activities has also been the focus of research all the time. Aryal et al. analyzed the differences in the adoption behavior of farmers of different genders from the perspective of gender differences. Since female farmers prioritize family food security rather than farm income, they are more likely to focus on CSA to ensure food security (Aryal et al. 2020). Awotide and others analyzed the determinants of farmers' adoption of improved rice varieties from the perspectives of seed cost, education level, and access to credit (Awotide et al. 2016). Konja (2022)analyzed the impact of family size, credit channel, and distance to regional capital on farmers' willingness to adopt improved peanut production technology.

Relevant research focuses on the impact of policy incentives, factor endowments, and farmers' cognition on farmers' technology adoption behavior, and lacks analysis from the perspective of natural environmental changes. However, the natural environment is the premise of agricultural technology adoption behavior. Agricultural technology adoption is to overcome the unfavorable aspects of agricultural development in the natural environment, and the most unfavorable aspects of agricultural development in the natural environment are agricultural natural disasters. Therefore, it is of great practical significance to study farmers' technology adoption behavior from the aspects of disaster type, disaster stage, and remedial measures (Baležentis et al., 2021).

2 RESEARCH BACKGROUND

2.1 Basic Overview

Xinjiang is the main production area of cotton in China. As a representative area of large-scale production, the technology adoption behavior in agricultural production has certain typicality. In the process of cotton production, farmers' choice of irrigation mode not only depends on the characteristics of irrigation mode itself but also on agricultural disasters and external market environment (Wang Z. et al., 2022).

At present, there are three ways to irrigate cotton fields in Xinjiang, which are flooding irrigation, sprinkler irrigation, and drip irrigation. Due to the lack of water resources in Xinjiang, flood irrigation not only causes low water and fertilizer utilization but also leads to a serious waste of water resources. However, due to the increasingly prominent contradiction between water and soil in Xinjiang, flood irrigation has gradually been abandoned by most farmers. As a simple irrigation method, sprinkler irrigation is suitable for various terrains and can be irrigated on multiple plots. Spray irrigation has the effect of resisting frost, dry, and

TABLE 1 | Statistical table of agricultural disaster-affected and disaster-affected areas in Xinjiang from 2001 to 2010 (unit: 1000 ha).

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010
Affected area	**520**	**767.7**	**741.8**	**516.6**	**735.3**	**950.1**	**2171.7**	**1244.3**	**1306.7**
Flood	160	82	42.5	88.2	41.4	131.1	27.7	8.6	183.1
Drought	168	397	369.3	355.8	351.8	459	1050	539.6	300.3
Hail	82	163.7	196.9	62.6	165.9	200	220.8	615.5	392.4
Frozen	110	125	55.2	10	175.6	160	873.2	80.6	430.9
Disaster area	**184**	**516**	**436.1**	**352.1**	**579.3**	**568.2**	**1326.1**	**778.1**	**649.1**
Flood	59	53	24.1	47.6	23.3	42.2	16.3	4.3	70.7
Drought	94	316	273	272.1	322.7	306	560.5	366.2	209.1
Hail	4	89	124	25.7	93.3	120	148.8	360.9	102.5
Frozen	27	58	15	6.7	140	100	600.6	46.8	266.8

The "Affected area" represents the area where the disaster situation occurs; the "Disaster area" represents the area where the disaster has a substantial impact, such as production reduction or equipment damage.
"Affected area" refers to the total area of the disaster stricken area, including but not limited to flood, drought, hail and frozen."Disaster area" refers to the total area of the area greatly affected by the disaster, including but not limited to flood, drought, hail and frozen.

hot wind, and pressure alkali desalination, but it is vulnerable to the influence of wind, the invalid evaporation loss is large, and the laid mobile pipeline is also easy to cause pests and diseases. Drip irrigation technology is one of the most water-saving and effective irrigation methods because of small drip flow, slow infiltration, and diffusion mainly by capillary tension. Drip irrigation technology is one of the most water-saving and effective irrigation methods because of small drip flow, slow infiltration, and diffusion mainly by capillary tension. Local accurate irrigation greatly improves the utilization of water, reduces weed breeding, improves soil structure, and reduces the requirement of water pressure.

In addition to the characteristics of various irrigation methods, the occurrence of agricultural disasters and the external market situation will have an important impact on farmers' choice of irrigation methods. The reason is that different irrigation methods have different abilities to resist agricultural risks, and different irrigation methods have a great impact on farmers' cotton production. When applying different irrigation methods, farmers will comprehensively consider the irrigation methods with higher net income. From the actual situation of cotton production, most farmers choose to apply drip irrigation water-saving technology, which fully demonstrates that drip irrigation water-saving technology is more conducive to cotton farmers to achieve cost-saving and efficiency improvement compared with other methods.

2.2 Trend of Agricultural Disasters in Xinjiang

The agricultural ecological environment in Xinjiang is fragile, and serious natural disasters often occur. In the process of agricultural planting, drought and hail disasters have become the most common natural disasters in Xinjiang's agricultural development. According to the periodic changes in drought and hail disasters, natural disasters in Xinjiang are divided into two stages in the study. All data come from the China National Bureau of Statistics.

2.2.1 Phase I: 2002–2010

It can be seen from **Table 1** that drought, hail, and frozen disasters were the main natural disasters in Xinjiang from 2002 to 2010. This stage is dominated by drought disaster.

Through data statistics, it can be clearly shown that drought has become the most influential natural disaster in agricultural development in Xinjiang from 2002 to 2010. Among them, the year with the largest drought disaster area was 2008, and its disaster area was as high as 1050 thousand hectares, accounting for 48.35% of the total disaster area in 2008. It was also the year with the largest drought disaster area in Xinjiang in the past two decades. With the progress of agricultural production technology and the promotion of drip irrigation water-saving technology, Xinjiang drought disaster-affected area and disaster area began to show an obvious downward trend. In 2010, the drought disaster area decreased to 300.3 thousand hectares, and the disaster area decreased to 209.1.

Although the occurrence of hail disaster is not regular, it shows an upward trend. The proportion of hail disaster in the total affected area increased from 15.77% in 2002 to 30.03% in 2010. At the same time, the disaster area of hail increased more significantly, about 20 times that of 2002 in 2010. Hail is becoming the largest natural disaster that endangers the agriculture in Xinjiang, and this trend is clearly confirmed again in the second stage.

Frozen disaster showed greater suddenness and contingency, but its destructiveness cannot be ignored. After the drought-affected area in 2008, the most affected year of frozen disaster was also 2008; the affected area reached 873.2 thousand hectares, accounting for 40.20% of the total affected area in 2008. The disaster area of frozen even exceeds that of drought.

Flood is a natural disaster with small threat to Xinjiang. Due to the special geographical conditions and ecological environment in Xinjiang, the impact of flood on agriculture in Xinjiang is minimal. From 2002 to 2010, the maximum disaster area was only 70.7 thousand hectares.

TABLE 2 | Statistical table of agricultural disaster-affected and disaster-affected areas in Xinjiang from 2011 to 2019 (unit: 1000 ha).

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
Affected area	**678.3**	**1125.8**	**564.8**	**1848.6**	**960**	**808.1**	**287.5**	**746**	**573**
Flood	62.6	44.7	70.4	30.6	90.3	418.7	43.9	35.8	-
Drought	142.3	522.2	134.6	576.3	224	19.5	17.1	10	-
Hail	278.8	431.5	321	812.2	568.5	359.9	204.5	643.7	549
Frozen	194.6	126.6	38.8	429.5	77.2	9.9	22	56.5	7
Disaster area	**348**	**619**	**390.6**	**1062.2**	**589.4**	**506.4**	**226.6**	**501.9**	**246**
Flood	19	20.7	30.6	32.5	55.2	289.8	23.1	27	-
Drought	75.3	217.8	99	190.8	85.3	19.3	13.4	9.7	-
Hail	194.3	285.2	244.5	575.8	400.4	192.5	171.5	434.9	239
Frozen	59.3	94.5	16.5	263.1	48.5	4.9	18.6	30.3	-

The "Affected area" represents the area where the disaster situation occurs; the "Disaster area" represents the area where the disaster has a substantial impact, such as production reduction or equipment damage.
"Affected area" refers to the total area of the disaster stricken area, including but not limited to flood, drought, hail and frozen."Disaster area" refers to the total area of the area greatly affected by the disaster, including but not limited to flood, drought, hail and frozen.

2.2.2 Phase II: 2011–2019

It can be seen from **Table 2** that the natural disasters suffered by Xinjiang from 2011 to 2019 mainly was hail. Except for 2012 and 2014 with a large disaster-affected area, the areas of drought, frozen, and flood in other years were small.

For hail disaster, it showed an obvious upward trend. In terms of its disaster area, the disaster area in 2011 was 194.3 thousand hectares, accounting for 55.83% of the total disaster area in 2011. In the following years, the lowest proportion was 38.01% in 2016, and the highest was 97.15% in 2019. Hail disaster has become the main disaster affecting agricultural production in Xinjiang. For flood and frozen disasters, the characteristics shown in the second phase are similar to those in the first phase, with little harm to agricultural production in Xinjiang except for very few years.

In the second stage, the most obvious change is the drought disaster, which shows a significant downward trend. This trend is due to the popularization of drip irrigation water-saving technology and the improvement of farmland water conservancy facilities.

2.3 Cotton Production in Xinjiang

The decline in drought disaster area has been accompanied by an increase in the use of drip irrigation technology. The application of drip irrigation water-saving technology has a significant effect on improving the growing environment of crops and increasing crop yields (Klomp and Hoogezand, 2018; Song et al., 2021; Li et al., 2022a; Li et al., 2022b; Wang H. et al., 2022). The study of drip irrigation water-saving technology adoption behavior decision-making has a very important practical implication because, although the overall drought disaster area trend is downward, this trend is not stable.

Considering that Xinjiang is a major cotton-producing province, and agricultural drip irrigation water-saving technology is widely used in cotton production, this phenomenon is universal in different agricultural protected areas. Therefore, when studying the impact of agricultural natural disasters on farmers' technology adoption behavior, we take the application of Xinjiang cotton farmers' drip irrigation water-saving technology as a sample. Given the diversity and periodicity of natural disasters, analyzing the impact of different disaster types and disaster stages on farmers' decision-making of technology adoption behavior is necessary.

Since the implementation of the target price subsidy policy in 2014, the cotton price has been showing violent fluctuations. Under the background of the unstable cotton market situation, reducing costs has become the common choice of most cotton farmers. Farmers' investment in the application of drip irrigation water-saving technology is affected by income fluctuations. Therefore, cotton farmers' decision-making on technology applications is also affected by the risk of market price fluctuations.

In summary, the contributions of this study are mainly of three points. First, we study farmers' technology adoption behavior from the aspects of disaster types and disaster levels, which supplements the existing literature; second, pay attention to the main agricultural producing province Xinjiang, and use its main crop cotton and drip irrigation water-saving technology as the research object to provide reference for other main agricultural producing provinces; thirdly, based on the actual survey data, a binary logistic model is constructed to analyze the impact of agricultural disasters and cotton price fluctuations on the application of drip irrigation water-saving technology for Xinjiang cotton farmers.

3 DATA SOURCE AND VARIABLE SELECTION

3.1 Data Source

The data come from a questionnaire survey, which took place from 2016 to 2018. It mainly visited and investigated more than 20 towns in Tacheng, Changji Hui Autonomous Prefecture, and Bortala Mongolian Autonomous Prefecture in Xinjiang. A total of 216 questionnaires were collected, and few of the data were missing in some questionnaires. Therefore, 198 valid data were used for the empirical analysis. In the questionnaire, the types of disasters and willingness to adopt water-saving technologies suffered by cotton farmers in recent 10 years were investigated in detail, and the characteristics of cotton farmers and their willingness to adopt technology were analyzed in depth.

Among 216 cotton farmers surveyed, 146 households adopted drip irrigation water-saving technology, accounting for 73.73%. There were 52 households without drip irrigation technology, accounting for 26.27%. It can be seen that there are more farmers using drip irrigation water-saving technology in Xinjiang cotton farmers, which is consistent with the research expectation. From the identity of the head of household, Xinjiang cotton farmers are mostly ordinary villagers. Among the survey samples, 183 households were ordinary villagers, accounting for 83.3%; the proportion of village cadres, party members, and veterans is small, accounting for 15.7%. According to the age distribution of household heads, most of the household heads engaged in cotton production are older. The proportion of farmers aged 41–50 years was 53.2%, the proportion of farmers aged 51–60 years was 20.8%, and the proportion of heads of households under 30 years was only 3.2%. From the perspective of the education level of household heads, the education level of most household heads is concentrated in primary school, junior high school, and senior high school, accounting for 14.8%, 68.5 %, and 7.9%, respectively. The total proportion of technical colleges and universities is 4.6%, indicating that the education level of most household heads is low. From the survey of farmers' annual household income, due to the large scale of cotton planting in Xinjiang, the total household income level of cotton farmers is mostly concentrated between 100,000 and 300,000 yuan, accounting for 34.7%. The proportion of farmers whose household income level is below CNY 500,000 is 97.9%. Since the income level is not the net income level of farmers, it is not substituted into the model calculation. In the early implementation of the target price subsidy policy in 2014, if the subsidy income is not calculated, the total income of farmers' cotton planting is mostly negative after deducting the cost of cotton planting and repaying bank loans.

3.2 Variable Selection

3.2.1 Technology Adoption Behavior

For cotton farmers, the adoption of new technologies is relatively conservative, on the one hand, due to costs, and on the other hand, due to limited risk tolerance. Combined with the investigation process, the selection of dependent variables is very limited. The common technical applications of cotton farmers are drip irrigation technology, soil testing formula, and the use of new agricultural tools. Among them, the vast majority of cotton farmers will use drip irrigation water-saving technology, and the use of soil testing formula and new agricultural machinery is limited by objective conditions such as cost and environment, and its usage rate is far lower than that of drip irrigation water-saving technology. However, in some regions of Xinjiang where water resources are relatively scarce, some farmers do not use drip irrigation water-saving technology, which has attracted our attention. In order to explore the reasons why they do not use drip irrigation water-saving technology and analyze the decision-making process of using drip irrigation water-saving technology, we choose "whether to use drip irrigation water-saving technology" as the dependent variable in the research process.

3.2.2 Basic Characteristics of Farmers

In the basic characteristics of farmers, there are four variables in total. For the survey sample farmers, the majority of household heads are "male", accounting for 93.9%; the proportion of cotton farmers headed by "women" was only 6.1%; it fully shows that the decision-making process of most cotton farmers is dominated by "male".

For the number of family labor force owned by farmers, 77.8% of farmers have two labor forces; families with three laborers account for 10.6%; the proportion of families with more than three laborers is only 11.6%. In terms of the absolute number of labor, it is impossible to complete the whole cotton planting process by relying solely on the family's own labor force, as well as the proportion of labor force of family members. Therefore, most cotton farmers need to employ foreign labor during cotton picking to help complete the cotton planting process. Correspondingly, this also increases the cost of cotton planting.

Most cotton farmers have long years of planting cotton. The average years of cotton production of the survey sample is 20.73 years, and the proportion of cotton farmers engaged in cotton production for more than 20 years is 67.1%, indicating that the aging of cotton farmers engaged in cotton production is relatively common, which also has a negative impact on the promotion of new technologies.

Most cotton farmers have large acreage. The cultivated area of cotton farmers includes two parts: privately cultivated land and leased cultivated land. The proportion of leased cultivated land accounted for more than 50% of the survey sample farmers, which is 61.6%. Therefore, the area of leased farmland is very important for cotton farmers because leased farmland will not only affect the use cost of drip irrigation water-saving technology but also affect the adoption of drip irrigation water-saving technology by cotton farmers. In the survey sample, the average cultivated land area of farmers' households is 2.172 ha, but most farmers have more leased cultivated land than private cultivated land.

From the overall situation of the sample, cotton farmers show the characteristics of low education level, old age, and low net income. Due to violent fluctuations in the cotton market situation, the cost of farmers using drip irrigation water-saving technology is increasing year by year. Therefore, it is the characteristics of farmers themselves or the external agricultural risk that will have a greater impact on the behavior decision of farmers using drip irrigation water-saving technology.

3.2.3 Risk of Cotton Price Fluctuations

Price fluctuation risk affects farmers' adoption of drip irrigation water-saving technology in terms of income. In the actual survey, it is found that in addition to the types and stages of agricultural disasters, price fluctuation risk is also an important factor affecting farmers' decision-making on technology adoption behavior. Among the surveyed groups, about 20% of farmers equate the risk of price fluctuation with the risk of agricultural disasters. Therefore, the risk of cotton price fluctuation is added to the empirical analysis. Compared with other types of natural disasters, the risk of cotton price fluctuation is an important source of risk for farmers' cotton production and operation.

Although the implementation of the cotton target price subsidy policy weakens the risk of some price fluctuations, the target price mechanism does not consider the price differences faced by individual farmers. Therefore, for farmers, the risk of market price fluctuation is still an important source of risk affecting farmers' income, and has a direct impact on the application of drip irrigation water-saving technology in cotton planting. At the same time, under the background of sharp price fluctuation in cotton market, cost reduction has become the common choice of most cotton farmers. When the risk of price fluctuation is large, the investment of farmers in the application of drip irrigation water-saving technology is affected.

3.2.4 Types of Agricultural Disasters

In the process of cotton planting, wind, frost, drought, and hail disasters are the most common types of disasters for cotton farmers in the research sample, accounting for 86.40%, 36.87%, 30.30%, and 25.25%, respectively, ranking the top among the common types of natural disasters. However, agricultural disasters are often the result of multiple disasters. Among them, wind disaster is the most common, accounting for the highest proportion and the greatest harm in the analysis of several types of disasters. When the wind reaches a certain level, the drip irrigation belt in the cotton field will blow away, causing significant damage to the cotton field. In addition, hail disaster is also a natural disaster type that directly cause damage to drip irrigation-related equipment. These two natural disasters not only do great harm to cotton fields but also have an important impact on the promotion of drip irrigation technology. Regarding frost damage and drought, these two affect cotton fields more than drip irrigation equipment. In general, the impact of agricultural disasters on drip irrigation equipment is destructive. If the disaster is serious, it is necessary to replace drip irrigation equipment, which will increase the planting cost of cotton farmers and affect the adoption and promotion of drip irrigation technology.

3.2.5 Disaster Stage and Remedies

Judging from the timely remedy after the disaster, about half of the cotton farmers will suffer natural disasters during the cotton sowing and growing periods. However, during the cotton harvest period, it is less affected by various natural disasters. The remedial stage selected by farmers is also concentrated in the sowing period and growth period of cotton. The proportions of remedial measures taken after the disaster in the sowing period and growth period are 34.80 % and 20.59%, respectively.

4 MODEL CONSTRUCTION

Since the explained variable of the model is whether farmers apply the drip irrigation water-saving technology, the results have two cases of "applying (adopting) drip irrigation water-saving technology" and "not applying (not adopting) drip irrigation water-saving technology"; which are binary selection variables. Therefore, this study adopts binary logistic model for analysis. The model form is as follows:

$$Y = \mathrm{Ln}\left[\frac{\gamma_i}{(1-\gamma_i)}\right] = \alpha_0 + \sum_{j=1}^{15} \alpha_j x_j + \varphi \tag{1}$$

Among them, γ_i represents the probability of the application of drip irrigation water-saving technology for the first farmer and x_j represents the jth independent variable affecting the application of drip irrigation water-saving technology. The specific variables and main statistics selected by the influencing factors in the model are shown in **Table 3**.

It should be noted that the dependent variable "application of drip irrigation water saving technology" and the independent variable "disaster type", "disaster stage and whether to remedy", are all relevant data since 2007. These data can fully reflect the drip irrigation water-saving technology often used by cotton farmers, the types of disasters often encountered, and the stage of crop production that is often affected by disasters. In order to deeply analyze the influence of different disaster types and different disaster stages on whether farmers adopt drip irrigation water-saving technology, this study will construct a binary logistic model to analyze the above influence relationship in detail.

5 ANALYSIS OF INFLUENCING FACTORS OF FARMERS' TECHNOLOGY ADOPTION BEHAVIOR DECISION-MAKING

5.1 Chi-Square Test and Binary Logistic Regression

In the process of empirical analysis, this study uses SPSS19.0 to analyze 198 sample data, and uses these data to fit the binary logistic model. To ensure the systematicness of the data, this study excludes the variables with more missing values. Before fitting the binary logistic model, we first performed chi-square analysis on all the above variables to test the difference between the dependent variable and the independent variable. The results are shown in **Table 4**.

From the results of the chi-square test, except for the variables of "number of labor force" "common cultivated land" "gender of head of household" "hurricane" "frozen" and "pests", which are not significant, other variables all showed a certain significant. These variables have a significant difference between them and the dependent variable.

Then, we fit a binary logistic model. Since the data of this questionnaire is cross-sectional data, individual heterogeneity needs to be considered in the regression. The variables of the above-mentioned basic characteristics of farmers were added to the regression as control variables to eliminate individual heterogeneity. The obtained results are shown in **Table 5**.

Combining the results of the above two tables, the regression results of the binary logistic model are basically consistent with the results of the chi-square analysis, which ensures the robustness of the results.

TABLE 3 | Selection and treatment of explanatory variables of the model.

Variable	Code	Option	Number of households	Proportion (%)	Mean value	Standard deviation
Dependent variable						
Whether farmers applied the drip irrigation water-saving technology	Y	Yes = 1	146	73.73	0.75	0.43
		No = 0	52	26.27		
Basic characteristics of farmers						
Number of labor forces (PCs.)	X_1		216		2.20	0.66
Cotton production duration (year)	X_2		216		20.70	7.47
Common cultivated land (hectare)	X_3		216		6.943	6.55
Gender of head of the household	X_4	Female = 0	12	6.06	0.94	0.24
		Male = 1	186	93.94		
Whether farmers are affected by the risk of cotton price fluctuations	X_5	No = 0	156	78.79	0.22	0.41
		Yes = 1	42	21.21		
Types of agricultural disasters						
Hurricane	X_6	No = 0	27	13.64	0.83	0.38
		Yes = 1	171	86.36		
Hail	X_7	No = 0	148	74.75	0.24	0.43
		Yes = 1	50	25.25		
Drought	X_8	No = 0	138	69.70	0.30	0.46
		Yes = 1	60	30.30		
Frozen	X_9	No = 0	125	63.13	0.36	0.48
		Yes = 1	73	36.87		
Diseases	X_{10}	No = 0	172	86.87	0.13	0.33
		Yes = 1	26	13.13		
Pests	X_{11}	No = 0	154	77.78	0.20	0.40
		Yes = 1	44	22.22		
Disaster stage and whether to remedy						
Post-disaster relief	X_{12}	No = 0	91	45.96	0.54	0.50
		Yes = 1	107	54.04		
Harvest period in disaster stage	X_{13}	No = 0	188	94.95	0.05	0.21
		Yes = 1	10	5.05		
Growth period in disaster-stricken stage	X_{14}	No = 0	100	50.51	0.48	0.50
		Yes = 1	98	49.49		
Seeding period in disaster stage	X_{15}	No = 0	99	50.00	0.48	0.50
		Yes = 1	99	50.00		

Effective N = 198.

TABLE 4 | Estimation results of binary logistic model.

Variable	Progressive significance (Two-sided)
Basic characteristics of farmers	
Number of labor forces	0.580
Cotton production duration	0.024**
Common cultivated land	0.476
Gender of head of the household	0.566
Cotton price fluctuation	0.000***
Types of agricultural disasters	
Hurricane	0.669
Hail	0.011**
Drought	0.006***
Frozen	0.288
Diseases	0.021**
Pests	0.863
Disaster stage and whether to remedy	
Post-disaster relief	0.000***
Harvest period in disaster stage	0.080*
Growth period in disaster-stricken stage	0.000***
Seeding period in disaster stage	0.000***

****, **, and * are significant at the statistical level of 1%, 5%, and 10%, respectively.*

5.2 Result Analysis

5.2.1 Basic Characteristics of Peasant Household

In the basic characteristics of farmers' families, the variables such as gender of head of household, number of labors, cotton production years, and common cultivated land have no significant influence on the application of drip irrigation water-saving technology for cotton farmers. From the results of the model, the above factors have not passed the test of visibility. In the actual investigation, it is found that the application of drip irrigation water-saving technology is greatly affected by the objective natural environment. Gender, the number of labor force, and the number of cultivated land cannot significantly affect the application of drip irrigation water-saving technology by cotton farmers. The reason is that the number of labor force in most cotton farmers is not enough to complete the related labor, whether it is the production process or the laying of drip irrigation equipment. Therefore, most cotton farmers will complete the daily management of cotton fields by employing short-term or long-term workers. Farmers engaged in cotton production for a long time, cotton field management experience, and planting experience are rich, but the

TABLE 5 | Estimation results of binary logistic model.

Variable	B	S.E.	Wals	Sig	Exp (B)
Basic characteristics of peasant households					
Gender of head of the household	0.5175	0.8096	0.4085	0.5227	1.6778
Number of labor force	0.1107	0.3305	0.1122	0.7377	1.1171
Cotton production years	0.0063	0.0267	0.0554	0.8139	1.0063
Common cultivated land	−0.0028	0.0023	1.4855	0.2229	0.9972
Cotton price fluctuation	3.0665**	1.2446	6.0705	0.0137	21.4670
Types of agricultural disasters					
Hurricane	−0.1366	0.5546	0.0606	0.8055	0.8723
Hail	−0.9634**	0.4686	4.2276	0.0398	0.3816
Drought	0.9085*	0.5122	3.1457	0.0761	2.4805
Frozen	−0.0131	0.4887	0.0007	0.9786	0.9870
Diseases	2.0104**	0.9683	4.3104	0.0379	7.4664
Pests	−0.8225	0.5629	2.1351	0.1440	0.4393
Disaster stage and whether to recovery					
Seeding period in disaster stage	−0.4131	0.6577	0.3946	0.5299	0.6616
Growth period in disaster-stricken stage	−1.7321**	0.6890	6.3193	0.0119	0.1769
Harvest period in disaster stage	−2.4062***	0.9045	7.0765	0.0078	0.0902
Post-disaster relief	1.0581**	0.4422	5.7260	0.0167	2.8810
Constant	1.2050	1.3652	0.7790	0.3774	3.3367

****, **, and * are significant at the statistical level of 1%, 5%, and 10%, respectively.*

application of drip irrigation water-saving technology is more based on the objective environment, therefore, the variable "cotton production years" on the application of drip irrigation water-saving technology is not obvious.

5.2.2 Cotton Price Fluctuation Risk

Cotton price fluctuation is an important factor affecting whether cotton farmers adopt drip irrigation water-saving technology. In the model calculation, the 5% significant level test is adopted and the correlation coefficient is positive. Under other conditions unchanged, farmers who take cotton price fluctuation as disaster risk are more willing to adopt drip irrigation water-saving technology compared with farmers who do not take cotton price fluctuation as a disaster risk. Through the actual investigation, it is found that cotton price is an important indicator variable for the formation of farmers' cotton planting income. Most of the farmers who are sensitive to price fluctuations have strong awareness of active risk prevention. Compared with other farmers who are passive recipients of price, when the cost of cotton planting is within an acceptable range, these farmers are more willing to adopt standardized management and advanced production technology. In order to hedge the price risk of cotton by increasing the unit yield of cotton fields.

5.2.3 Types of Agricultural Disasters

In the calculation of the model, the frozen injury, wind disaster, and insect pest did not pass the significant indigenous test, indicating that with other conditions unchanged, frozen injury, wind disaster, and insect pest had no significant indigenous effect on the adoption of drip irrigation water-saving technology. The main reasons are concentrated in two aspects: First, in the survey area, in the past 10 years, the occurrence degree of frost, wind, and insect disasters has not caused serious damage to drip irrigation water-saving technology equipment. However, drip irrigation water-saving technology equipment has the characteristics of recycling, which greatly reduces the cost of farmers applying drip irrigation water-saving technology. Secondly, in the actual investigation, it is found that since the drip irrigation belt is close to the root of the plant, the damage of wind disaster after the cotton enters the growth stage mainly affects the cotton crop itself, and has little effect on the drip irrigation facilities. Due to the high controllability of drip irrigation, the harm of frozen and insect pests is also concentrated on the crop itself, and the impact on drip irrigation equipment is not obvious. Therefore, the cost of farmers adopting drip irrigation water-saving technology will not increase significantly due to these disasters.

In the model calculation, the variable "hail" passed the 5% significant level test and the correlation coefficient was negative. Under other conditions unchanged, the occurrence of hail disaster will reduce the adoption of drip irrigation water-saving technology by cotton farmers. The results are highly consistent with the reality. In the actual investigation, it is found that the occurrence of hail disaster not only has great destructive effect on crops itself but also has strong destructive effect on drip irrigation equipment (Charveriat, 2000; De Haen and Hemrich, 2007). A large number of damaged drip irrigation equipment cannot be recycled, which will seriously increase the cost to cotton farmers and reduce the income of cotton planting. Therefore, the occurrence of hail disaster has a strong obstacle to the application of drip irrigation water-saving technology.

In the model calculation, the variable "drought" passes the 5% significant level test and the correlation coefficient is positive. Under other conditions unchanged, the occurrence of drought

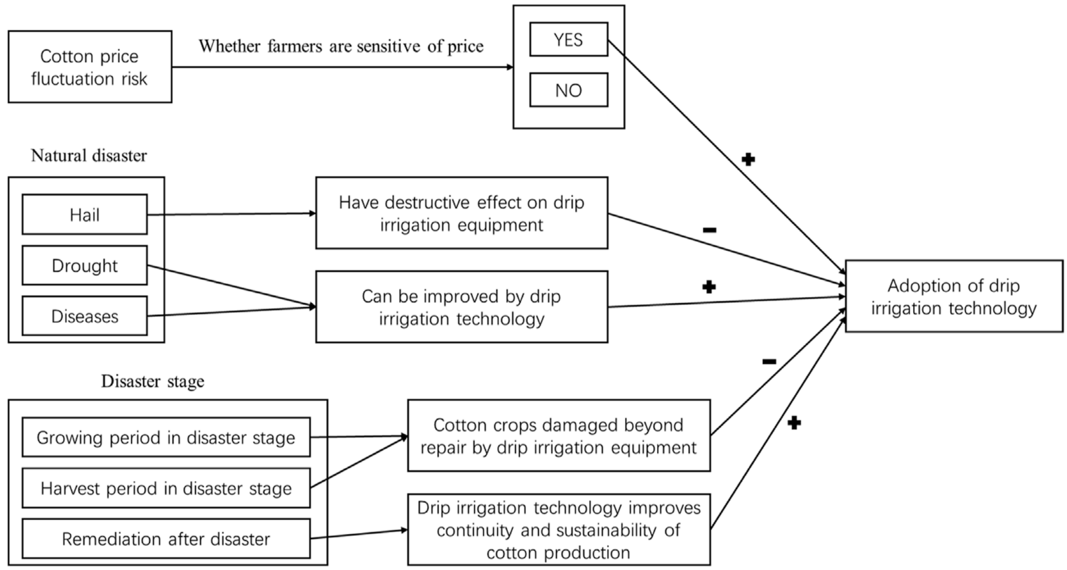

FIGURE 1 | Influence mechanism analysis. "+" stands for positive effects, "–" for negative effects.

will improve the adoption of drip irrigation water-saving technology by cotton farmers. This is related to the characteristics of the technology itself. The starting point of water-saving technology development and application is to improve the efficiency of agricultural water use in arid areas (Tan et al., 2017; Yang et al., 2021). Therefore, the occurrence of drought will promote farmers to adopt water-saving technology.

In the model calculation, the variable "diseases" passes the 5% significant level test and the correlation coefficient is positive. Under other conditions unchanged, the occurrence of disease will improve the adoption of drip irrigation water-saving technology by cotton farmers. This is related to the fact that drip irrigation water-saving technology can effectively reduce the occurrence rate of diseases (Zhu et al., 2020; Aydinsakir et al., 2021). In the process of cotton production, drip irrigation technology can effectively reduce water evaporation, reduce air humidity around crops, and thus effectively reduce the occurrence of diseases. Therefore, the occurrence of diseases will improve the willingness of cotton farmers to adopt drip irrigation water-saving technology.

5.2.4 Disaster Stage and Whether to Remedy

The results of the model showed that the influencing factors "affected stage was sowing date" did not pass the significance test. It shows that if the cotton field disaster stage is in the sowing period, it does not affect the adoption of drip irrigation water-saving technology. From the actual cotton planting process, if the drip irrigation technology is used during the cotton planting period, the drip irrigation belt will be laid and cotton will be sown in advance, and covered with plastic film. Therefore, if natural disasters occur during this period, the mulching film and cotton seeds that have been sown will be affected, but the impact of natural disasters on drip irrigation equipment is relatively small. Therefore, the disaster in this period is more likely to encourage farmers to carry out supplementary inoculation, and the impact on the willingness to adopt drip irrigation technology is very small.

The variables "growing period in disaster stage" and "harvest period in disaster stage" had significant effects on farmers' adoption of drip irrigation water-saving technology. In the model operation, the correlation coefficient was negative by 5 % and 1% test, respectively. When other conditions remain unchanged, agricultural disasters in the cotton growth period and harvest period will reduce the use of drip irrigation water-saving technology by cotton farmers. There are few remedial measures when the cotton growth period suffers from agricultural disasters. If supplementary inoculation cannot recover the disaster loss, the cotton farmers will stop investing in the disaster-affected cotton fields, and thus reduce the application and adoption of drip irrigation water-saving technology by farmers. The consequences of agricultural disasters in the cotton harvest period are very serious. On the one hand, it will directly reduce farmers' income, and on the other, it will affect farmers' investment in cotton planting in the next period, and weaken farmers' willingness to adopt water-saving technologies.

The variable "remediation after disaster" has a significant impact on cotton farmers' decision-making on whether to adopt drip irrigation technology. In the model operation, the variable "disaster recovery" passed the 5% significance level test and the correlation coefficient was positive. With other conditions unchanged, post-disaster recovery will improve the use of drip irrigation water-saving technology by cotton farmers. In the actual cotton production process, in most cases, the "post-disaster recovery" can stop losses and recover benefits in a timely manner, while increasing the continuity and sustainability of cotton farmers' production. The adoption of drip irrigation water-saving technology as a measure of post-disaster recovery is valued by most farmers, and the cotton fields that have experienced post-disaster recovery will quickly restore production capacity, thereby promoting the adoption of drip irrigation water-saving technology by cotton farmers.

5.3 Decision Influence Mechanism

Through the above analysis, we have clarified the specific factors that affect the decision-making of farmers in Xinjiang to adopt drip irrigation water-saving technology. According to the above analysis results, we present the influence mechanism diagram as shown in **Figure 1** below, and sort out the relationship between variables.

6 MAIN CONCLUSION

In summary, this study uses the binary logistic model to empirically analyze the impact of agricultural disasters and cotton price fluctuations on cotton farmers' application of drip irrigation water-saving technology. Through the analysis of the model results, the following conclusions are obtained.

The adoption behavior of drip irrigation water-saving technology of cotton farmers is less affected by their own family characteristics; it is greatly affected by the risk of cotton price fluctuation. This is related to farmers' subjective cognition. This subjective cognition is mainly reflected in risk awareness. Farmers with strong risk awareness will have higher willingness to adopt agricultural production technology. Farmers with low-risk awareness tend to adopt agricultural production technology passively.

The influence of agricultural disasters on farmers' decision-making to adopt drip irrigation water-saving technology mainly includes three aspects. The first is whether agricultural disasters will destroy agricultural technology equipment. If agricultural technology equipment is greatly affected by disasters, farmers' willingness to adopt the technology will be reduced. The second is whether it can help to reduce diseases and improve unit yield because reducing diseases in agricultural production has a great improvement in unit yield, which can directly improve farmers' cotton planting efficiency. Therefore, in favor of reducing diseases and improving agricultural production technology per unit yield, farmers will increase their willingness to adopt. The third is the characteristics of agricultural technology itself. Farmers' adoption of agricultural technology hopes that the use of a certain agricultural technology can meet the needs of many aspects at the same time. Therefore, if the use of agricultural technology can be significantly beneficial to many agricultural production processes, farmers' willingness to adopt technology will also be significantly improved.

The influence of variable "disaster stage and whether to remedy" on farmers' technology adoption behavior decision is mainly reflected in the following aspects. Cotton disaster stage and whether to use remedial measures will seriously affect the final income of cotton farmers. Through the above analysis, it can be found that the growth period and harvest period of the disaster stage have a significant negative impact on the application of drip irrigation water-saving technology for cotton farmers because the impact of these two stages on farmers' cotton income is huge. However, post-disaster remediation can significantly improve the final income of cotton farmers. Therefore, in agricultural production, when the disaster stage has a great impact on the final income, it will hinder farmers to adopt agricultural technology; if post-disaster remediation can achieve significant results, remedial measures will promote farmers' adoption of agricultural technology.

From the above analysis, it can be found that in the process of cotton farmers adopting drip irrigation water-saving technology, it is necessary to actively do a good job of disaster relief and improve the use of drip irrigation water-saving technology by farmers. Compared with other irrigation technologies, drip irrigation water-saving technology has greater comparative advantages in different types of agricultural disasters. Therefore, in the management of cotton fields, it is necessary to improve the familiarity and use of drip irrigation water-saving technology by cotton farmers. At the same time, it is also necessary to consider the external market environment. In the case of high risk of cotton price fluctuation, farmers are encouraged to adopt drip irrigation water-saving technology with high efficiency to improve the quality of lint and increase farmers' income, so as to improve the farmers' ability to resist market risks and agricultural disasters.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethics review and approval/written informed consent was not required as per local legislation and institutional requirements.

AUTHOR CONTRIBUTIONS

YY: data collection and methodology; JW: writing initial draft. All authors have read and agreed to the published version of the manuscript.

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