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RESEARCH ARTICLE

Farmers' perceptions of climate change and adaptation behavior in Wushen Banner, China

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Abstract

A better understanding of farmers' perceptions of and responses to climate change is important for decision-makers to design more effective adaptation policies. This study investigates farmers' perceptions of climate change, actual adaption responses at the farm level, and factors influencing farmers' decisions on climate change adaptation in Wushen Banner, China. A questionnaire survey was conducted among 220 farmers with a random sampling technique. We found that farmers were generally concerned about climate change. Most farmers have adopted adaption measures to address the adverse effects of climate change. Adjusting farming behavior and using financial means were the main adaptation measures used by local farmers. The results revealed that the implementation of adaptation measures was constrained by the lack of technology, shortage of money, and poor infrastructure. The binary logistic regression results showed that farmers' socioeconomic characteristics, such as education, farming experience, and gender, had significant impacts on farmers' decisions to choose adaptation strategies. The regression results also indicated that farmers who believed climate change would affect their health were more willing to choose financial instruments, and farmers who believed climate change would affect their agricultural productions were likely to diversify their livelihoods. The findings provide some critical insights based on local perceptions of climate change and enhance our understanding of cognitive beliefs attached to adaptive responses.

Keywords Climate change · Perception · Adaptation · Farmer · China

Introduction

Climate change has been occurring over the past few years (IPCC 2014). Agriculture is extremely vulnerable to climate change (Abid et al. 2019; Habtemariam et al. 2019; Kabir et al. 2017; Nelson et al. 2009). Although climate change may have beneficial effects on certain crops, the negative impacts of climate change have been widely acknowledged and documented, especially by policymakers and researchers, which have affect farmers' livelihoods (Zhong et al. 2019; Arora et al. 2020). Farmers need to make adjustments to their agricultural systems to adapt to a changing climate (Khanal and Wilson 2019). As a factor important to agricultural activity, farmers' perceptions of climate change and actual adaptive responses to address climate change have direct impacts on regional agricultural development. To help policymakers develop more effective policies, there is a need to understand the extent of farmers' perceptions of climate change, actual responses to climate change, and the factors influencing their adoption of adaptation measures (Habtemariam et al. 2016; Shi et al. 2019).

In the existing literature, there are an increasing number of studies focusing on climate change adaptation (Mase et al. 2017; Mulenga et al. 2017; Tripathi and Mishra 2017), and some potential adaptation measures have been identified (Deressa et al. 2011). However, climate change is expected to affect agriculture very differently in different parts of the world (Glantz et al. 2009). Thus, different regions have

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different adaptive strategies due to their different national, political, and cultural backgrounds. For example, farmers in the Midwestern USA are using off-farm work to stabilize their incomes in response to the impact of climate change on agricultural production (Mase et al. 2017). The main adaptation measures of Pakistani farmers are to adjust sowing time and to plant drought-tolerant varieties (Ali and Erenstein 2017). Farmers along the Yarlung Zangbo River in Tibet are accustomed to intercropping to address climate change (Li et al. 2013). Therefore, information on the implications of actual adaptation responses by local farmers will be useful for effective adaptation planning.

A better understanding of the factors influencing farmers' adaptation decisions can provide references for policymakers to develop better adaptation policies (Eitzinger et al. 2018; Habtemariam et al. 2016; Lane et al. 2019). Recent studies show that there are some factors influencing farmers' adaptation strategies to climate change, such as age, income, and education. However, many of the studies focus on socioeconomic and demographic factors (Ali and Erenstein 2017; Hitayezu et al. 2017; Woods et al. 2017). Not much is known about the effects of psychosocial and cognitive factors, such as individuals' perceptions (Shi et al. 2019). Analyses of local farmers' perceptions of climate change can provide distinct location-based results that are important to better understanding local farmers' responses while guiding future research (Fahad and Wang 2018; Kuruppu and Liverman 2011).

As a big agricultural country, China is highly vulnerable to the impacts of climate change (Hou et al. 2012; Song et al. 2019; Wang and Chen 2015). Especially, rural farmers who depend on natural resources for their livelihoods have been severely affected by climate change (Shi et al. 2019; Zhai et al. 2018). Some studies have been conducted to understand Chinese farmers' perceptions and adaptation measures to cope with climate change. For instance, Shi et al. (2019) studied the perceived efficacy of farmers on climate change adaptive behavior in the Loess Plateau. Kibue et al. (2016) conducted questionnaire surveys on farmers in Anhui and Jiangsu province to study farmers' perceptions of climate variability. Some other studies were conducted in the Middle Yarlung Zangbo River Valley and Gorges area (Bai et al. 2010; Li et al. 2013; Zhu et al. 2018). However, few studies have reported on the current status of rural and farming-pastoral ecotone of China with little known about farmers' perceptions of climate change and adaptation measures in use. This study is based on a survey on local farmers in Wushen Banner, which is a representative area of the agro-pastoral ecotone in China.

The research objectives of this study are (1) to understand farmers' perceptions of climate change, (2) to investigate the adaptation measures taken by farmers to cope with climate change, (3) to identify the obstacles that affect farmers' implementation of adaptation measures, and (4) to analyze the factors that affect farmers' climate change adaptation decisions. Specifically, we want to understand local farmers' perceptions of climate change and its impacts, what adaptation measures are taken and their efficacy, what factors can promote farmers to take adaptation measures, what factors prevent farmers from adopting adaptation measures, and the positive or negative factors affecting farmers' adaptation decisions. The findings of this study can contribute to the literature on better understanding farmers' perceptions of climate change and factors influencing their adaptation decisions at the farm level.

Materials and methods

Figure 1 shows the schematic flow chart of this study. Based on questionnaire data, statistical analysis was used to study farmers' perceptions of climate change, actual adaptation measures, and the influencing factors in the study area.

Study area

The study was undertaken in Wushen Banner, located in the south of the Inner Mongolia Autonomous Region, between 37° and 39° N and 108° and 109° E. The total area of this district is 11,645 km^2. In 2017, the total population of the district was 116,277, of which the agricultural population accounted for 77.4%. The per capita disposable income of the region was approximately CNY 32,733 (US$4633), of which the per capita disposable income of the farmers was CNY 18,263 (US$2585). The average yearly temperature is approximately 6.8 °C, and the annual rainfall is 350–400 mm. From 1862 to 2012, the average daily temperature in Inner Mongolia showed an obvious upward trend, increasing by 0.37 °C every decade (Hu et al. 2015). Rising temperatures and increased drought frequency have affected local grain production. Farmers may face more risks in the future because of the impact of climate change.

Survey design and data collection

The survey questionnaire design was divided into three stages. First, based on the existing research on climate change adaptation strategies, a preliminary questionnaire was designed. Second, several focus group discussions (FGDs) were organized in April of 2018, where six experts on climate change, three local government officials, and eight local farmers participated. An informal, semi-structured discussion format lasting about 2 h was employed for the FGDs. Based on participants' views and opinions on climate change and local adaptation behavior, the preliminary questionnaire was modified and restructured. The five most common adaptation strategies adopted by local farmers were identified, namely adjusting planting methods, adopting crop diversification, choosing financial instruments, taking rotational grazing, and investing in

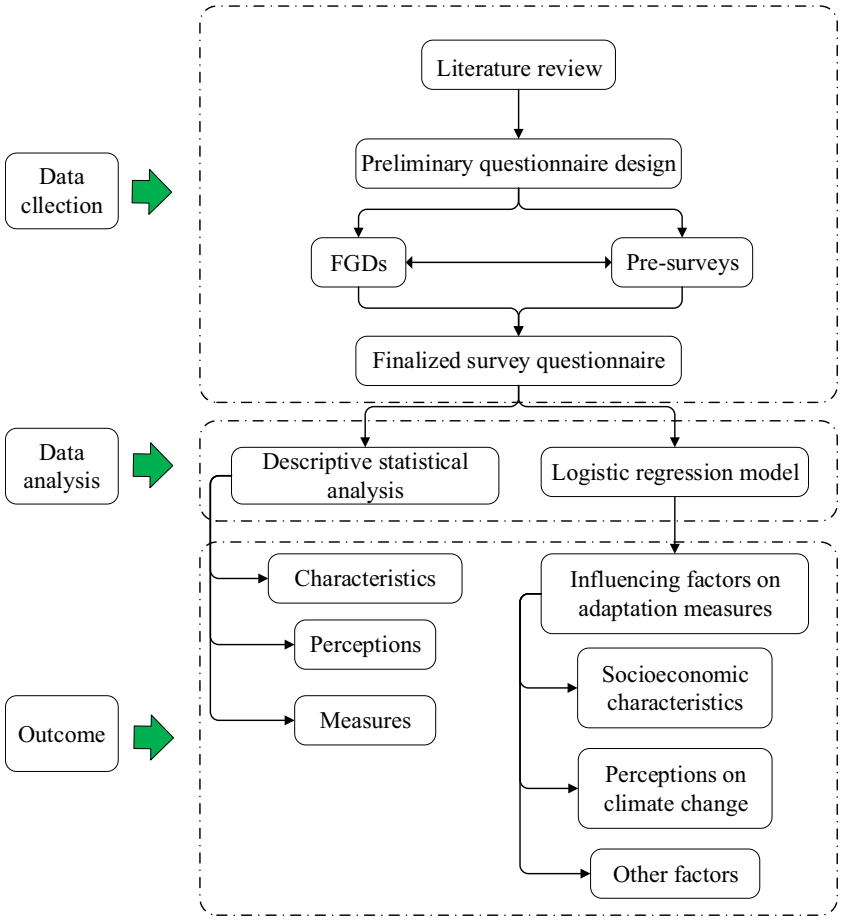

Fig. 1 The schematic flow chart of this study

other productions. Third, the questionnaire was pretested on 30 local farmers in Wushen Banner. Then, the questionnaire was modified based on the results of pre-surveys.

The finalized questionnaire consisted of three major sections (see Appendix). The first section was designed to collect information on farmers' knowledge and perceptions of climate change and adaptation. In this study, respondents were asked about whether they had observed any climate variability over the past 10 years. Specifically, respondents were asked whether they have observed any changes in temperature, precipitation, drought frequency, and intensity over the past 10 years. Respondents were further asked whether they agreed with some views on climate change and adaptation. In the second section, respondents were asked what adaptation measures had been taken to adapt to climate change and whether these existing measures were effective or not. Respondents were asked about changes in their lives as a result of adaptation to climate change and barriers to adaptation. The third section included a number of relevant questions regarding the respondents and their household socioeconomic characteristics, such as gender, education, age, arable land area, proportion of labor input to farming and animal husbandry, and household income.

The final survey was conducted by the research team in July of 2018 in Wushen Banner. Respondents were randomly selected from Wushen Banner by using the multiple-stage random sampling method. First, the research team selected two towns (Galutu and Wudinghe) based on the town area and the town population size from the six towns in Wushen Banner. Second, five villages were randomly chosen in the two selected towns. Third, based on the population size of each village, 30–50 households were randomly selected in each village. A list of farmers for each village was obtained from the respective village leaders. The number of respondents in each village was chosen based on its percentage of households in total household of the whole village. The members of the research team were trained to conduct face-to-face interviews with farmers who were heads of households or household agricultural decision-makers in each household. Each interview lasted approximately 30–50 min. Among the 220 household heads randomly selected, 216 households ultimately participated in our study.

Data analysis

In this study, descriptive statistical analysis was used to analyze survey results, such as socioeconomic characteristics of

the sample, farmers' perceptions of climate change, and the farmers' actual adaptation measures. Because the adaptation measure to climate change is a binary case, i.e., to adapt (1) or not to adapt (0), per Abid et al. (2015) and Jin et al. (2018), the binary logit model was employed to identify the factors influencing farmers' adoption of different adaptation measures. Parameters were estimated using the logistic program in Statistical Package for Social Sciences (SPSS) v. 22. The specification of the empirical model or the reduced form that was estimated is as follows (Hosmer and Lemeshow 2000):

$$Y_i = \text{logit}(P) = \beta_0 + \beta_i \sum_{i=1}^{n} X_i + \varepsilon_i$$

where Y_i is a dichotomous dependent variable (respondents using any climate change adaptation measure or not, specified as 1 = yes, 0 = otherwise); β_0 is the constant term; β_i is a set of coefficients to be estimated; and X represents a set of explanatory variables. The positive sign represents the explanatory variable that helps to increase the probability of adopting a certain climate change adaptation measure, and a negative sign indicates the opposite effect. ε_i is an error term (Bender and Grouven 1998).

Results

Basic socioeconomic characteristics of the sample

Table 1 shows the basic socioeconomic characteristics of the respondents. The average age of the participants in our sample was 53.57 years old. This result is realistic since many young people leave villages for better jobs in cities. The average educational level of our sample was elementary school. Further analysis of educational level indicates that 29.5% of the respondents were illiterate; approximately 27.3% had completed their primary education; and 25.5%, 13.6%, 3.6%, and 0.5% had attained junior high school, senior high school, college, and university, respectively. Household annual income was CNY 30,000 (US$4412) to CNY 50,000 (US$7352). The overall average household size was 3 persons. On average, each household owned 2.07 ha of cultivated land. The average household grassland area was 10.88 ha. The average number of farming years was 33.7 years. Almost half of the household heads of our sample (48%) had access to credit, borrowing money from banks, or rural credit unions.

Farmers' perceptions of climate change and adaptation

Farmers' perceptions of climate change

The results show that most respondents were concerned about climate change (Fig. 2). We used the five-point Likert scale to indicate farmer concerns about climate change, with 1 representing not concerned at all, 2 representing not concerned, 3 representing generally concerned, 4 representing concerned, and 5 representing very concerned. Approximately 41.3% of respondents were very concerned about climate change. Approximately 50.5% of respondents were concerned about climate change. Only 3.7% of respondents said they had no feelings or did not concern about climate change.

The respondents in the sample had a consistent attitude towards climate change. All respondents agreed that climate change was occurring. Approximately 94.5% of the farmers believed that the average annual temperature had increased (see Fig. 3). A majority of the respondents (85.9%) believed that the average annual precipitation had decreased. Most farmers (95%) agreed that high-temperature days had

Table 1 Socio-economic characteristics of the sample

Variables	Descriptions	Mean	Std. Dev.
Age	Age of the respondent	53.57	13.68
Education	Education of the respondent (1 = uneducated, 2 = elementary, 3 = junior high school, 4 = senior high school, 5 = college, 6 = university, 7 = master degree)	2.36	1.172
Income	Household annual income (1 = 0–5000, 2 = 5000–10,000, 3 = 10,000–30,000, 4 = 30,000–50,000, 5 = 50,000–70,000, 6 = 70,000–100,000, 7 = 100,000–150,000, 8 = 150,000–200,000, 9 = 200,000–300,000, 10 = 300,000 and above) (CNY)	4.00	1.972
H size	Household population size	2.54	1.108
Farm size	Cultivated land size (ha)	2.07	2.05
Grassland	Grassland size (ha)	10.88	35.55
Farm years	Years involved in agricultural activities	33.70	16.56
Credit	Access to credit (1 = yes, 0 = no)	0.48	0.501

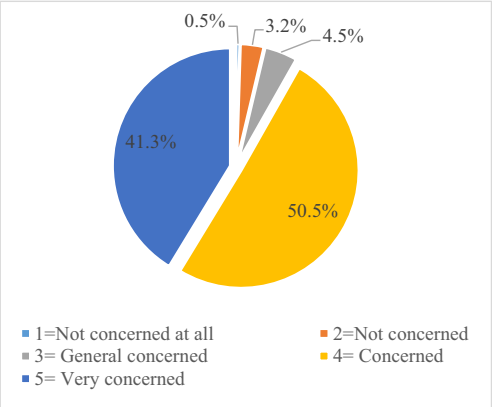

Fig. 2 Farmers' levels of concern about climate change

increased. Approximately 90.9% of the respondents thought that the intensity of droughts had increased, and 89.1% of the sample believed that the frequency of droughts had increased.

Table 2 presents the results of the farmers' perceptions about the negative impacts of climate change on agriculture. Very few respondents (0.5%) believed that climate change had no impact on agriculture. Approximately 79% of the farmers believed climate change had reduced their agricultural and animal husbandry production yields. Most farmers (74%) believed that climate change had driven up production costs. The proportion of farmers who believed that climate change had led to grassland degradation was 47%. Approximately 46.1% and 34.7% of farmers believed that climate change had increased the cost of adaptation measures and had changed the growing season of crops, respectively.

Farmers' perceptions of climate change adaptation

The survey results show that almost all farmers (96.8%) believed that climate change had affected their farming activities (Fig. 4). Approximately 87% of the farmers agreed that farmers should take appropriate measures to address climate change. Moreover, most farmers (80.3%) believed that implementing adaptation measures could mitigate the adverse effects of climate change. However, more than half of the farmers (65%) believed that human capacity to cope with climate change was limited and still at a low level. Approximately 79.8% of the farmers thought the cost of implementing climate change adaptation measures was high.

Farmers' expectations of climate change and obstacles to adapting

The results show that farmers agreed that the local climate would change further, and the farmers estimated the proportion of average crop loss due to climate change for the next growing season at 29%. Table 3 shows the obstacles to implementing adaptation measures. The main obstacles reported by local farmers included lack of technology, money, knowledge, and information; poor infrastructure; and water and labor shortages. A total of 79% of farmers said they had to address with climate change on their own. In addition, 62.1%, 80.8%, and 57.5% of farmers believed that agricultural technology training, targeted agricultural subsidies, and improved infrastructure could help improve their abilities to adapt to climate change, respectively.

Farmers' actual adaptation measures

Figure 5 shows that approximately 88.1% of the farmers adjusted their planting methods to address climate change, such as adjusting fertilization or pesticide use behavior and changing the method or frequency of irrigation. Most farmers (84.5%) chose financial instruments, including buying agricultural insurance or seeking farm credit to adapt to climate change. Almost half of the farmers (49.5%) had implemented rotational grazing and rest grazing. A total of 41.6% of the farmers adopted crop diversification in response to climate change. Only 20.1% of the farmers attempted to diversify livelihoods.

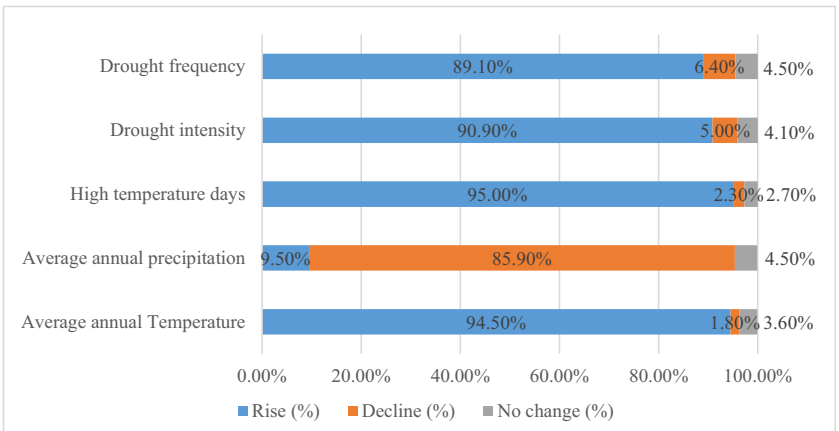

Fig. 3 Respondents' perceptions of climate change

Table 2 The negative impacts of climate change on agriculture

Negative impact	Agreement (%)
Reducing agricultural and animal husbandry production yields	79.0
Increasing production costs	74.0
Grassland degradation	47.0
Increasing the cost of adaptation	46.1
Changing crop growing seasons	34.7
No negative impact	0.5

In terms of the changes resulting from implementing adaptation measures, more than half of the respondents (57.5%) were satisfied with the efficacy of the measures taken, with only 11.8% of the respondents being dissatisfied or very dissatisfied with the measures taken. Respondents were likely to believe that their lives had changed after adopting measures to adapt to climate change. Specifically, approximately 62.3% of the farmers indicated that their agricultural income ratio had changed (Fig. 6). Many farmers (71.3%) believed that the quality of family life had improved after implementing adaptation measures. Approximately 54.2% of the farmers believed that their capacity to cope with climate had improved. Some farmers (45.8%) indicated that the quality of their arable land or grassland improved.

Factors influencing farmers' adoption of adaptation measures

Binary logit models were used to investigate the factors influencing farmers' adoption of climate change adaptation measures. Table 4 shows the definitions of the explanatory variables used and their main statistics. To eliminate the influence of collinearity between variables, we performed a collinearity analysis on the explanatory variables. If the indicator "tolerance" (TOL) was less than 0.1 or "the variance inflation factor" (VIF) was greater than 10, then collinearity existed (Bai et al. 2010). The results in Table 5 show that all the TOL values were greater than 0.1 and all the VIF values were less than 10, suggesting that there was no serious collinearity problem.

The results of the regression analysis are shown in Table 6. Almost all the explanatory variables were significant at the 10% level or less in at least one model. The likelihood value statistics were highly significant ($p < 0.001$), suggesting that the models were statistically significant. A Nagelkerke R^2 value represents the fitting degree of a model and data. The value of Nagelkerke R^2 is between 0 and 1. A larger value indicates a better fitting. When Nagelkerke R^2 is greater than 0.2, it shows a relatively good fit in social science research (Clark and Hosking 1986). All the Nagelkerke R^2 values in this study are greater than 0.2, which indicates perfect fits. The overall percentage represents the probability of correctly predicting the model. Table 6 shows that the prediction accuracy of each model was greater than 0.5.

The regression results in Table 6 suggest some important findings. First, the model results show that farm size and education had significant impacts on farmers' diversification strategy. In comparison with other farmers, those with higher education levels and more farmland were more likely to adopt crop diversification to address the impacts of climate change. Second, the modeling results show that in comparison with other farmers, those who have farmed longer were more likely to adjust their planting methods to address climate change. Moreover, risk-averse farmers tended to adjust planting behavior to cope with the adverse effects of climate change. Third, farmers who believed that climate change has a great

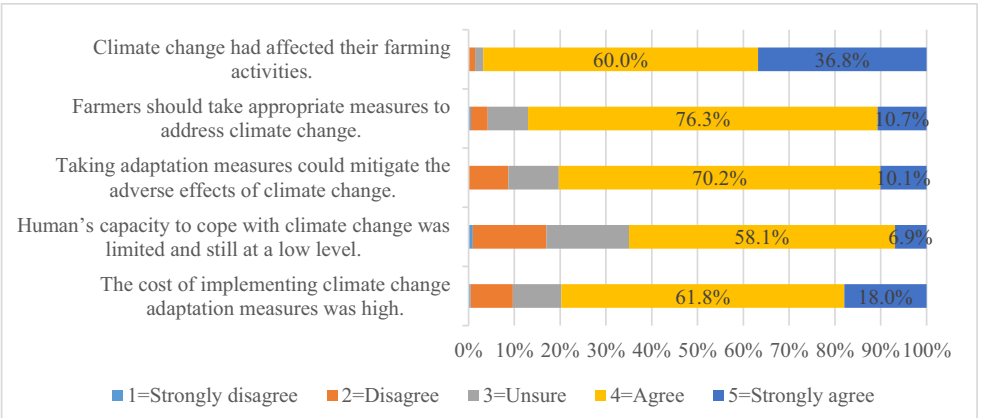

Fig. 4 Farmers' perceptions of climate change adaptation

Table 3 Obstacles to implementing adaptation measures

Obstacles	Percentage
Lack of technology	49.8
Shortage of money	47.0
Poor infrastructure	46.5
Water shortage	42.4
Lack of knowledge on climate change adaptation	40.1
Labor shortage	30.4
Lack of climate change information	21.2

impact on human health were more likely to adopt rotational grazing. Additionally, in comparison with female farmers, male farmers were more likely to adopt a rotational grazing policy. Farmers who believed that climate change has a great impact on production preferred to diversify their livelihoods. In addition, farm size, level of education, and household income also had significant and positive effects. Finally, the regression results show that farmers who believed that climate change has a greater impact on human health were more likely to buy agricultural insurance and seek agricultural credits.

Discussion

The survey results show that farmers were highly concerned about climate change. Most farmers believed that the average annual temperature in Wushen Banner had increased and the annual precipitation had decreased. They also believed that the frequency and intensity of droughts in the study area had increased. The majority of farmers (79%) in the study area believed that climate change has negatively affected their agricultural production. In addition, respondents estimated that the crop losses due to climate change in the past 3 years are 27.7%, which influenced their livelihoods. These findings are comparable with those of other studies (Abid et al. 2019; Hou et al. 2012; Mase et al. 2017; Shi et al. 2019). Previous studies also have established that climate change has affected farming and animal husbandry, such as the growing season of crops in China (Li et al. 2013). Ochieng et al. (2016) and Bhatta et al. (2015) found that a decrease in precipitation attributed to climate change is considered to be major reasons for a reduction in crop production. Future research can pay more attention to the differences in the impact of climate change on different crops in the region, such as which crop got a decline in production and how much quantity.

The results show that there are several obstacles for farmers in adopting adaptation measures to address climate change, such as the lack of technology, shortage of money, and poor infrastructure. This result is comparable with those of other studies (Abid et al. 2015; Abid et al. 2019; Jin et al. 2016; Woods et al. 2017). Farmers are unwilling to adapt to climate change because of limited resources and financial constraints (Abid et al. 2019; Jin et al. 2015). Similar problems are noted in other studies on adaptation barriers, such as the lack of money, lack of technology, and lack of information in Pakistan (Abid et al. 2015). The results also indicate that the most commonly adopted adaptation measures are adjusting planting methods and choosing financial instruments. This corroborates the findings of existing research (Abdul-Razak and Kruse 2017; Adhikari et al. 2018; Kabir et al. 2017). For instance, Adhikari et al. (2018) found that changing planting practices had been the major household-level adaptation practices.

The regression results show that respondents' perceptions of climate change have effects on choosing adaptation measures. Farmers who believe that climate change has health effects were more willing to use adaptation measures, such as buying agricultural insurance or seeking agricultural credits. Earlier evidence also suggests farmers perceiving major risks have a higher willingness to pay to reduce health risks (Khan and Damalas 2015; Wang et al. 2018). Moreover,

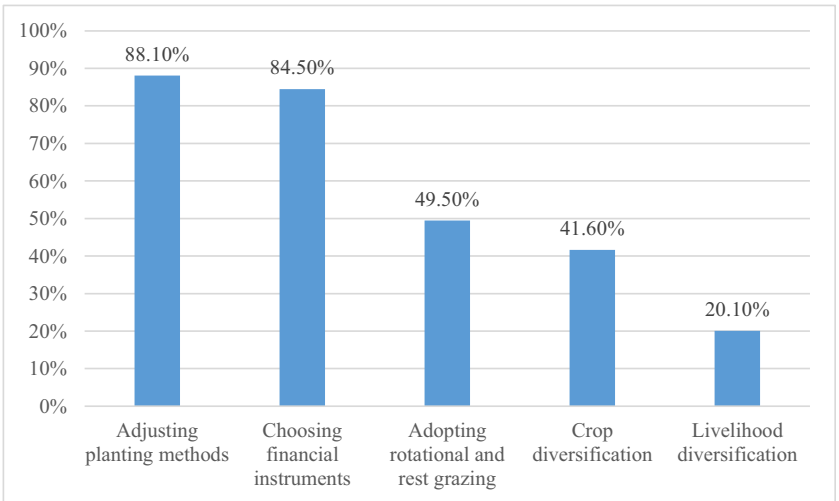

Fig. 5 Farmers' adaptation measures to cope with climate change

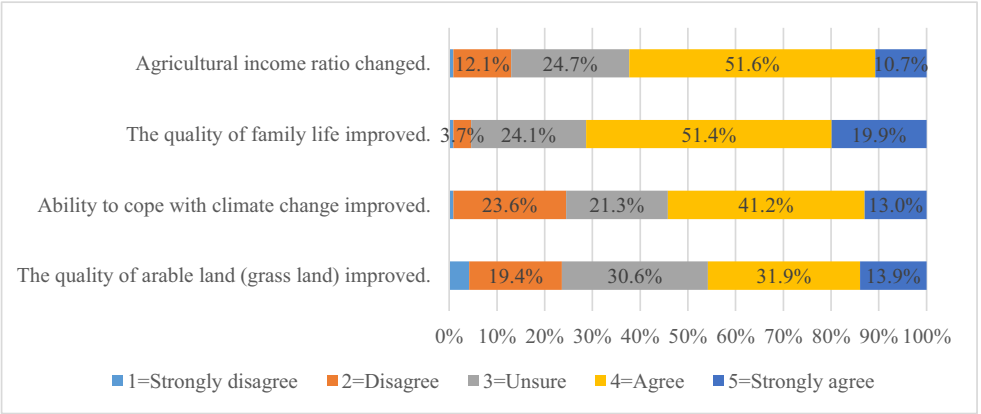

Fig. 6 Changes resulting from implementing adaptation measures

farmers who believe that climate change affects their agricultural production were more likely to diversify their livelihoods. This is understandable. Kuruppu and Liverman (2011) also found that the changes in climate affected livelihoods forcing some respondents to move houses.

The regression results also show that farmers' levels of education have significant and positive effects on choosing adaptation measures. These results are consistent with those in other studies (Barnes et al. 2013; Whitmarsh 2011). They found that higher levels of education resulted in more acceptance of climate change adaptation actions. Khanal and Wilson (2019) also indicated that better-educated households are more likely to employ adaptation practices. The possible reason for this result is that higher levels of education can help farmers better understand climate change–related information and knowledge about climate change adaptation. In addition, farming experience has a significant and positive impact on adjusting farming methods. This suggests that the respondents who have more experience in farming are more willing to adjust farming methods. This finding is consistent with the analysis conducted by Li et al. (2013) in Tibet that used descriptive statistical analysis to indicate that farmers adjusted planting seasons based on personal experiences. Moreover, there are gender differences in choosing some adaptation measures. For instance, male farmers were more likely than female farmers to adopt a rotational grazing strategy. This result can be explained by the fact that men are more likely than women to access information about climate change and its adaptation. These results are consistent with those in other related studies. Ali and Erenstein (2017) and Li et al. (2013) also reported that in comparison with female-headed households, male-headed households are willing to adopt more adaptation measures.

Table 4 List of explanatory variables and descriptive statistics

Variables	Definitions	Mean	Std. Dev.
Production effect	The impact of climate change on production and living on a scale of 1 to 5 (1 = little influence, 5 = great influence)	4.16	0.86
Health effect	The impact of climate change on human health on a scale of 1 to 5(1 = little influence, 5 = great influence)	3.92	1.04
Farm size	Farm size(ha)	2.07	2.05
Gender	1 = male; 0 = female	0.63	0.48
Farm years	Years of farming activities (years)	33.70	16.56
Education	Education of the respondent (1 = uneducated, 2 = elementary, 3 = junior high school, 4 = senior high school, 5 = college, 6 = university, 7 = master degree or above)	2.36	1.17
Income	Household annual income (CNY, 1 = 0–5000, 2 = 5000–10,000, 3 = 10,000–30,000, 4 = 30,000–50,000, 5 = 50,000–70,000, 6 = 70,000–100,000, 7 = 100,000–150,000, 8 = 150,000–200,000, 9 = 200,000–300,000, 10 = 300,000 and above) (Yuan)	4	1.97
Risk	The farmer's willingness to take risks from 0 to 10 (0 represents not willing to take risks, 10 represents very willing to take risks)	3.73	3.19

Table 5 Multicollinearity diagnosis indexes for explanatory variables

Variables	TOL	VIF
Produtio neffect	0.72	1.39
Health effect	0.71	1.41
Farm size	0.79	1.26
Gender	0.75	1.33
Farm years	0.19	5.34
Education	0.46	2.16
Income	0.64	1.56
Risk	0.86	1.14

Based on the findings of this study, some policy implications for the responsible authorities can be obtained. First, the local government should improve farmers' perceptions of climate change and its adaptation through increasing the effective dissemination and the training programs of climate change adaption–related information. Then, infrastructure, both hard infrastructure and education infrastructure, needs to be strengthened for farmers to improve their ability to adopt adaptation measures in response to uncertain climate change impacts. In addition, the government should strengthen financial support, including special subsidies and investment guidance, to help local farmers to adapt to climate change better.

Finally, although several findings were obtained through this study, there are some limitations. First, the findings from this study were based on a sample in a very specific area of China. Obviously, climate change adaptation behavior varies by local climate, economic, and culture. More related research should be conducted. Second, it is important to take into account farmers' perceptions of climate change or variability as they are likely to shape the types of adaptation strategies (Kuruppu and Liverman 2011). To measure farmers' perceptions of the change in climate are accurate or not, future research can compare the changes perceived by respondents on temperature and rainfall with the changes in climatic pattern based on historical meteorological data.

Conclusions

This study explored local farmers' perceptions of climate change, actual adaptation actions at the farm level, and the factors driving and constraining farmers' decisions to implement adaptation measures in Wushen Banner, China.

The results show that farmers in the study area were concerned about climate change. Respondents agreed that climate change was occurring and they perceived the negative impacts of climate change. Most respondents believed that adaptation measures should be implemented to cope with climate change.

Adjusting farming practices (e.g., fertilization, irrigation, or planting time) and using financial instruments (e.g., credit and insurance) were the two most important adaptation measures to deal with climate change. The main obstacles for local farmers in the adoption of adaptation measures were lack of technology, shortage of money, and poor infrastructure.

Farmers' perceptions of climate change had positive and significant impacts on some adaptation measures. Farmers who believed that climate change would affect their livelihoods were more likely to diversify their livelihoods. Farmers who believed that climate change would affect their health were more willing to buy insurance or seek credits. Farmers who had farmed longer tended to adjust their farming behavior to cope with climate change. Farmers' levels of education and farm sizes had positive and significant impacts on farmers' decisions to diversify crop practices. These results

Table 6 Factors influencing the adoption of adaptation measures

Variables	Diversification	Adjusting	Grazing	Livelihood	Financial
Constant	− 2.06	5.33	− 2.40	− 5.32**	− 0.52
Production effect	− 0.23	− 0.43	0.04	0.62*	0.14
Health effect	0.05	0.35	0.59***	0.01	0.98***
Farm size	0.24**	0.35	0.19*	0.26**	− 0.10
Gender	− 0.04	0.14	1.37***	−0.32	0.58
Farm years	− 0.01	0.12**	0.06**	0.03	0.04
Education	0.53**	0.25	0.05	0.57**	0.08
Income	0.10	− 0.11	− 0.07	0.22*	0.10
Risk	− 0.12	− 0.14**	0.03	0.03	− 0.14
Summary statistics					
-2Log likelihood	234.6[a]	99.3[a]	228.1[a]	164.8[a]	112.3[a]
Overall percentage	0.68[b]	0.92[b]	0.72[b]	0.82[b]	0.89[b]
Nagelkerke R^2	0.21	0.26	0.28	0.25	0.30

***Indicates significance at the 1% level; **Indicates significance at the 5% level; *Indicates significance at the 10% level; [a] Estimation terminated at iteration number 5 because parameter estimates changed by less than 0.001. [b] The cut value is 0.500

provide some critical insights into local perceptions of climate change and enhance our understanding of cognitive beliefs attached to adaptive responses.

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