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Farmers' perceptions of climate change in China: the influence of social networks and farm assets

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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 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 relationship. The study found that >70% of farmers in China perceived an increasing trend of annual mean temperature over the past 10 yr, while only 8% of farmers perceived a decreasing trend. Moreover, only 18% of farmers perceived a temperature change that was 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 study 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 & Bargh (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 2-stage decision process: (1) they perceive or detect a change in climate correctly; (2) they adapt certain behaviors as a response (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 (Deressa et al. 2009, 2011, Mertz et al. 2009, Tambo & Abdoulaye 2012, Sjögersten et al. 2013, Rashid et al. 2014), none of these studies explore whether farmers' perceptions agree with actual climate trends. Hansen et al. (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 7 years. Conversely, Hageback et al. (2005) found that farm-

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ers 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 degree of consistency of farmers' perceptions with actual climate trends. However, 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, Langyintuo & Mungoma 2008, Gueye 2009). Semenza et al. (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 2 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 of 9 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 for measuring climate change.

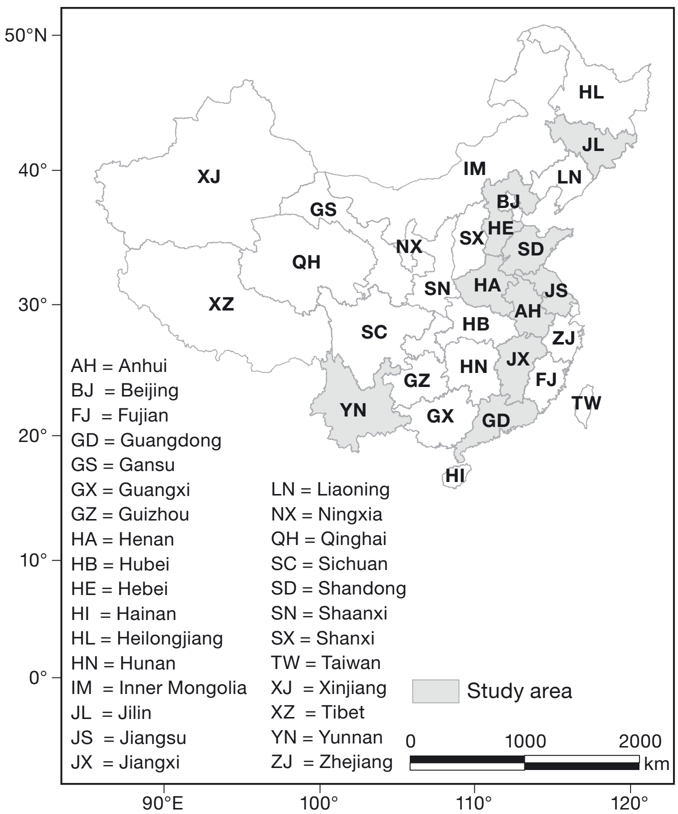

Fig. 1. Study areas

2. DATA

This study employs 2 datasets: (1) a large-scale household survey conducted from late 2012 to early 2013 and (2) a meteorological record dataset of 9 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 2 datasets allows us to identify the consistency of farmers' perceptions with the actual data.

The household survey was conducted in 9 provinces: Jilin, Hebei, Henan, Shandong, and Anhui Provinces in northern China, and Jiangsu, Jiangxi, Yunnan, and Guangdong Provinces in southern China (Fig. 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 2 conditions: (1) had experienced a serious drought or flood during 2010–2012[2] and (2) had experienced a normal weather year during 2010–2012. Within each county, a stratified random sampling was used to select 3 townships. Town-

[1] Surveys in Jiangxi and Guangdong provinces were funded by 2 projects that used the same sampling framework and survey questionnaires

[2] We sampled the county based on drought or flood for other important research questions which are not included in this paper. We have confidence that such sampling methods will not affect the results of this study

ships were stratified into 3 groups by the condition of their rural water infrastructure judged by county-level water departments: one-third of the sample with above-average conditions, one-third with average conditions, and one-third with below-average conditions. One township was randomly selected from each of the 3 groups. Within each township, 3 villages were selected randomly, and 10 farmers were randomly selected from each village. In total, the sample included 3330 households from 330 villages in 37 counties in 9 provinces of China. For more detailed sampling rules, please refer to Huang et al. (2014).

The data used in this study are a subset of the above primary household survey. In a section of the survey, farmers were asked their perceptions of the pattern of annual mean temperature over the past 10 yr (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 — as opposed to simply consisting of isolated residential, farm and business properties — and the village's distance from the county seat). Social networks were measured by 3 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 3 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 the Appendix (Table A1).

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 from 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 et al. (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 have also been used by Zhang et al. (2013).

3. DESCRIPTIVE ANALYSIS

3.1. Temperature trends

While the annual mean temperature for most provinces has increased over the past 50 yr, the past decade showed a decreasing trend. The annual mean temperature for each sample county during 2003–2012 is plotted in Fig. 2. A simple linear regression model was used to examine the trend of annual mean temperature in each county.[3] Thirty of the 37 sample counties experienced a decreasing temperature trend over the past 10 yr (2003–2012), while, during the same period, 5 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 yr, 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

[3]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°C per annum as the cutting points, based on the fact that China's surface mean temperature increased by 1.1°C over the past century (1908–2007). On average, it increased by 0.01°C yr^{-1}

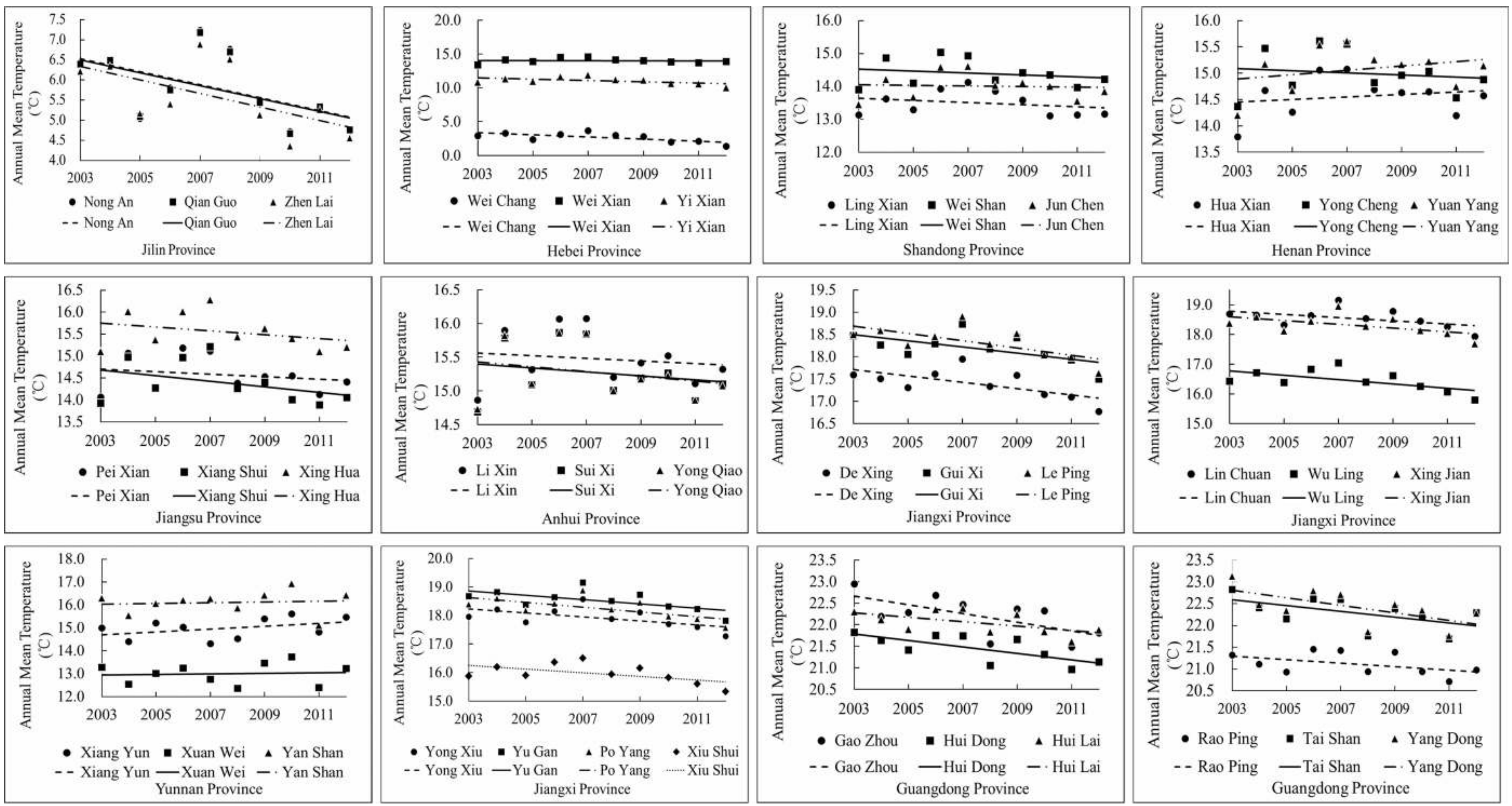

Fig. 2. Annual mean temperature and its trend in 37 counties in 9 provinces in China from 2003 to 2012. Note: each line represents an estimated linear regression function for a county

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

Province	Increasing	Decreasing	Unchanged	Don't 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

Table 2. Social networks, farm assets, and consistency of farmers' perceptions. ***$p < 0.01$; **$p < 0.05$; *$p < 0.10$

	Percentage of farmers whose perceptions were consistent with actual meteorological data
Mean	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
Relative as 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 (≤61 350 RMB)	21.2
Medium (61 350–156 200 RMB)	18.8*
High (≥156 200 RMB)	13.1***

[a]The sample is divided into 2 equal subsamples from the lowest to the highest value by number of relatives. The median is 13

[b]The sample is divided into 3 equal subsamples from the lowest to the highest value by farm size. The category 'small farm' was selected as the baseline for the *t*-test

[c]The sample is divided into 3 equal subsamples from the lowest to the highest value by wealth level. The group with low wealth level was selected as the baseline for the *t*-test. RMB: unit of Chinese currency

northern China. Only 8% of farmers perceived decreasing temperatures over the last 10 yr (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 yr, with Henan (30.7%) and Jiangsu (25.2%) provinces ranking as the top 2. Only 3.2% of farmers said they did not know the trend of annual temperature over the last 10 yr.

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 3225 valid household responses. Through this comparison, we divided all farmers into 2 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 3225 farmers' perceptions of temperature were consistent with the actual recorded data (second column in Table 2). It is not surprising to see such low consistency, since the actual data showed decreasing trends (Fig. 2), 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' organizations (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. >13 relatives within 3 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 have better measures to ameliorate the effects of high temperature on personal comfort (e.g. air conditioning, better quality clothing), or are in more of a managerial role and less frequently outside in the open, 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).

Table 3. Adoption rates of adaptive measures and farmers' perceptions. ***p < 0.01; **p < 0.05; *p < 0.10

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

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 2003–2012 for each county. The empirical model is specified as follows:

$$C_{ijkp} = \beta_0 + \beta_1 \boldsymbol{SN}_{ijkp} + \beta_2 FA_{ijkp} + \beta_3 FC_{ijkp} + \beta_4 VC_{jkp} + \beta_5 CT_{kp} + \beta_6 CV_{kp} + \beta_7 PD_p + \varepsilon_{ijkp} \quad (1)$$

where i, j, k and p represent the ith farmer in the jth village in the kth county of the pth province. ε_{ijp} is the error term and all βs 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 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) the number of living relatives within 3 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.[4]

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.

Table 4. Estimation results on the determinants of consistency of farmers' perceptions (Logit model); ***p < 0.01; **p < 0.05; *p < 0.10. Consistency — 1: consistent, 0: inconsistent; parentheses: robust *z*-statistics

Explanatory variables	Consistency of farmers' perceptions: Coefficient	Marginal effect
Social networks		
Village with farmers' organization (yes = 1; no = 0)	0.237** (2.06)	0.027**
No. of relatives within 3 generations	0.028*** −3.21	0.003***
Relative as 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[a]		
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 (yr)	−0.009 (−1.59)	−0.001
Gender (male = 1; female = 0)	0.045 (−0.27)	0.005
Education (yr)	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]The sample is divided into 3 equal subsamples from the lowest to the highest value by wealth level. The baseline is low wealth level. RMB: unit of Chinese currency

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-squared 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 the variance inflation factor (VIF) for all variables was <10 (ranging from 1.02 to 3.90).

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

4.2.1. 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). Each additional relative within 3 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.

4.2.2. 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 1 ha, the likelihood of consistent perception increased by 0.6%. Generally speaking, farmers with larger farms usually are those with the greatest farming capacities (e.g. planting skills, management skills), which may also 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 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 systems, which enable them to adapt to, and to focus less on, temperature changes.

4.2.3. 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 tend to have higher population density and therefore lend themselves to higher levels of contact between residents. Because of this, there are increased possibilities 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 are more concerned with temperature change, since they have fewer off-farm job opportunities and are more focused on agriculture.

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 yr

(2003–2012), the mean annual temperature in most sample counties decreased. However, our large-scale field survey data from 9 provinces in China show that >70 % of farmers reported that the annual mean temperature tended to increase over this period.

Historical temperature data show that, while the average annual mean temperature increased over the past 50 yr, the past decade showed a decreasing trend. When we asked farmers about the overall trend of temperatures in the past 10 yr, the older farmers tended to recall temperature trends longer than 10 yr. While we did ask farmers' perceptions of temperature trends in the past 30-plus years, we chose to use 10 yr as the reference time frame, as a large number of respondents explained that they could not recall that long a period of time. 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 affected by temperature changes in recent years (e.g. 10 yr or so) in making 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 (in e.g. others or climate information institutions) and collective action (Narayan & 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 1 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.

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Appendix

Table A1. Descriptive statistics of the variables used in regression analysis. Number of observations = 3225. RMB: Chinese currency (1 RMB = 0.1626 US$ in 2014)

Variables	Mean	SD
Consistency of farmers' perceptions (1 = consistent; 0 = inconsistent)	0.177	0.382
Social networks		
Village with farmers' organization (yes = 1; no = 0)	0.353	0.478
No. of living relatives within 3 generations	14.11	6.338
Relative as village leader (yes = 1; no = 0)	0.125	0.331
Farm assets		
Farm size (ha)	1.158	2.602
Wealth level (1000 RMB)	152.3	277.9
Respondent's characteristics		
Age (yr)	52.85	10.07
Gender (male = 1; female = 0)	0.892	0.310
Education (yr)	6.670	3.094
Village characteristics		
Village with continuous residential area (yes = 1; no = 0)	0.583	0.493
Distance to county seat (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

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