Social Networks, Farm Assets, and Farmers' Perceptions of Climate Change in China

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Abstract:

Farmers' perceptions of the local climate reflect their awareness of climate change and may affect their adaptation behaviors. However, current literature suffers a knowledge gap on understanding farmers' perceptions of climate change. This study examines farmers' perceptions of annual mean temperature, the consistency of these perceptions with meteorological record data, and what influences this consistency. The study found that more than 70% of farmers in China perceived an increasing trend of annual mean temperature over the past 10 years, while only 18% of farmers correctly perceived a decreasing trend, which is consistent with the meteorological record data. Econometric analysis shows that social networks can improve a farmer's ability to correctly perceive temperature changes. Additionally, those with a larger farm size are more likely to be able to consistently perceive temperature. This paper concludes with several policy and research implications.

Key words: social networks, farm assets, perception, consistency, climate change, China

1. Introduction

Scholars and policy makers have focused on how to improve the adaptive capacity of the agricultural sector, due to its vulnerability to climate change (Fischer et al. 2002, Parry et al. 2004, Piao et al. 2010). Anatomies or typologies have been developed to systematically classify and characterize agricultural options for adapting to climate change (Smit & Skinner 2002, Lim et al. 2005). Evaluations of these various adaptation measures have shown that farmers' adaptations play a significant role in mitigating the negative impacts of climate change (Kaiser et al. 1993, Smit & Pilifosova 2001, Reidsma et al. 2010, Olesen et al. 2011).

The first step in the process of adaptation, according to some scholars, is understanding farmers' perceptions of climate change. Dijksterhuis et al. (2001) pointed out that farmers' perceptions reflect their awareness of climate change and determine whether they will take adaptive actions. Farmers' adaptation behaviors can be viewed as a two-stage decision process. First, farmers perceive or detect a change in climate correctly. Second, farmers adapt certain behaviors (Moser & Ekstrom 2010). Therefore, before examining whether farmers will take adaptive actions and what kinds of adaptive measures they take, scholars must understand how farmers perceive changes in climate and whether their perceptions are consistent with the actual change(s) that occur.

Although some studies show that most farmers have perceived significant past climate changes (Mertz et al. 2009, Deressa et al. 2009, Deressa et al. 2011, Tambo et al. 2012, Sjögersten et al. 2013, Rashid et al. 2014), none of these studies explore whether farmers’ perceptions agree with actual climate trends. Hansen and coauthors (2004) reported some inconsistencies between farmers’ recollection of years with extreme cold temperatures and available local meteorological data in the Argentine Pampas and South Florida; for example, farmers claimed to have experienced 13 freeze years whereas official data reported only seven years. Conversely, Hageback and coauthors (2005) found that farmers in the Danangou watershed in China agreed on a warming and drying trend, and these perceptions of climatic variability corresponded with the meteorological record.

Some studies examined factors affecting farmers’ perceptions of climate change, but not the determinants of the consistency of farmers’ perceptions with actual climate trends. Deressa et al. (2011) found that social networks influenced farmers’ perceptions of climate change. Social networks have been viewed as critical factors in information dissemination, and farmers with greater assets are believed to be more likely to seek and make use of shared information (Demiryurek et al. 2008, Gueye 2009, Langyintuo & Mungoma 2008). Semenza and coauthors (2008) show that individuals with lower incomes are more concerned with climate change. Other factors such as gender, ethnic background, membership in environmental groups, education, access to extension services (e.g., climate information and production technologies), and exposure to mass media affect peoples’ perceptions as well (Leiserowitz 2007, Gbetibouo 2009, Akter & Bennett 2011).

Given this knowledge gap, several research questions emerge. How do local farmers perceive climate trends, and do these perceptions correspond with meteorological records? What factors affect the consistency of farmers' perceptions? Why do discrepancies exist between farmers' perceptions and meteorological data? Answering these questions is critical not only to better understanding farmers' perceptions of climate change, but also to providing empirical evidence for policies that aim to improve farmers' adaptive capacity by enhancing their ability to correctly perceive climate change.

As such, our paper has two specific objectives: (1) examining the consistency of farmers' perceptions, and (2) identifying the factors that influence this consistency. We used a large-scale primary household survey in nine provinces in China to compare farmers' perceptions with the corresponding meteorological dataset. Although there are many indicators of climate change, due to data limitation, we only selected air temperature as a key indicator to measure climate change.

This paper is organized as follows. Section 2 describes the data sources and major variables used in our analysis. Section 3 presents historical trends in temperature change, farmers' perceptions of temperature change and their consistency with the meteorological record, a descriptive analysis on the relationships between this consistency, social networks and farm assets, and the relationship between farmers' perceptions and adaptive behaviors. Section 4 analyzes the impacts of social networks, farm assets, and other control variables on the consistency of farmers' perceptions with the meteorological record, using an econometric model. Conclusions and recommendations are included in Section 5.

2. Data

This study employs two datasets: (1) a large-scale household survey conducted from late 2012 to early 2013, and (2) a meteorological record dataset of nine provinces in China. The household survey shows how local farmers perceive climate change, while the meteorological data are used to determine the actual change in climate. Comparing the two datasets allows us to identify the consistency of farmers' perceptions with the actual data.

The household survey was conducted in nine provinces: Jilin, Hebei, Henan, Shandong, and Anhui Provinces in northern China, and Jiangsu, Jiangxi, Yunnan, and Guangdong Provinces in southern China (Figure 1). Three counties in each province except for Jiangxi (10 counties) and Guangdong (6 counties)[1] were randomly selected from the counties that met the following two conditions: (1) had experienced a serious drought or flood during 2010-2012, and (2) had experienced a normal weather year during 2010-2012. Within each county, a stratified random sampling was used to select three townships. Townships were stratified into three groups by the condition of their rural water infrastructure: 1/3 of the sample with above average condition; 1/3 with average condition; and 1/3 with below average condition. One township was randomly selected from each of the three groups. Within each township, three villages

[1] Surveys in Jiangxi and Guangdong provinces were funded by two projects that used the same sampling framework and survey questionnaires.

were selected randomly and 10 farmers were randomly selected from each village. In total, the sample includes 3,330 households from 330 villages in 37 counties in 9 provinces in China. For more detailed sampling rules, please refer to Huang and coauthors (2014).

The data used in this study are a subset of the above primary household survey. In this section, farmers were asked their perceptions of the pattern of annual mean temperature over the past 10 years (from 2003 to 2012). Four choices were available: increasing, decreasing, unchanged, and unknown.

The survey also covered basic information on farmers' social networks, farm assets, demographic characteristics (e.g., age, education, and gender), and village characteristics (e.g., whether the village had a continuous residential area and the village's distance from the county seat). Social networks were measured by three indicators: (1) whether the village had farmers' organizations (e.g., water user association, agricultural production or marketing cooperative, or a women's association), (2) number of living relatives of farmers within three generations, and (3) whether these relatives served as village leaders. Farm assets were measured by farm size and wealth (i.e. the total value of durable consumption assets and structures). The descriptive statistics of these indicators are summarized in Appendix Table 1.

Meteorological information on the annual mean temperature was obtained from the National Meteorological Information Center. The dataset contained daily temperature measurements from 1960 to 2012 in 756 national ground-based meteorological stations located throughout China. We assumed that temperature was homogenous across a county. However, in our 37 sampled counties, only 14 contained national meteorological stations. In order to obtain county-level temperature data for the other 23 counties, a spatial interpolation method proposed by Thornton and coauthors (1997) was used. Their method has been widely used (White et al. 1997, Hasenauer et al. 2003) and is based on the spatial convolution of a truncated Gaussian weighting filter with a set of station locations. Required inputs include digital elevation data and observations of maximum temperature, minimum temperature, and precipitation from ground-based meteorological stations. A cross-validation analysis was performed and the temperature prediction has been validated. The same interpolation data has also been used by Zhang and coauthors (2013).

3. Descriptive analysis

3.1 Temperature trends

While the annual mean temperature for most provinces has increased over the past 50 years, the past decade showed a decreasing trend. The annual mean temperature for each sample county during 2003-2012 is plotted in Figure 2. A simple linear regression model was used to examine the trend of annual mean temperature in each county.[2] Thirty of the 37 sample counties experienced a decreasing temperature

[2] An increasing (decreasing) trend is implied by a positive (negative) coefficient greater (less) than 0.01 (-0.01) without considering statistical significance. If the coefficient is between 0.01 and -0.01, an unchanged trend is assigned. We select ±0.01℃ per annum as the cutting points based on the fact that China's surface mean temperature increased by 1.1℃ over the past century (1908-2007). On average, it increased by 0.01℃ per annum.

trend over the past 10 years (2003-2012), while during the same period, five counties (Wei Chang in Hebei Province, Hua Xian and Yuan Yang in Henan Province, Xuan Wei and Yan Shan in Yunnan Province) showed an increasing temperature trend. Two counties (Wei Xian in Hebei Province and Jun Cheng in Shandong Province) did not experience significant changes.

3.2 Farmers' perceptions of temperature change and their consistency with the meteorological record

Interestingly, although most study counties showed falling temperatures over the past 10 years, 72% of farmers still perceived an increasing temperature trend over the same period (Table 1). The percentage of farmers who perceived the increased temperature trend was higher in southern China than in northern China. For example, 78%, 80%, and 83% of farmers in Jiangxi, Guangdong, and Yunnan provinces in southern China, respectively, perceived an increasing trend in temperature, while these numbers were lower in Jilin (57%) and Henan (61.5%) provinces in northern China. Only 8% of farmers perceived decreasing temperatures over the last 10 years (Table 1). The northernmost province, Jilin, had the highest proportion of farmers who reported a decreasing trend (24.1%), while this number was the lowest for farmers in Yunnan Province, located in southern China (9.6%). Overall, 16.6% of farmers thought that the temperature had not changed over the last 10 years, with Henan (30.7%) and Jiangsu (25.2%) provinces ranking as the top two. Only 3.2% of farmers said they did not know the trend of annual temperature over the last 10 years.

Farmers' perceptions of temperature changes were then compared with the corresponding actual temperature data presented in the previous subsection. In the analysis, we excluded the 3% of farmers who answered "did not know," and ended up with 3,225 valid household responses. Through this comparison, we divided all farmers into two groups: (1) those consistent with the actual temperature record trends in their own counties, and (2) those inconsistent with the recorded trends.

Only 17.7% of the 3,225 farmers' perceptions of temperature were consistent with the actual recorded data (second row in Table 2). It is not surprising to see such low consistency, since the actual data showed decreasing trends (Figure 3) while the farmers perceived increasing trends. Why were some farmers' perceptions consistent with actual meteorological record data, but others were not? In the following sections, we will explore this issue based on both descriptive analysis and an econometric estimation.

3.3 Social networks, farm assets, and farmers' perceptions

Social networks play a significant role in information exchange (Isham 2002). Deressa et al. (2011) found that social networks influenced farmers' perceptions of climate change, and used farmer-to-farmer extension services as well as the number of relatives in the village as indicators.

We expect that farmers with more developed social networks are more likely to perceive temperature changes that are consistent with actual data. As shown in Table 2, in those villages with farmers' organizations, 19.6% of farmers' perceptions of temperature were consistent with the meteorological record data, higher than those in villages without farmers' organization (16.6%) (p-value < 0.05). This difference implies that the availability of and attendance at farmers' organization activities can increase farmers' opportunities to obtain actual information on local weather. In addition, having more relatives in the village also extends farmers' networks to acquire more information. If the farmers had more relatives (i.e., more than 13 relatives within three generations) in their family, the consistency of their perceptions (18.7%) was also higher (p-value < 0.05). However, to our surprise, the consistency rate for the households that included a relative who was a village leader (9.4%) was much lower than households without a village leader (18.9%) (p-value < 0.01).

Regarding farm assets, the descriptive analysis supports that farmers with more significant assets are more likely to have perceptions consistent with real data. As shown in Table 2, 19.6% of farmers who operated large farms had perceptions that were consistent with meteorological data, while this number was only 17.4% for small farm holders and 16% for medium farm holders. This could imply that larger farms are more concerned about temperature changes. However, wealthier farmers were less likely to have consistent perceptions (13.1%), compared to 18.8% of moderately wealthy farmers, and 21.2% of the least wealthy farmers. Possibly, wealthy farmers are better able to adapt to temperature (by using air conditioners or having better quality clothes), leaving them less sensitive to temperature changes.

3.4 Farmers' perceptions and their adaptive behaviors

Examining the consistency of farmers' perceptions of temperature will have more significant implications if these perceptions are shown to impact farmers' adaptive responses. Our descriptive analysis showed that farmers who perceived an increasing temperature trend were more likely to irrigate their land and to use drought-resistant crop varieties. As shown in Table 3, 61% of farmers who perceived an increasing temperature trend took irrigation actions, while this number was only 54.7% for those with decreasing and unchanged trends (p-value < 0.01). The adoption rate of drought-resistant crop varieties was 10.5% for the farmers who perceived an increasing temperature trend, but only 8.2% for those who perceived a decreasing trend (p-value < 0.05).

4. Determinants of the Consistency of Farmers' Perceptions

It is impossible to isolate the impact of a single factor by descriptive statistical analysis, since it cannot control the impacts of other factors. Therefore, this section employs an econometric model to estimate the effects of social networks, farm assets, and other control variables on the consistency of farmers' perceptions of temperature.

4.1. Specification of econometric model

To explain the consistency rates of farmers' perceptions of temperature, we chose specific explanatory variables based on literature and data availability. As discussed in Section 3, the key independent variables included social networks and farm assets. Media coverage is also expected to be a key factor in shaping farmers' perceptions; however, we had to exclude this indicator due to a shortage of available data. In addition, controlled variables included characteristics of the farmers, villages, and counties. We also added a set of provincial dummy variables to control regional variations. To capture the effect of temperature variation, we added the coefficients of variation of temperature during 2003 to 2012 for each county. The empirical model is specified as follows:

$$C_{ijkp} = \beta_0 + \beta_1 SN_{ijkp} + \beta_2 FA_{ijkp} + \beta_3 FC_{ijkp} + \beta_4 VC_{jkp} + \beta_5 CT_{kp} + \beta_6 CV_{kp} + \beta_7 PD_p + \varepsilon_{ijkp}$$

where *i*, *j*, *k* and *p* represent the i^{th} farmer in the j^{th} village in the k^{th} county of the p^{th} province. ε_{ijp} is the error term and all β s are the parameters to be estimated. Given the nature of the dependent variable, a logistic model was used to estimate the econometric model.

The dependent variable, *C*, is whether or not a farmer's perception was consistent with the actual temperature trend on record, with 1 denoting consistency and 0 for inconsistency. The first set of the independent variables, *SN*, is a vector of variables that reflects social networks. As we discussed above, this included (1) whether a village had any farmers' organizations (yes = 1; no = 0), (2) number of living relatives within three generations, and (3) whether a family member was a village leader (yes = 1; no = 0). The second set of independent variables, *FA*, is a vector of variables that reflects farm assets, including farm size in hectares and wealth level. Wealth is measured by durable consumption assets and house value in thousand RMB.[3]

Other socio-economic characteristics of farmers and villages were controlled. Farm-level controls are represented by a vector of variables, *FC*, that includes education level (number of school years), age (years) and gender (male = 1; female = 0) of the respondent farmers. Variables representing village characteristics, *VC*, include whether a village had a continuous residential area (yes = 1; no = 0) and distance to the county seat (km).

We also controlled some county-level and provincial-level factors. *CT* is a dummy variable that represents county type (drought county = 1; flood county = 0). *CV* is a variable that represents the temperature variation, indicated by the coefficients of variation of temperature during the study period, and *PD* is a set of provincial dummy variables that control the differences among provinces.

4.2 Estimation results

The estimated results suggest that the logistic model performed well. The likelihood ratio statistics were significant, at a 1% significance level that passed the Chi square test (Table 4). The pseudo R^2 was 0.23, high enough for a multivariate analysis based on cross-sectional data. Furthermore, the signs of the estimated parameters for all variables were consistent with our expectations, and most of them were statistically significant. Multicollinearity was not a problem in this model, since

[3] RMB is the unit of Chinese currency. 1 RMB = 0.1626 US dollars in 2014.

the variance inflation factor (VIF) for all variables was less than 10 (ranging from 1.02 to 3.90).

Social networks and consistency of farmers' perceptions of temperature

Our estimation results reveal that social networks enhanced the consistency of farmers' perceptions. The coefficient of the dummy variable representing a village with farmers' organization(s) was positive and statistically significant (Table 4). This implies that the existence of farmers' organizations increases the probability of consistency between farmers' perceptions of temperature and real data. Marginal effects show that farmers who lived in a village with farmers' organizations had a 2.7% higher probability of reporting consistent perceptions compared to those in villages without any farmers' organizations. This result implies that farmers' organizations can serve as hotspots for disseminating climate change information, as farmers who attend the organization's activities may exchange farming experiences and information, including those related to climate change.

The more relatives the farmers have, the more likely they are to have perceptions that are consistent with recorded data. The coefficient of the number of relatives was positive and statistically significant (Table 4). One more relative within three generations increased the probability of consistent perceptions by 0.3%. This result is consistent with our descriptive analysis shown in Table 2. Therefore, relatives are important social networks and information sources for farmers. However, the coefficient of village leaders was not significant: after controlling for the impacts of other factors, the observed difference in the consistency of perceptions between households with and without a village leader was not statistically significant.

Farm assets and consistency of farmers' perceptions of temperature

Our estimation results show that farm size had a positive impact on the consistency of farmers' perceptions (Table 4). If farm size was increased by one hectare, the likelihood of consistent perception increased by 0.6%. Generally speaking, farmers with larger farms usually are those with the greatest farming capacities, which may include a better capacity to detect temperature trends. These farmers may pay more attention to climate factors, as temperature change may affect their crop production more significantly than those on smaller farms.

However, we found that wealthier farmers were less likely to have consistent perceptions. The coefficients of wealth dummy variables were negative and the one of the high wealth level is statistically significant (Table 4). The probability of having perceptions consistent with data for the high wealth group is 2.9% lower than that for the low wealth group. Possibly, wealthier farmers have more durable consumption assets and better living conditions, such as air conditioners or heating system, which enable them to adapt to and care less about temperature changes.

Other factors and consistency of farmers' perceptions of temperature

Estimation results show that consistency of farmers' perceptions of temperature did not vary based on farmers' characteristics (Table 4). The coefficient of age was negative but statistically nonsignificant, while the coefficients of gender and education were positive but also statistically nonsignificant.

Two village characteristics, however, did have significant influence on the consistency of farmers' perceptions. Interestingly, a continuous residential area positively affected the consistency of farmers' perceptions (Table 4). Continuous residential areas provide convenient ways for farmers to communicate information, including information relevant to climate change. Another interesting result was that consistent perceptions were more often reported by farmers who live farther from the county seat. This is perhaps because farmers living farther from the center of county activity have less information to process than those who live closer.

Our results also show that it was more difficult for farmers to have consistent perceptions when facing larger temperature variations. The coefficient of temperature variation was negative and statistically significant, consistent with our expectations.

5. Concluding Remarks

This study sought to examine the consistency of farmers' perceptions of temperature and its influencing factors, particularly the relationship between consistency, social networks, and farm assets. Meteorological record data show that in the past 10 years (2003-2012), the mean annual temperature in most sample counties decreased. However, our large-scale field survey data from nine provinces in China show that more than 70% of farmers reported that the annual mean temperature tended to increase over this period.

There are two possible reasons for this low level of consistency between perceptions and real data. Historical temperature data show that while the average annual mean temperature increased over the past 50 years, the past decade showed a decreasing trend. When we asked farmers the overall trend of temperatures in the past 10 years, the elder farmers tended to recall temperature trends longer than 10 years. While we did ask farmers’ perceptions of temperature trends in the past 30-plus years, we chose to use 10 years as the official time frame, as a large number of respondents explained that they could not recall that long time period. One implication suggested by our findings is to reconsider the design of an appropriate time horizon for similar studies (e.g., varying in accordance with respondents’ ages). If farmers have been more dependent on temperature changes in recent years (e.g., 10 years or so) to make their adaptation decisions, then the low consistency of perceptions found in this study implies that greater efforts are needed to help farmers better understand actual temperature or climate changes so that they can adapt appropriately.

Although complex forces including psychological, cultural, and political factors can shape farmers’ perceptions, our study found that social networks can significantly enhance the consistency of farmers’ perceptions. However, this result should not be limited to farmers’ organizations and the number of relatives, as examined in this study. Researchers should give similar attention to other dimensions of social capital that are not examined here but that could also improve and enlarge farmers’ social networks, such as trust and collective action (Narayan and Cassidy 2001). The positive relationship between farm size and consistent perceptions implies that while efforts are needed to improve climate change knowledge for all farmers, particular attention should be paid to the small farm holder.

This study did not rigorously examine the impact of farmers' perceptions of climate change on their adaptive measures. As such, this is an area that also requires further research. If farmers' perceptions have significant impacts on their adaptive behaviors, examining the consistency of farmers' perceptions of climate change with actual data could provide substantial results. This examination could help identify whether or not farmers are adapting to climate change in appropriate and effective ways. Adapting to climate change through inappropriate measures wastes resources and could exacerbate the adverse impacts from climate change. For example, if actual data show that temperature decreased in spring while farmers' perceptions were that it increased, farmers should delay the planting date rather than advancing it.

We only focused on farmers' perceptions of one indicator of climate change: temperature trends. Perceptions of other indicators of climate change, such as precipitation (i.e., drought frequency and flood frequency), may have more direct significance to adaptive responses. As a result, further research is suggested that addresses the consistency of farmers' perceptions based on additional indicators of climate change.

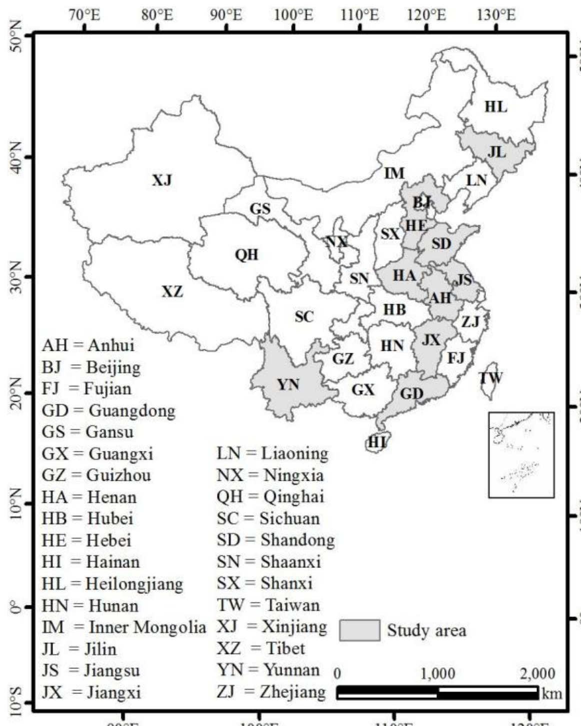

Figure 1. Locations of the study areas

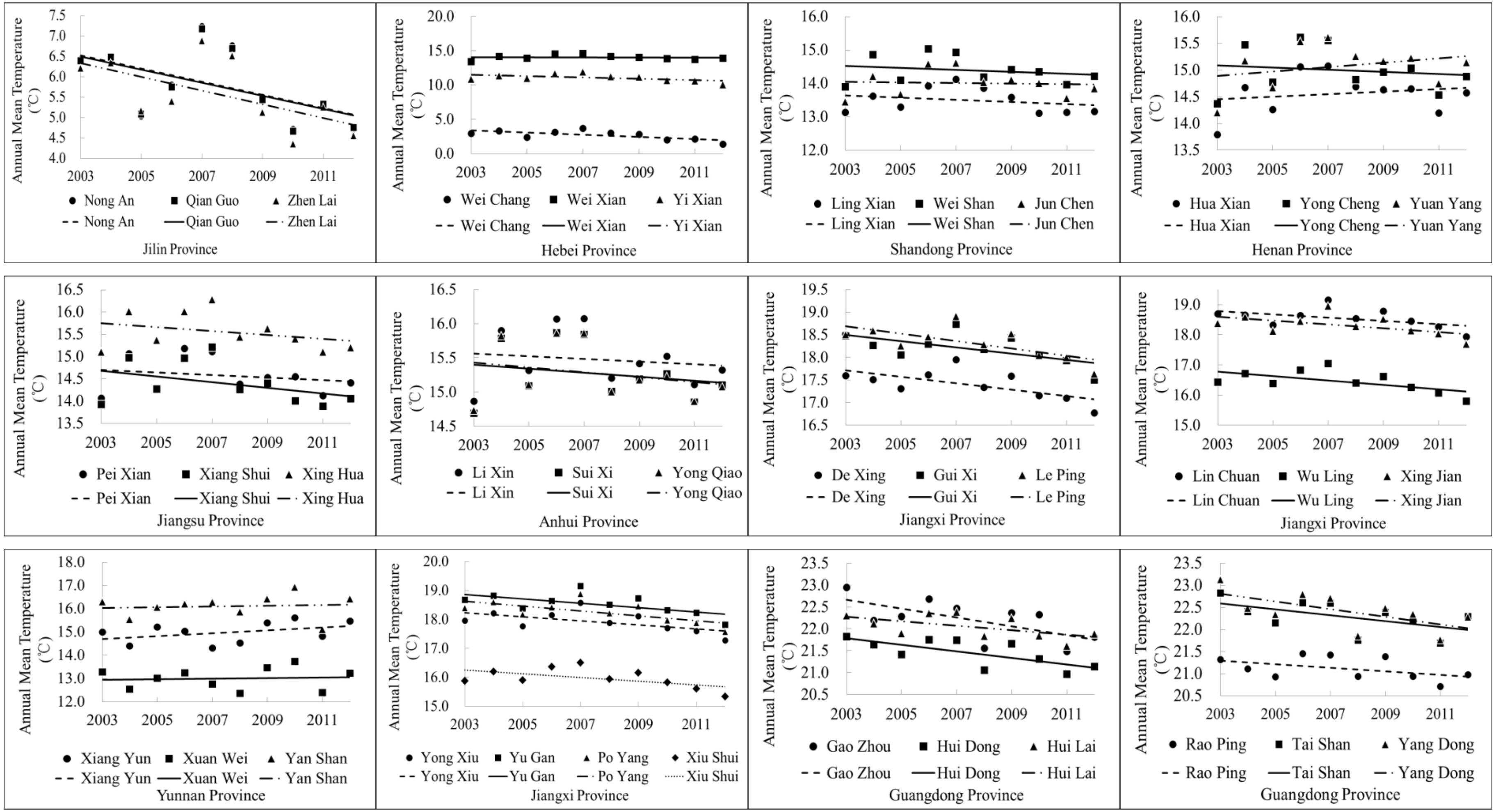

Figure 2. Annual mean temperature and its trend in 37 counties in 9 provinces in China from 2003 to 2012

Note: Each line represents an estimated linear regression function for a county.

Table 1. Percentage of farmers' perceived changes on annual temperature in the past 10 years by province

Province	Increasing	Decreasing	Unchanged	Did not know
Average	72.3	8.0	16.6	3.2
Jilin	57.4	24.1	14.4	4.1
Hebei	66.3	10.0	20.4	3.3
Shandong	73.3	4.8	19.6	2.2
Henan	61.5	4.4	30.7	3.3
Jiangsu	61.5	10.0	25.2	3.3
Anhui	68.2	7.0	21.5	3.3
Jiangxi	78.2	8.2	10.3	3.2
Guangdong	79.9	2.6	14.2	3.3
Yunnan	82.6	5.2	9.6	2.6

Source: Authors' survey.

Table 2. Social networks, farm assets, and consistency of farmers' perceptions

	Percentage of farmers whose perceptions were consistent with actual meteorological data
Average	17.7
Social Networks	
Village with farmers' organization	
Yes = 1	19.6**
No = 0	16.6
No. of relatives within 3 generations [a]	
The higher half sample (≧13)	18.7**
The lower half sample (<13)	16.5
Village leader	
Yes = 1	9.4
No = 0	18.9***
Farm Assets	
Farm size[b]	
Small (≦0.4 ha)	17.4
Medium (0.4~0.8 ha)	16.0
Large (≧0.8 ha)	19.6*
Wealth level [c]	
Low (≦61,350RMB)	21.2
Medium (61,350 ~ 156,200 RMB)	18.8*
High (≧156,200 RMB)	13.1***

Source: Authors' survey

[a] The sample is divided into two equal subsamples from the lowest to the highest value by number of relatives. The median is 13.

[b] The sample is divided into three equal subsamples from the lowest to the highest value by farm size. Small farm is selected as baseline for t-test.

[c] The sample is divided into three equal subsamples from the lowest to the highest value by wealth level. The group with low wealth level is selected as baseline for t-test.

*** for $p<0.01$, ** $p<0.05$ and * $p<0.10$

Table 3. Adoption rates of adaptive measures and farmers' perceptions

Farmers' perceptions	Adoption rates of adaptation measures (%)	
	Irrigation	Drought-resistant crop varieties
Average	59.5	9.9
Increasing	61.0***	10.5**
Decreasing or unchanged	54.7	8.2

Source: Authors' survey

*** for p<0.01, ** p<0.05, and * p<0.10

Table 4. Estimation results on the determinants of consistency of farmers' perceptions (Logit model) [a]

Explanatory Variables	Consistency of farmers' perceptions (consistency = 1; inconsistency = 0)	
	Coefficient	Marginal effect
Social Networks		
Village with farmers' organization (yes = 1; no = 0)	0.237** (2.06)[a]	0.027**
No. of relatives within 3 generations	0.028*** (3.21)	0.003***
Village leader (yes = 1; no = 0)	-0.119 (-0.58)	-0.013
Farm Assets		
Farm size (ha)	0.063*** (3.59)	0.007***
Wealth level[b]		
Medium (61,350 ~ 156,200 RMB)	-0.040 (-0.32)	-0.004
High (≧156,200 RMB)	-0.259* (-1.85)	-0.029*
Respondent's Characteristics		
Age (years)	-0.009 (-1.59)	-0.001
Gender (male = 1; female = 0)	0.045 (0.27)	0.005
Education (years)	0.008 (0.43)	0.001
Village Characteristics		
Village with continuous residential area (yes = 1; no = 0)	0.337*** (2.83)	0.038***
Distance to county (km)	0.009*** (3.71)	0.001***
County type (drought = 1; flood = 0)	1.199*** (6.53)	0.134***
Temperature variation measured by Coefficient of Variation	-3.522*** (-2.59)	-0.397***
Province dummy variables and constant	Not reported here	
Number of observations	3225	
Log likelihood ratio chi squared	683.15***	
Pseudo R^2	0.227	

[a] All numbers in parentheses are robust z-statistics.

[b] The sample is divided into three equal subsamples from the lowest to the highest value by wealth level. The baseline is low wealth level.

*** for p<0.01, ** p<0.05, and * p<0.10

Appendix Table 1. Descriptive statistics of the variables used in regression analysis

Variables	Mean	Std. dev.
Consistency of farmers' perceptions (consistency = 1; inconsistency = 0)	0.177	0.382
Social Networks		
Village with farmers' organization (yes = 1; no = 0)	0.353	0.478
No. of relatives within 3 generations	14.11	6.338
Village leader (yes = 1; no = 0)	0.125	0.331
Farm Assets		
Farm size (ha)	1.158	2.602
Wealth level (1,000 RMB)	152.3	277.9
Respondent's Characteristics		
Age (years)	52.85	10.07
Gender (male = 1; female = 0)	0.892	0.310
Education (years)	6.670	3.094
Village Characteristics		
Village with continuous residential area (yes = 1; no = 0)	0.583	0.493
Distance to county (km)	31.48	20.99
County type (drought = 1; flood = 0)	0.649	0.477
Temperature variation measured by Coefficient of Variation	0.041	0.051

Source: Authors' survey.

Note: Number of observations = 3,225.

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Reference:

Akter S, Bennett J (2011) Household perceptions of climate change and preferences for mitigation action: the case of the carbon pollution reduction scheme in Australia. Climatic Change 109:417-436

Demiryurek K, Erdem H, Ceyhan V, Atasever S, Uysal O (2008) Agricultural information systems and communication networks: the case of dairy farmers in the Samsun province of Turkey. Information Research 3 (2), 343.

Deressa T, Hassan R, Ringler C (2011) Perception of and adaptation to climate change by farmers in the Nile Basin of Ethiopia. The Journal of Agricultural Science 149:23-31

Deressa TT, Hassan RM, Ringler C, Alemu T, Yesuf M (2009) Determinants of farmers' choice of adaptation methods to climate change in the Nile basin of Ethiopia. Global Environmental Change 19:248-255

Dijksterhuis A, Bargh JA (2001) The perception-behavior expressway: automatic effects of social perception on social behavior. Advances in Experimental Social Psychology 33:1-40

Fischer G, Shah M, van Velthuizen H(2002) Climate Change and Agricultural Vulnerability, A Special Report Prepared as a Contribution to the World Summit on Sustainable Development, International Institute for Applied Systems Analysis, Laxenburg, Austria

Gbetibouo GA. (2009). Understanding farmers' perceptions and adaptations to climate change and variability: the case of the Limpopo Basin, South Africa. International Food Policy Research Institute, Discussion Paper No. 00849. Washington DC, USA.

Gueye E (2009) The role of networks in information dissemination to family poultry farmers. World's Poultry Science Journal 65:115-124

Hageback J, Sundberg J, Ostwald M, Chen D, Yun X, Knutsson P (2005) Climate variability and land-use change in Danangou watershed, China—examples of small-scale farmers' adaptation. Climatic Change 72:189-212

Hansen JW, Marx SM, Weber EU (2004) The role of climate perceptions, expectations, and forecasts in farmer decision making: the Argentine Pampas and South Florida. International Research Institute for Climate Prediction, New York, USA

Hasenauer H, Merganicova K, Petritsch R, Pietsch SA, Thornton PE (2003) Validating daily climate interpolations over complex terrain in Austria. Agricultural and Forest Meteorology 119:87-107

Huang J, Jiang J, Wang J, Hou L (2014) Crop Diversification in Coping with Extreme Weather Events in China. Journal of Integrative Agriculture 13:677-686

Isham J (2002) The effect of social capital on fertilizer adoption: evidence from rural Tanzania. Journal of African Economies 11:39-60

Kaiser HM, Riha SJ, Wilks DS, Rossiter DG, Sampath R (1993) A farm-level analysis of economic and agronomic impacts of gradual climate warming. American Journal of Agricultural Economics 75:387-398

Langyintuo AS, Mungoma C (2008) The effect of household wealth on the adoption of improved maize varieties in Zambia. Food Policy 33:550-559

Leiserowitz, A. (2007). International public opinion, perception, and understanding of global climate change. In: Fighting climate change: human solidarity in a divided world, Human Development Report 2007/2008,United Nations Development Program, UN.

Lim B, Spanger-Siegfried E, Burton I, Malone E, Huq S (2005) Adaptation policy frameworks for climate change: developing strategies, policies, and measures, Cambridge University Press, Cambridge

Mertz O, Mbow C, Reenberg A, Diouf A (2009) Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. Environmental Management 43:804-816

Moser SC, Ekstrom JA (2010) A framework to diagnose barriers to climate change adaptation. Proceedings of the National Academy of Sciences 107:22026-22031

Narayan D and Cassidy MF (2001) A dimensional approach to measuring social capital: development and validation of a social capital inventory.Current sociology 49(2): 59-102.

Olesen JE, Trnka M, Kersebaum K, Skjelvåg AO and others (2011) Impacts and adaptation of european crop production systems to climate change. European Journal of Agronomy 34:96-112

Parry ML, Rosenzweig C, Iglesias A, Livermore M, Fischer G (2004) Effects of climate change on global food production under SRES emissions and socio-economic scenarios. Global Environmental Change 14:53-67

Piao S, Ciais P, Huang Y, Shen Zand others (2010) The impacts of climate change on water resources and agriculture in China. Nature 467:43-51

Rashid M, Afroz S, Gaydon D, Muttaleb A, Poulton P, Roth C, Abedin Z (2014) Climate change perception and adaptation options for agriculture in Southern Khulna of Bangladesh. Science and Education 2:25-31

Reidsma P, Ewert F, Lansink AO, Leemans R (2010) Adaptation to climate change and climate variability in European agriculture: The importance of farm level responses. European Journal of Agronomy 32:91-102

Semenza JC, Hall DE, Wilson DJ, Bontempo BD, Sailor DJ, George LA (2008) Public perception of climate change: voluntary mitigation and barriers to behavior change. American Journal of Preventive Medicine 35:479-487

Sjögersten S, Atkin C, Clarke M, Mooney S, Wu B, West H (2013) Responses to climate change and farming policies by rural communities in northern china: a report on field observation and farmers' perception in dryland north Shaanxi and Ningxia. Land Use Policy 32:125-133

Smit B, Pilifosova O (2001) Adaptation to climate change in the context of sustainable development and equity. In: Climate change 2001: impacts, adaptation, and vulnerability-Contribution of working group II to the third assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK

Smit B, Skinner MW (2002) Adaptation options in agriculture to climate change: a typology. Mitigation and Adaptation Strategies for Global Change 7:85-114

Tambo JA, Abdoulaye T (2012) Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian Savanna. Regional Environmental Change:1-14

Thornton PE, Running SW, White MA (1997) Generating surfaces of daily meteorological variables over large regions of complex terrain. Journal of Hydrology 190:214-251

White MA, Thornton PE, Running SW (1997) A continental phenology model for monitoring vegetation responses to interannual climatic variability. Global Biogeochemical Cycles 11:217-234

Zhang T, Huang Y, Yang X (2013) Climate warming over the past three decades has shortened rice growth duration in china and cultivar shifts have further accelerated the process for late rice. Global change biology 19:563-570