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Gender differences in farmers' responses to climate change adaptation in Yongqiao District, China

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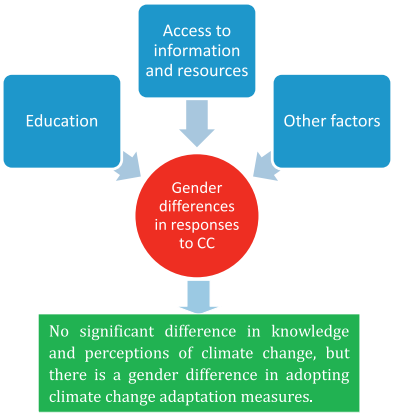
HIGHLIGHTS

- We explore the gender differences in farmers' responses to climate change adaption.
- Male and female farmers are not significantly different in their knowledge.
- There is a gender difference in adopting climate change adaptation measures.
- Male are more likely to adopt new technology and to increase investment.
- Male and female heads' adaptation decisions are influenced by different factors.

GRAPHICAL ABSTRACT



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ABSTRACT

This study examines the gender differences in farmers' responses to climate change adaption in Yongqiao District, China. A random sampling technique was used to select 220 household heads, while descriptive statistics and binary logit models were used to analyze the data obtained from the households. We determine that male and female respondents are not significantly different in their knowledge and perceptions of climate change, but there is a gender difference in adopting climate change adaptation measures. Male-headed households are more likely to adopt new technology for water conservation and to increase investment in irrigation infrastructure. The research also indicates that the adaptation decisions of male and female heads are influenced by different sets of factors. The findings of this research help to elucidate the determinants of climate change adaptation decisions for male and female-headed households and the strategic interventions necessary for effective adaptation.

1. Introduction

Climate change is a clear fact in our world (IPCC, 2007). There is a consensus among scientists that climate change will have disproportionally harmful socio-economic effects on developing countries (Singh et al., 2010) and the most vulnerable people and groups.

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A large majority of them are rural communities, particularly women. China is a typical meteorological disaster-prone country and is highly exposed to natural disasters as well as the potential impact of climate change (Liu et al., 2010). Climate change is expected to adversely affect China's agricultural production and local farmers (Edition Committee of China's National Assessment Reporton Climate Change, 2012).

Adaptation is considered an appropriate response to climate change, especially for smallholder farmers (Ozor et al., 2012). Adaptation to climate change refers to the adjustment of natural or human systems in response to actual or expected climatic stimuli or their effects to moderate harm or exploit beneficial opportunities (IPCC, 2001; Deressa et al., 2009). Adaptation to climate change at the farm level includes many possible responses, such as using new crop varieties and livestock species that are better suited to new conditions, irrigation, crop diversification, adoption of mixed crop and livestock farming systems, and purchasing insurance (Elizabeth et al., 2013; Deressa et al., 2009). An in-depth knowledge of the coping and adaptation measures and practices along with the factors that influence farmers' choices could not only enhance policy measures to mitigate the negative impacts of climate change but also increases the farm households' capability of coping and adapting to the challenges posed by climate change to their agro-based livelihood (Muhammad et al., 2014).

The impacts of climate change are unlikely to be gender-neutral (Singh et al., 2010). Men and women farmers in many developing countries experience different levels of vulnerability and adaptive capacity to climate change (Denton, 2002). Compared to men, women are more vulnerable to the effects of climate change and natural disasters such as floods, droughts, cyclones and storms because of their limited access to resources, restricted rights, and limited mobility and voice in community and household decision-making (UNDP, 2008). This is unfair and can lead to unfortunate consequences for all, as women play a unique role in the stewardship of natural resources and support of households and communities (Seema, 2011). A United Nations (UN) policy brief stressed that it is crucial that adaptation efforts integrate gender issues at all levels (Habtezion, 2013). It is therefore vital that men's and women's different perspectives and choices of climate change adaptation strategies be taken into consideration when planning community-based adaptation activities (UNDP, 2010).

There is a growing recognition of gender-based vulnerability to climate change and consequent adaptation and adaptive capacity (Terry, 2009; Dankelman, 2010; MacGregor, 2010; Aoyagi et al., 2011; UNDP, 2012). The literature on gender and climate change adaptation in developing countries is growing. Some studies have shown that gender is an important variable affecting adoption decisions at the farm level (Dolisca et al., 2006; Bayard et al., 2007). Men and women may respond differently to climate change adaptation because of their different levels of education and access to information and resources. However, there is little documented evidence from China on which factors are important and the magnitude of their influence in climate change adaptation decision-making in male and female household heads. There is a need to look at these factors for men and women separately to be able to develop gender-specific adaptation policies and strategies (Hemmati and Röhr, 2007). Thus, the purpose of this study is to gain a better understanding of the determinants of climate change adaptation decisions by male and female-headed smallholder farmers in China. Specifically, this study will try to answer the following questions: (Anim, 1999) Is there any difference between male and female farmers in their knowledge and perceptions of climate change? (Anley et al., 2007) What types of actual climate change adaptation measures were taken by male and female farmers? Are there any differences between them? (Aoyagi et al., 2011) What factors will influence male and female farmers' choices of climate change adaptation measures? In the context of China, this is the first study that primarily addresses climate change adaptation methods and factors affecting the choices of male and female-headed farm households.

The remainder of this paper is organized as follows. Section 2 describes the study area, the research design and the analytical method. Section 3 reports the empirical results and discussions. The final section provides the conclusions and policy implications.

2. Materials and methods

2.1. Study area

The study was undertaken in Yongqiao District, located in the north of Anhui Province of central China. Yongqiao is the largest county-level district in China, and it is the first region in which wheat drought weather index insurance was issued. The total area of this district is 2868 km^2. The average yearly temperature is approximately 14 °C, and the annual rainfall is 900 mm. In 2012, the population of the district was 1,880,000, among which the agricultural population accounted for 78%. The average per capita GDP was approximately CNY 20,059 (USD 3280). Wheat and corn are the two main crops in this area. In 2013, more than 90% of households grew wheat, and over 85% grew corn.

The region was purposely selected owing to its fragility and sensitivity to climate variability. Yongqiao lies in the Huaibei Plain and the watershed of the Huai River. The surface is generally undulating, and the soil is very porous with low capacity to retain water. This makes it vulnerable to flood and drought. Heat waves during the crop's flowering phase in July and August and rainfall shortages are the main problems affecting a stable crop harvest. Due to the effect of climate change, farmers may face more risky situations in the future. Because agricultural production remains the main source of income for most rural communities in the region, adaptation is imperative to enhancing the resilience of the agriculture sector, protect the livelihood of the poor, and ensure food security.

2.2. Survey instrument

To identify and assess current and potential household-level adaptation strategies available to rural communities, data were collected using household surveys. The survey instrument was developed and revised based on a series of focus group discussions and pre-test surveys. Focus group discussions were carried out among government officials and local farmers, each with 5–8 people varying in age from 30 to 60 years. The purpose of the focus group discussions was to assess local changes in the climate and the households' adaptation or coping strategies in response to climate change. A series of pre-test surveys was issued to further identify and correct potential problems. Questions that were poorly understood were modified for clarity.

The questionnaire consisted of three major sections. The first section was to collect information on farmers' knowledge and perceptions of climate change and its possible impacts. In this study, we define climate change as perceived changes in the average temperature and average rainfall over the last 10 years. Respondents were asked about whether they had perceived an increase in the average temperature and a decrease in the average precipitation over the last 10 years. Respondents were then asked about whether they had heard about climate change. Respondents were also asked to rank the first two risks that were of greatest concern to them for their agricultural production. Six common risks were provided: flood, drought, erratic rainfall, heat waves, insect attack and bad seeds. A blank space was provided for the respondents to fill in other risks that concern them. Respondents were further asked about their opinions on whether climate change would affect their agricultural yields or not. They were asked to estimate the annual average percentage of crop losses due to bad weather (e.g., heavy rain, drought, high temperature) in the last 5 years and in the next 5 years, respectively.

The second section contained some questions about respondents' choices of climate change adaptation strategies. At the farm level, adaptation to climate change includes many possible choices (Ozor

et al., 2012). However, characterizing these decisions in a manner suitable for analysis is challenging. The climate change adaptation measures that were used for this study were selected based on focus group discussions. Because the main disaster in Yongqiao is drought, in this study, we mainly focus on the adaptation measures to the drought hazard. The adaptation measures that the respondents were asked about include planting new crops that are drought-tolerant and/or resistant to temperature stresses, adopting new technology for water conservation that can enable more efficient use of the available water, increasing investment in irrigation infrastructure, crop diversification on the same plot or on different plots to reduce the risk of complete crop failure because different crops are affected differently by climate events, and purchasing wheat drought weather index insurance.

The last section included a number of relevant questions regarding the respondents and their households' demographic and socio-economic characteristics.

2.3. Sampling and surveying method

Respondents were randomly selected from Yongqiao District. In most cases, we interviewed the head of the household. When the head of the household did mostly off-farm work (i.e., leaves the village for work in larger cities), we interviewed the family member who was the most responsible for farm work. A total of 220 household heads were randomly selected, and 200 household heads ultimately participated in our study. Among them, 84 respondents were male, and 116 were female.

Personal interviews were used as the survey method to encourage more responses and to offer respondents the largest response scope for detailed questions, pictures and answers. The professional interviewers were trained to effectively conduct face-to-face interviews.

2.4. Econometric model

Econometric analysis was performed to examine the factors influencing farmers' adoption of different climate change adaptation measures. Because the adaptation to climate change is a binary case, to adapt or not to adapt (0,1), per Solomon et al. (2014), we used binary logit regression models. Gujarati (2004) provides an excellent theoretical exposition of the model that can be estimated as a probability. Detailed descriptions of the logistic regression technique can be found in Hosmer and Lemeshow (2000) and Kleinbaum and Klein (2002). The specification of the empirical model or the reduced form that was estimated is as follows:

$$Y_i = \alpha + \beta_i \sum_{i=1}^{n} X_i + \varepsilon_i$$

where Y_i is a dichotomous dependent variable (farmer using any climate change adaptation measure or not, specified as yes = 1, 0 = otherwise), α is the Y-intercept, β_i are a set of coefficients to be estimated, and X denotes the set of explanatory variables hypothesized to influence adaptation to climate change. A positive sign means that the explanatory variable helps to increase the probability of adopting a climate change adaptation strategy, and a negative sign implies the opposite effect. ε_i is an error term.

2.5. Empirical specifications of model variables

The dependent variable in the empirical estimation of this study is whether the respondents adopted an adaptation option from the set of adaptation measures provided. The explanatory variables that were included in our analysis are selected based on theoretical behavioral hypotheses, empirical literature and data availability. The explanatory variables considered in this study include farmers' perception and knowledge variables and socioeconomic factors. We present a brief description of these variables below and develop some hypotheses about their expected influence on farm-level adaptations.

Various studies have shown that education and farming experience are important variables influencing adaptation decisions at the farm level. Several studies have shown that improving education and disseminating knowledge are important policy measures for stimulating local participation in various development and natural resource management initiatives (Dolisca et al., 2006; Anley et al., 2007; Tizale, 2007). Educated and experienced farmers are expected to have more knowledge and information on climate change and agronomic practices that they can use in response (Maddison, 2006). However, some studies found that education was an insignificant determinant of adoption decisions (e.g., Clay et al., 1998), while Okoye (1998) found that education was negatively correlated with such decisions. We expect that education and farming experience positively influence farmers' decisions to adopt adaptation measures.

Awareness and perception of the problem and the potential benefits of taking action is another important factor leading to the adoption of agricultural decisions. Maddison (2006) found that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making. It is our hypothesis that farmers who notice and are aware of changes in the climate would have a higher probability of taking up adaptation measures.

It has been claimed that high social capital contributes to climate change adaptation (Wolf et al., 2010). In its Third Assessment Report (TAR), the IPCC underlines that farmers' good health may affect their households' ability to adapt to climate-induced changes (IPCC, 2001). We hypothesize that the farmers' health status has a positive effect on their adoptions of climate change strategies.

Several studies have shown that access to credit is an important determinant enhancing the adoption of various technologies (Tizale, 2007; Hassan and Nhemachena, 2008; Obayelu et al., 2014). With more financial and other resources at their disposal, farmers are able to make use of all available information to change their management practices in response to changing climatic and other conditions. We therefore expect that access to credit has a positive effect on adaptation behaviors.

The influence of farm size on adaptation has been mixed in the literature. For example, a study on soil conservation measures in South

Table 1
Socio-economic characteristics of the sample.

Variables	Descriptions	Male	Female	Total sample
Age	Age of the respondent	38.88 (13.14)	42.19 (11.93)	40.81 (12.53)
Education	Education of the respondent (1 = elementary, 2 = junior high school, 3 = senior high school, 4 = college, 5 = university and above)	3.11 (0.76)	2.85 (0.79)	2.96 (0.79)
Farmsize	Farm size (Mu)	13.07 (6.26)	15.28 (12.07)	14.35 (10.08)
HHsize	Household size	4.82 (1.19)	4.79 (1.38)	4.81 (1.30)
Farmyears	Years involved in agricultural activities	18.33 (12.64)	19.94 (12.59)	19.27 (12.61)
Income	Household monthly income (USD)	544 (411)	586 (400)	569 (404)
Credit	1 = access to credit; 0 = otherwise	0.25 (0.43)	0.22 (0.42)	0.24 (0.42)

Note: numbers are means. Numbers in parentheses are standard deviations.

Table 2
Farmers' actual adaptation measures.

Definitions	% of female respondents	% of male respondents
Adopting technology on new water conservation	38	70
Increasing investment in irrigation infrastructures	67	85
Panting new drought tolerant crops	81	77
Crop diversification	32	31
Purchasing the drought weather index insurance	53	51

Africa showed that farm size was not a significant adoption factor (Anim, 1999). Other studies, however, found that farmers with larger farms would have more land to allocate for constructing soil bunds (embankments) and improved cut-off drains in Haiti (Anley et al., 2007). Nyangena (2008) found that farmers with a small area of land were more likely to invest in soil conservation than those with a large area. This study hypothesizes that farm size may have different impacts on different adaptation measures.

3. Results and discussion

3.1. Basic socio-economic characteristics of the sample

Table 1 shows the basic socio-economic characteristics of the sample respondents. The typical participant in our sample was 40.81 years old. The average education level of our sample was close to senior high school. A further analysis of education indicates that 2% of the respondents were illiterate, 22% had completed their primary education, and 58% and 18% had attained junior high school and higher education, respectively. The overall average household size was five persons. The average farming experience was approximately 20 years, with 28% of the respondents having farming experience of more than or equal to 25 years. The average monthly household income was approximately 569 US dollars. Only a few household heads of our sample (24%) had access to credit; they borrowed money from the bank.

A two-sample mean comparison test for differences in the means of the socioeconomic variables of male and female household heads shows there are no significant differences in age, farm size, household size, farming experience and household monthly income between the two groups. However, there is a significant difference in educational levels between male and female household heads ($t = -2.36$; p value $= 0.01$), with male household heads having a significantly higher educational level than female household heads. This is in line with the existing literature that men usually have a higher educational level than women, especially in rural areas of developing countries (Meng and Glewwe, 2010).

3.2. Perceptions of climate change

Our results show that an overwhelming majority of the farmers perceived an increase in average temperatures (82%) and a decrease in average precipitation (80%) over the last 10 years. The results indicate that 95% of the respondents had heard about climate change. This suggests a high level of awareness of the subject matter in the area, which can be attributed to extensive awareness creation made through electronic media and social networks. When we look to the difference between male and female household heads, we find that 95.37% of the female respondents and 94.56% of the male respondents had heard about climate change, a non-significant difference.

Respondents were asked in the questionnaire to choose the top two risks to their agricultural production in the past 5 years from a list. The results show that the first risk was drought and the second risk was heat waves, which are consistent with the actual situation in this area. Approximately 92% of the female sample and 89% of the male respondents thought that climate change would affect their agricultural yields. Respondents were asked to estimate the yearly average percentage of crop losses due to bad weather (e.g., heavy rain, drought, and high temperature) in the last 5 years. For the females, the annual average loss was estimated to be approximately 36%, while for the male, it was 31%. Female respondents thought the probability of incurring crop losses in the upcoming growing season was 26%, not significantly different from male respondents (24%). Based on the above results, it can be observed that male and female respondents are not significantly different in their knowledge and perceptions of climate change and its impacts.

3.3. Farmers' actual adaptation measures

Table 2 presents the actual adaptation strategies adopted by female and male household heads in the area in cushioning the effects/impacts of climate change. It is clear from Table 2 that the most commonly used adaptation practices were planting new drought-tolerant crops and increasing investment in irrigation infrastructure. Cross-tabulation of the results shows that the majority of the male-headed households (70%) adopted new technologies for water conservation to adapt to climate change, which is significantly higher than the number of female-headed households (38%). The results also show that the percentage of male respondents who increased their investment in irrigation infrastructure (85%) is significantly higher than the percentage of female respondents (74%). Our results are consistent with the existing literature that male-headed households are more likely to adopt new technology and undertake risky business investment than female-headed households (Asfaw and Admassie, 2004; Deressa et al., 2009). For the adaptation measures of planting new drought-tolerant crops,

Table 4
Multicollinearity diagnosis indexes for explanatory variables.

Variables	Tolerance (TOL)	Variance inflation factor (VIF)
Farmyears	0.942	1.062
Healthst	0.815	1.226
HighEduc	0.966	1.036
Perception	0.891	1.123
Futureloss	0.881	1.135
Credit	0.923	1.083
Nfarmsize	0.914	1.094
Logincper	0.889	1.124

Table 3
List of variables and descriptive statistics.

Variables	Definitions	Female		Male	
		Mean	Std. dev.	Mean	Std. dev.
Farmyears	Years of farming activities (years)	19.95	12.60	18.33	12.64
Healthst	Farmers' health status on a five-point scale (1 = very poor, 5 = very good)	2.89	1.23	3.30	1.32
Higheduc	1 = above junior middle-school; 0 = otherwise	0.16	0.37	0.26	0.44
Perception	1 = climate change can affect crop yield; 0 = otherwise	0.88	0.40	0.93	0.26
Futureloss	Estimated percentage of future crop loss caused by climate change	26.97	15.49	24.01	13.60
Credit	Access to credit (1 = yes and 0 = no)	0.22	0.42	0.25	0.44
Nfarmsize	Land owned per adult	4.60	4.22	4.85	3.31
Logincper	Logged value of monthly income per household member	2.79	0.31	2.75	0.32

Table 5
Determinants of adaptation to climate change among female respondents.

Variables	Newcrop	Newtech	Moreinvest	Diversification	Insurance
Constant	−6.14 (5.40)	−2.55 (2.68)	−6.65 (3.19)**	−4.44 (2.67)*	−2.36 (2.60)
Farmyears	−0.07 (0.04)*	−0.05 (0.02)**	0.00009 (0.02)	−0.002 (0.02)	0.06 (0.02)***
Healthst	1.60 (0.74)**	0.91 (0.26) ***	1.16 (0.35)***	1.25 (0.30)***	0.68 (0.26)***
Higheduc	0.61 (1.10)	−0.35 (0.71)	−0.31 (0.73)	−0.87 (0.86)	1.47 (0.70)**
Perception	3.97 (1.11)***	1.89 (1.11)**	2.24 (0.76)***	−0.57 (0.85)	1.41 (0.75)*
Futureloss	0.08 (0.03)**	−0.01 (0.02)	0.006 (0.02)	0.003 (0.02)	0.07 (0.02)***
Credit	−1.42 (1.12)	−0.12 (0.60)	0.29 (0.69)	0.11 (0.07)	0.20 (0.60)
Nfarmsize	−0.08 (0.09)	−0.03 (0.05)	−0.03 (0.05)	−0.13 (0.89)	0.09 (0.07)
Logincper	0.64 (1.64)	−0.36 (0.87)	0.93 (0.99)	−4.44 (2.67)	−0.77 (0.89)
Summary statistics					
Log likelihood	−19.69	−57.85	−45.63	−49.63	−54.69
LR chi^2 (Bai et al., 2010)	73.31	38.28	55.46	47.47	50.88
Prob > *chi*^{2}	<0.001	<0.001	<0.001	<0.001	<0.001
Pseudo R^2	0.65	0.25	0.38	0.32	0.32
Numbers	105	105	105	105	105

*** Indicates significance at the 1% level.
** Indicates significance at the 5% level.
* Indicates significance at the 10% level.

crop diversification and purchasing wheat drought weather index insurance, there are no significant differences between the male and female household heads.

3.4. Determinants influencing farmers' adaptation measures

Table 3 shows the definitions of the variables used for our estimation and their main statistics. Econometric analysis with cross-sectional data is usually associated with the problem of multicollinearity. The term collinearity implies that two variables are near perfect linear combinations of each another. When more than two variables are involved, it is often called multicollinearity. Multicollinearity among explanatory variables can lead to imprecise parameter estimates. “Tolerance” (TOL) and “the variance inflation factor” (VIF) are two important indices for multicollinearity diagnosis (Zhu and Huang, 2006). A value of TOL that is smaller than 0.1, or a value of VIF that is greater than 10, is one indicator of serious multicollinearity between independent variables (Bai et al., 2010; Menard, 2002). To explore the potential multicollinearity among the explanatory variables, the tolerance and variance inflation factors were calculated (Table 4). The smallest TOL in this study was larger than 0.1, and the largest VIF is less than 10 (Table 4), showing that multicollinearity is not a serious problem in the models.

The results from the regression analysis over the female and male samples of farmers are presented in Table 5 and Table 6, respectively. The results show that most of the explanatory variables are statistically significant at 10% or lower at one or two models. The chi-square results show that the likelihood ratio statistics are highly significant ($p < 0.001$), suggesting that all the models have a strong explanatory power. The pseudo R^2 value cautiously indicates how the logit model fits the dataset (Menard, 2002). A pseudo R^2 equal to 1 indicates a perfect fit, whereas 0 shows no relationship (Ayalew and Yamagishi, 2005). When a pseudo R^2 is greater than 0.2, it shows a relatively good fit (Clark and Hosking, 1986). All the pseudo R^2 values in this study are higher than 0.2 (Table 5 and Table 6). The signs on most variables are as expected. The results indicate that the adaptation decisions of male and female heads are influenced by different sets of factors.

It is clear from Table 5 and Table 6 that the farmers' health status has a significant and positive effect on the probability of adopting almost all adaptation measures. The effects of the farmers' health status are not different between female and male farmers. This result is in line with our expectation. This finding is understandable because a healthier farmer can have a better capacity to change their agricultural practices in response to climate change and would have a higher probability of taking up adaptation measures.

Table 6
Determinants of adaptation to climate change among male respondents.

Variables	Newcrop	Newtech	Moreinvest	Diversification	Insurance
Constant	−17.41 (5.50)***	−1.06 (3.35)	−14.94 (8.29)*	−5.04 (3.96)	−7.95 (4.43)*
Farmyears	−0.02 (0.03)	−0.06 (0.03)**	−0.10 (0.07)	0.03 (0.03)	0.06 (0.03)**
Healthst	1.09 (0.36)***	1.22 (0.34)***	3.03 (1.01)***	1.61 (0.38)***	0.62 (0.27)**
Higheduc	−0.07 (0.85)	0.21 (0.68)	2.57 (1.47)*	−0.08 (0.74)	1.13 (0.79)
Perception	4.79 (1.63)***	−0.10 (1.31)	5.99 (2.87)**	0.01 (1.29)	−0.06 (1.30)
Futureloss	0.08 (0.06)	0.04 (0.02)	0.20 (0.10)**	0.02 (0.03)	0.13 (0.05)***
Credit	0.94 (0.96)	0.21 (0.74)	4.91 (2.42)**	0.08 (0.83)	1.22 (0.95)
Nfarmsize	−0.18 (0.14)	0.08 (0.13)	−0.84 (0.35)**	−0.07 (0.09)	0.27 (0.14)**
Logincper	4.03 (1.54)***	0.04 (0.99)	2.32 (2.12)	−0.81 (1.18)	−0.02 (1.21)
Summary statistics					
Log likelihood	−24.97	−35.99	−12.33	−32.29	−31.20
LR chi^2 (Bai et al., 2010)	37.34	30.30	44.24	42.36	53.99
	<0.001	<0.001	<0.001	<0.001	<0.001
Prob > *chi*^{2}					
Pseudo R^2	0.43	0.29	0.64	0.40	0.46
Numbers	80	80	80	80	80

*** Indicates significance at the 1% level.
** Indicates significance at the 5% level.
* Indicates significance at the 10% level.

It was found that farming experience has different impacts on different adaptation methods. Our results show that farming experience has a significant and negative influence on planting new drought-tolerant crop varieties and adopting new technology for female farmers. For male farmers, farming experience has a significant and negative influence on their decisions to adopt new technology for water conservation. The results also show that farming experience is positively significant in influencing female and male farmers' decisions to purchase wheat drought weather index insurance.

The effect of education in our study appears to be adaptation measure specific and gender-specific. An educated female farmer is more likely to purchase the wheat drought weather index insurance, and a more educated male farmer has a higher probability of increasing their investment in irrigation systems.

The two variables of individuals' awareness of the impact of climate change (Perception and Futureloss) are positively and significantly related with adaption options such as planting new crop practices, higher investment in irrigation systems and purchasing wheat drought weather index insurance. For female farmers, their perceptions of the possible impacts of climate change have a significantly positive impact on almost all adaption measures expect for crop diversification. Male farmers' perceptions also have a positive influence on their decisions to plant new drought-tolerant crops and increasing investment in irrigation infrastructure. Our results also indicate that if a farmer's estimation of the crop yield loss caused by climate change is higher, he or she would have a higher probability of adopting adaptation measures. For female farmers, their estimations of future crop loss have a significant positive impact on their adaptation choices of planting new crops and purchasing insurance, while for male farmers, their estimations of future crop loss significantly influence their decisions on purchasing wheat drought weather index insurance.

Our results indicate that access to credit, farm size per adult and household income did not seem to be of significance in influencing female farmers' adaptation, as almost all coefficients were statistically insignificant and their signs do not suggest any particular pattern. However, for male farmers, better access to credit services seems to have a positive influence on the probability of increasing investment in irrigation systems. One possible reason for this could be that access to credit may increase the financial resources of male farmers (Benhin, 2006; Gbetibouo, 2009). The farm size per adult has a negative impact on increasing investment in irrigation systems, but it has a positive impact on purchasing crop insurance. The household income has a positive and significant impact on planting new crop varieties for male farmers. This is understandable because planting new crop varieties would incur a new cost on the household.

4. Conclusions and policy implications

Climate change is expected to have a significant impact on agricultural production in China. Small producers, therefore, must take appropriate adaptation measures to reduce the negative impact of climate change. Female and male farmers may differ in their choices of climate change adaptation measures because of major differences between them in terms of education, access to assets and other services (Bayard et al., 2007). This study is to examine the gender differences in farmers' responses to climate change in China.

The results show that most farmers in the study area were aware of climate change. Farmers took measures to protect their livelihoods against perceived changes in climate. The main practices actually adopted by local farmers are planting new drought-tolerant crops and increasing their investment in irrigation systems.

Our results indicate that male and female respondents are not significantly different in their knowledge and perceptions of climate change and its impact. However, there is a gender difference in adopting adaptation measures to climate change. Male-headed households are more likely to adopt new technologies for water conservation and to increase investment in irrigation infrastructure. The research also shows that the adaptation decisions of male and female heads are influenced by different sets of factors.

For policy implications, it is evident in this study that both female and male farmers' health statuses have significant and positive impacts on their adaptation to climate change, and these results are consistent with other studies as well, so that investment in human capital can be underlined as a policy option for the reduction of the negative impacts of climate change in rural areas.

The results of the empirical analyses confirm that farmers' perception and awareness of climate change have a significant and positive impact on their decisions on climate change adaptation measures. This suggests that better knowledge and information on climate change and agronomic practices can stimulate farm-level climate change adaptation.

Our results indicate that some determinants of climate change adaptation decisions among male and female farmers are different. Thus, it would be wise to take gender-specific differences into account when designing or implementing climate change adaptation strategies. Local government officials and decision-makers need to interact with rural communities including women and involve women in decision making.

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