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Management adaptation to flood in Guangdong Province in China: Do property rights Matter?

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ABSTRACT

Improving land rights in China is often considered as an important factor that facilitates farmers' investments in agriculture. However, whether securing land rights is important for farmers' adaptation to changing climate or not has not been addressed in the literature, particularly with respect to management decisions. This paper examines the relationship between land tenure types and farmer adaptation through management decisions in response to extreme weather events in Guangdong Province in China. Based on a household survey of rice farmers, our results show that compared to a normal year with minor weather events farmers with contracted land are more likely to implement adaptation measures in response to extreme weather events than those who have rented their land from the collective and from other farmers. The results suggest that farmers' adaptive behaviour in response to extreme weather events is significantly different from their day-to-day adaptation to ongoing changes in climate. Farmers' adaptive capacity is also positively influenced by age, the public provision of information, by the presence of social capital, and by plot quality. The results of this study highlight the importance of properly defined land rights for the likelihood of adaptation, and thereby increasing agricultural productivity and ensuring food security in the context of a changing climate.

1. Introduction

Extreme weather events, such as droughts and floods, are occurring more often and becoming more severe. In China, in the past 60 years, the frequency and intensity of extreme events have been increasing (National Bureau of Statistics in China, 2012; Zhao et al., 2004). For example, from the late 1980s to 1990s, China suffered from an increasing frequency of flood disasters (Climate Change Centre of China Meteorological Administration, 2011). Particularly in the 1990s, flood disasters were even more severe, occurring at a frequency 2.4 times higher than in the 1980s. After entering the 21st century, the trend has not slowed significantly (Chen, Yin, & Chen, 2011; Huang, Zhang, & Zhang, 2007). Compared to the longer term changes in temperature and rainfall, these events are the immediate impacts of climate change and they pose significant threats to agricultural production in rural China and to food security. From the 1950s to the 1990s, the annual average crop area hit by flood in China expanded from 4.6 million hectares to more than 9 million hectares. Since 2000, this area has reached 6.5 million hectares (Ministry of Water Resources, 2011). This situation of rising frequency and severity of weather events is expected to continue (Intergovernmental Panel on Climate Change (2012), 2012).

Faced with increasingly serious extreme weather events, the question of how to mitigate their impacts through appropriate adaptations has received significant attention from scholars. Some even refer to adaptation studies as "mainstream" research (Klein et al., 2007). Existing studies suggest that investing in irrigation infrastructure (e.g. reservoirs, dams, and other irrigation facilities) or adopting farm management measures (e.g. adjusting cropping systems or varieties) can improve the adaptability of farmers to extreme weather events (Huang, Wang, & Wang, 2015; Martin-Ortega, 2011). However, adaptation is influenced by many factors. Most studies conducted in China and other countries focus on the influence of adaptation policies (e.g. providing early warning and prevention information, or financial or technical policy support) and farmers' socio-economic factors (e.g. social capital, farmers' assets) (Chen, Wang, & Huang, 2014; Deressa et al., 2009; Hassan & Nhemachena, 2008; Wang et al., 2008; Wang et al., 2014). There

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are also some studies conducted in Africa on the relationship between land rights and the use of adaptation measures (Gbetibouo et al., 2009; Maddison, 2007; Nhemachena and Hassan, 2007). Despite the significant change in land rights, there is no study of their importance in the process of adaptation by farmers in China.

Since the late 1970s, China has been implementing a significant program of land rights reform. The major change has been to allocate control of land and income rights to individual farmers through a contract with the village collective, who retain land ownership rights (Brandt, Huang, Li, & Rozelle, 2002; Ding, 2003; Dong, 1996). The reform was called the household responsibility system (HRS), and the land referred to in the contract was known as contract land. Contracts are made for long periods of time. The first term of the land contract was for 15 years until the late 1990s, when the contracts were renewed for another 30 years. Villages allocated contracted land to households based mainly on the number of family members. As well as contracted land, there are other two types of land, though the areas are small. These are *ziliu di* (private land), a small amount of land allocated to households to produce food for their own consumption before the introduction of HRS reform, and *jiti jidong di* (collective land), which is the land that has been kept by villages. Land could be rented from the collective or from other individual farmers but the rental periods were short, on average one half of the contracts were less than 1 year and over 90 percent were less than 5 years (Gao, Huang, & Rozelle, 2012).

Most studies of the impact of changes in land rights examine the impact on investment decisions and are not linked with farmers' adaptation behaviour. For example, Li, Rozelle, and Brandt (1998) claimed that long-term land use rights encourage agricultural investment and Wen (1995) and Besley (1995) found evidence that uncertainty in land rights discourages investment. According to Brandt et al. (2002), lack of secure tenure over land has limited farmers' adoption of new technologies in China. Others have found that more secure land rights improve access to credit through the use of land as collateral (Demsetz, 1967; Ma, Heerink, Ierland, Berg, & Shi, 2013; Wen, 1995) and facilitate gains from trade and encourage long-term investments in land (Besley, 1995; Rapaczynski, 1996). Here we seek to answer the question of whether the land rights change will affect farmers' adaptation behaviour, especially their management practices rather than their investment decisions, and thereby to contribute to the existing literature.

The remainder of this paper is organized as follows. Section 2 describes the data and discusses the sampling procedure. Section 3 illustrates the impact of extreme weather events and farmers' responses to these events in the study area. Section 4 introduces the main hypothesis and presents the estimation method. The empirical results are presented in Section 5, where the most important results are discussed in detail, emphasizing their relevance in the context of farmer adaptation in China. Section 6 contains the conclusions and a discussion of policy implications.

2. Sampling approach and data

This study is based on a household survey in Guangdong Province in China, which includes two rice farming seasons, early-season rice and late-season rice. Farm level surveys were conducted in counties that are particularly susceptible to the impacts of climate change especially flood. Based on China's national definition of disasters, we have classified counties into four groups: the most severe, severe, moderate and small.[1] The years of moderate or lesser flood events were defined as "normal years" and the years during which farmers experienced the most severe flood were defined as "disaster years". Thus, a disaster year was defined by the presence of more disaster events (in frequency and magnitude) compared to a normal year. Within each group of counties, we randomly selected one county to be in our sample. From the counties selected using such a stratified random sampling approach, four counties were selected as the study areas; namely, Gaozhou, Taishan, Huilai, and Yangdong.

Townships were then selected randomly in those counties from three main groups on the basis of their agricultural production infrastructure, which was categorized as above average, average, and below average. This variation allows us to examine the effect of these different categories of infrastructure on farmer decision making. One township was selected from each category. The selection of three villages followed the same method, that is, the overall sample of villages within each township was stratified by infrastructure, and villages were selected randomly within the strata. Finally, 10 households were randomly selected within each village. We have data for a number of plots for each household, for late and early rice and for different land qualities, for each of the two years sampled. The final total sample of data usable for the statistical work consisted of 1890 observations.

The surveys collected the following data relevant to household characteristics: plot numbers, farm size, age, education, household size, wealth per capita, access to information, and social capital. Plot characteristics included disaster information (disaster year or normal year), use of new farm management measures (changing the crop variety to be flood tolerant, changing the sowing or harvesting date, reseeding, and fixing (or putting upright) the seedling), characteristics of land tenure, plot quality, and land form.

The survey was conducted by face-to-face interviews. In order to complete the village questionnaires, we interviewed village leaders, such as the village party secretary, the village head, and accountants who are familiar with the village. The interviewees for the household surveys were household heads who made decisions about agricultural production. To ensure data quality, we conducted strict training in advance for all enumerators and carried out training in the field in the sample provinces.

In the survey, we first collected data for 2012 (the year in which the survey was conducted). Then, according to the occurrence of disasters in the past three years (2012, 2011 and 2010), we chose a second year for which we collected data. Data for these earlier years was based on the recall of farmers. The general principle was that we tried to collect data for 2011. For example, if 2012 was a disaster year, and 2011 and 2010 were normal years, then we collected data for 2011. However, if 2012 and 2011 were both disaster years, and only 2010 was a normal year, then we had to collect data for 2010. Based on our experience, farmers are well able to recall information within three years.

3. Extreme weather events, land rights and adaptation measures

Extreme weather events have caused a loss of production and reductions in yields in the study zone. Tables 1 and 2 present the impacts of flooding on rice production in early rice and late rice. On average, around 60% of plots cultivated for early rice were affected, causing a 19% yield reduction in disaster years (e.g. due to severe flood events) compared to 34% of affected plots in a normal year (e.g. due to moderate or lesser flood events) and resulting in a 12% loss (Table 1, rows 9 and 10). Although 75% of plots in the Taishan county sample were affected, resulting in a 17% yield reduction, Yangdong county was the most affected during a disaster year, reporting a 22% yield reduction.

[1] Given the objective of the analysis, the impact of floods is the focus here. Nevertheless, the original survey also included counties affected by droughts.

Table 1
Impacts of flood events on production of early rice in the study sample.

County	Year type	Year	Percentage of plots (%)	Yield reduction (%)	Yield (kg/ha)	Yield change (%)
Gaozhou	Normal	2012	50	20	4,718	
	Disaster	2010	57	19	4,590	−2.71
Taishan	Normal	2010	55	11	4,493	
	Disaster	2012	75	17	4,246	−5.50
Huilai	Normal	2012	21	9	5,535	
	Disaster	2011	52	19	5,288	−4.46
Yangdong	Normal	2012	23	8	4,455	
	Disaster	2011	50	22	3,713	−16.66
Average	Normal		34	12	4,703	
	Disaster		59	19	4,568	−2.87

Source: Authors' calculations based on the survey.

Table 2
Impacts of flood events on production of late rice in the study sample.

County	Year type	Year	Percentage of plots (%)	Yield reduction (%)	Yield (kg/ha)	Yield change (%)
Gaozhou	Normal	2012	33	16	4,253	
	Disaster	2010	72	29	4,118	−3.17
Taishan	Normal	2010	54	6	4,883	
	Disaster	2012	68	8	4,658	−4.61
Huiying	Normal	2012	10	6	5,693	
	Disaster	2011	27	10	5,243	−7.9
Yangdong	Normal	2012	23	6	4,500	
	Disaster	2011	51	20	3,983	−11.49
Average	Normal		30	9	4,545	
	Disaster		55	17	4,433	−2.46

Source: Authors' calculations, based on the survey.

Likewise, the damage for late rice in a severe disaster year in terms of plots affected and yield reduction is 55% and 17% on average, respectively (Table 2, row 10). This was an increase from 30% and 9% for the normal year, respectively (Table 2, row 9). In case of late rice, Gaozhou county reported the largest reduction in yield (29%), followed by Yangdong county (20%).

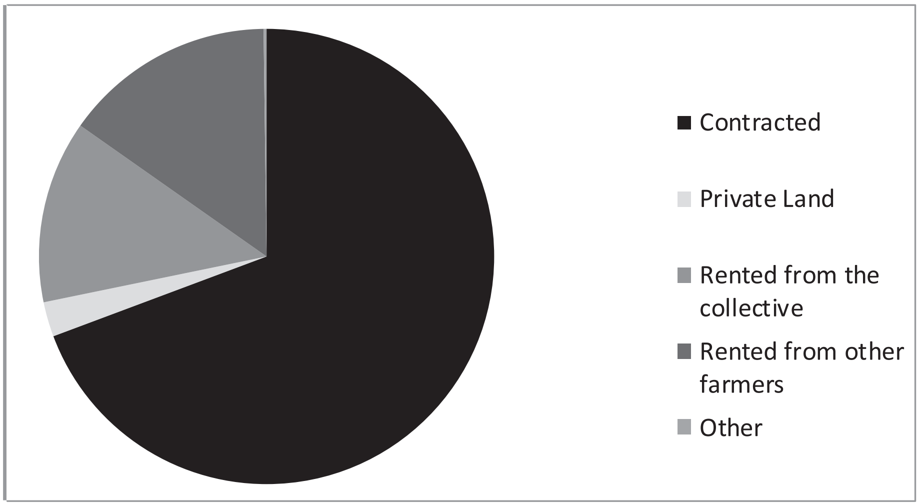
There are four major types of land rights: contracted land, land rented from the village collectives, land rented from other individual farmers, and private land. Figure 1 shows the distribution of land procurement types in the study sample in Guangdong Province. Contracted land accounted for nearly 70% of the cultivated land of the study sample, followed by land rented from other farmers (15%) and from the collective (13%). Only 3% of farmers were endowed with private land.

We limit our analysis of adaptation to changes in farm management measures, which are crucial during the crop growing reason. Four measures are analysed: (1) changing crop variety (to one which is flood tolerant), (2) changing the sowing or harvesting date, (3) reseeding, and (4) fixing the seedling. These are the most common farm management measures undertaken by rice farmers in the study area during the crop growing season. They can be undertaken within the household's own capacity, without depending on the availability of village infrastructure. Limiting our study to farm management measures therefore better serves our objective.

Among these four measures, changing crop variety not only needs extra labour input, since farmers need to spend time to buy new varieties, but also may need extra money, since the price of new varieties is higher than the traditional varieties. Generally, farmers will choose those new varieties that can adapt to extreme weather events better and avoid the possible yield loss. However, if it is a normal year, there is possibly no yield difference between new varieties and traditional varieties, and farmers have to face the risk of losing money from the change. However, due to rural market development and the government's efforts on technology extension, it is not hard for farmers to access to new varieties. On the other hand, changing sowing or harvesting date does not need extra labour input but farmers have to coordinate their labour arrangement with other activities. For reseeding and cleaning and fixing the seedlings, farmers need extra labour input to sow seeds again and to clean off the mud attached to rice leaves.

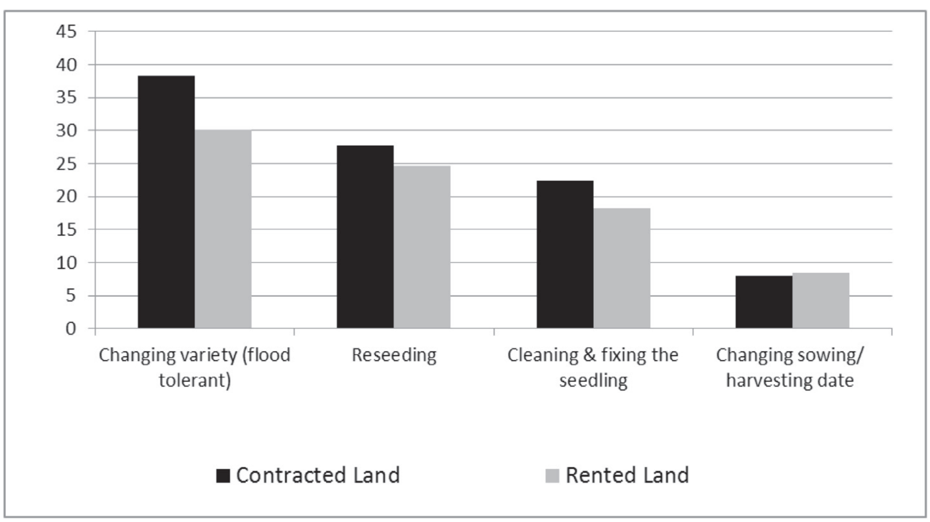
Fig. 2 shows the changes in farm management measures with reference to current ownership of farming land in Guangdong Province. Higher proportions of farmers with contracted land are observed to make use of these measures, compared to farmers with rented land. Changing the variety of rice was the most commonly used farm management strategy in both groups. This measure has been adopted by more of those who are endowed with contracted land (36%) compared to those who have rented their land (30%). We also found similar evidence for other two measures, reseeding and cleaning & fixing the seedling. For example, in contracted land plots, 28% of land holders adopted reseeding measures to deal with extreme weather events, but this percentage is lower for rented land at 25%. The difference on adopting cleaning and fixing the seedling between contracted and rented land was 4 percentage points (22% vs 18%). As we have discussed above, all these three kinds of measures need extra labour input, even extra expenditure. Despite these extra inputs, farmers with contracted land appear more likely to apply them. However, for rented land, farmers use measures that do not need too much effort and investment. For example, changing the sowing or harvesting date was slightly more popular among farmers with rented land we expect for this reason.

Based on the survey, farm households were likely to have adapted more effective measures in response to a disaster year compared to a normal year. We compare the adaptation behaviour across these types of years and between households with contracted land and those who have rented their land. Low level adaptation refers to adaptation of one measure, changing sowing or harvesting date, reseeding or fixing the seedling. Middle level adaptation includes changing crop variety (flood tolerant) or adaptation of any other two measures. Higher level adaptation refers to



Source: Authors' calculations based on the survey

Fig. 1. Shares of land areas by type of tenure of the study sample. Source: Authors' calculations based on the survey.



Source: Authors' calculations, based on the survey

Fig. 2. Percentage of plots with adaptation of major farm management measures by land tenure types in Guangdong Province (%). Source: Authors' calculations, based on the survey. Note: Adaptation of measures are not mutually exclusive, and therefore do not sum to 100%.

changing crop variety together with another measure. Adaptation at the highest level involves 3 or 4 measures taken together.

Table 3 shows the percentage plots in normal and disaster years for contracted and rented land according to these levels of adaptation. Compared to those with rented land, farmers with contracted land are more responsive in the use of measures during a disaster year (comparing column 2 and column 4 in Table 3). It is also evident from Table 3 that the percentage difference in the adoption of measures between disaster and normal years becomes wider when the number of adaptation measures increases. This implies that farmers tend to adopt more and more measures simultaneously in order to reduce the adverse effects of extreme weather events.

4. Econometric model

Farmers experience minor weather shocks during any growing season. In response to these relatively minor events, adaptive actions are likely occurring as a part of their day-to-day farming activities. These day-to-day adaptations are nevertheless different from farmers' adaptations to extreme events, which are "truly impact-reducing" activities that minimize the negative (and enhance the positive) impacts of climate change (Lobell, 2014). We hypothesise that farmers who might not be responsive to minor weather events do adapt during a severe weather shock, due to the large production and income effects associated with these events.

Our hypothesis is that farm households with contracted land are more likely to implement adaptation measures on that land in response to extreme weather events. Long-term access to land rights through the contracting process provides incentives for action. At the same time, uncertainty or frequent re-allocations of rented land by village leaders, accompanied by other regulations, restrict the effective use of farming land and discourages long-term investments. Inability to use rented land as collateral may also constrain farmers' access to credit to fund adaptation.

Table 3
Percentage of plots with adaptation measures by disaster and normal years.

	Contracted land		Rented land	
	Normal Year	Disaster year	Normal Year	Disaster year
No measures	38.48	33.58	50.37	40.81
Low level adaptation	14.71	15.75	11.03	18.01
Middle level adaptation	34.47	30.76	27.94	25.00
Higher level adaptation	8.47	10.10	9.19	8.09
Highest level adaptation	3.86	9.81	1.47	8.09
Total (No.)	673 (No.) 100 (%)	673 (No.) 100 (%)	272 (No.) 100 (%)	272 (No.) 100 (%)

Source: Authors' calculations, based on the survey.

Modifying the theoretical model of Besly (1995)[2] to incorporate the effects of extreme weather events, we estimate the following reduced form equation to investigate the relationship between climate adaptation and land tenure types:

$$Y_{ijt} = \alpha + (\beta_1 + \beta_2 D)L_{ijt} + \beta_3 Z_{ijt} + U_{ijt}$$

The dependent variable, Y_{ijt}, refers to the degree of adaptation undertaken by farm household j in plot i in time t . This index ranges from zero to four corresponding to the levels of adaptation referred to in Table 3. It has the value of zero if farm households in the sample have not adopted any of the four measures. It takes the value of one if farm households have carried out low level adaptation, the value of two for middle level adaptation, the value of three for the higher level and the value of four for the highest level of adaptation. The distribution of the dependent variable is given in Table 4.

The present study defines the dependent variable as the degree of adaptation. By way of its construction, the dependent variable is more sophisticated than the measures used in the literature. Many studies have used a binary variable of adaptation as the dependent variable, which is likely to result in losing valuable correlations and causations between household characteristics and adaptation measures. Bryan, Deressa, Gbetibouo, and Ringler (2009) in their analysis of the determinants of adaptation in Ethiopia and South Africa used a discrete choice model. The dependent variable in their model refers to farmer adaptation, which is a dummy variable equal to 1 if the farmer adapted any of the measures chosen in the study and 0 otherwise. Bryan, Ringler, Okoba, Roncoli, and Herrero (2013) analysed factors influencing farmers' decision to adopt in Kenya using a binary response model. Some studies, such as Nhemachena and Hassan (2007) and Gbetibouo (2009) used a multinomial logit model with the dependent variable as a choice between multiple adaptation decisions. Importantly however, compared to these studies, the present study provides a superior construction of the dependent variable by grouping adaptation measures into the levels of adaptation from zero to the highest degree of adaptation.

With the respect to other variables, D is a dummy variable taking the value of 1 in a disaster year and 0 in a normal year. L is a binary variable taking the value of 1 when the land is contracted land and 0 if it is rented from the collective or from other farmers. The coefficient β_2 captures the significance of effect of land tenure arrangements on the response to a disaster year. This is the key variable of interest of this analysis.

The vector Z consists of control variables and U is the error term. Based on the existing literature (e.g. Gbetibouo, 2009; Maddison, 2007; Nhemachena and Hassan, 2007; Wang et al., 2010; Wang et al., 2014), three main types of control variables are hypothesised to influence farmers' adaptation of measures: household characteristics (age, education, household size, wealth per capita), plot characteristics (plot size, plot quality, land form—hilly or flat), and institutional factors (information, social capital). These variables can also be categorized under incentives and capabilities. Generally, capabilities include household characteristics, whereas many institutional factors and social capital appear to have provided incentives for adaptation. Given that rice farming in Guangdong Province is characterized by double seasons, a dummy variable for late rice is also included in the vector of control variables.

Summary statistics of all the variables are given in Table 5. The prospective exogenous variables and their expected signs are listed in Table 6. Except for a few variables, most of the control variables are expected to have a positive impact on adaptation decisions. Although it could be argued that older farmers are more risk averse than younger farmers and are therefore less likely to adopt measures, age could also positively influence the adaptation decision. Gbetibouo (2009) argues that the impact of household size depends on whether members are available for farming activities or for off-farm activities.

(Place Tables 5 and 6 about here)

An ordered probit model is used to test the main hypotheses, given the nature of the dependent variable ranging from 0 to 4 reflecting the degree of adaptation. The main independent variable of interest (the interaction term LD) is considered to be exogenous because the allocation of contracted land is exogenously determined by the land reform policy of the government. Contracted land accounts for majority of the cultivated plots of the study sample. The presence of rented land could be endogenous because a

Table 4
Sample distribution – dependent variable.

Order	Description	No	%
0	No measures	733	38.78
1	Low level adaption: (One measure) changing sowing/ harvest date or reseeding or fixing the seedling	284	15.03
2	Middle level adaptation: Changing crop variety or A4 or A5 or A6	583	30.85
3	Higher level adaptation: A1 or A2 or A3	172	9.10
4	Highest level adaptation: All four or B1 or B2 or B3 or B4	118	6.24
		1890	100

Notes:
A1: changing crop variety + Changing sowing or harvesting date.
A2: changing crop variety + Reseeding.
A3: changing crop variety + Fixing the seedling.
A4: Changing sowing or harvesting date + Reseeding.
A5: Changing sowing or harvesting date + Fixing the seedling.
A6: Reseeding + Fixing the seedling.
B1 : Changing variety + Changing sowing or harvesting date + Reseeding.
B2: Changing variety + Changing sowing or harvesting date + Fixing the seedling.
B3: Changing variety + Reseeding + Fixing the seedling.
B4: Changing sowing or harvesting date + Reseeding + Fixing the seedling.

[2] Besly (1995) examines the relationship between property rights and investment incentives. The present study examines the link between property rights and adaptation incentives. The present study adapts Besly (1995) in developing the reduced form equation for the estimation. The main departure from Besly (1995) is the inclusion of different exogenous variables in testing the main hypothesis.

Table 5
Summary statistics.

Variable	Mean	Std. dev.	Min	Max
Adaptation (dep. variable)	1.29	1.24	0	4
Contracted Land	0.71	0.45	0	1
Interaction term Contracted Land × Flood	0.36	0.48	0	1
Late rice	0.52	0.50	0	1
Age of household head (HH) (years)	55.53	9.04	27	87
Education of HH	7.76	2.68	0	16
Household size (No.)	5.97	2.76	1	19
Wealth per capita (RMB)	2,625.87	5,798.84	25	89,846.16
Land area (Mu)	13.26	35.84	0.4	500
Best plot quality	0.16	0.37	0	1
Middle plot quality	0.70	0.45	0	1
Land form (hilly/flat)	1.43	0.49	0	1
Provision of information	0.44	0.49	0	1
Social capital (No.)	0.40	0.57	0	3
No. observations = 1,890				

Table 6
Exogenous variables and their expected signs.

Variables in Z vector	Description	Value	Expected sign
Household characteristics			
Age	Age of the head of the farm household (HH)	Years	No prior sign
Education	No. years of HH head's formal schooling (excluding pre-school or training)	Years	Positive
Household size	No. family members in household	Number	No prior sign
Wealth per capita	Per capita value of household durable goods	Value in RMB 10,000	Positive
Plot characteristics			
Plot size	Farm land area owned by HH	Mu/ Hectares	Positive
Best plot quality	Whether it is best plot quality	1 = best quality 0 = otherwise	Positive
Middle plot quality	Whether it is middle plot quality	1 = middle quality 0 = otherwise	Positive
Land form	Whether it is hilly or flat	1 = hilly, 0 = flat	Negative
Institutional factors and social capital			
Information	Whether publicly provided weather-related information was available before the disaster	1 = yes, 0 = no	Positive
Social capital	No. relatives working in the government/township leadership	Number	Positive
Other			
Late rice	Whether late rice or early rice	1 = late rice, 0 = early rice	No prior sign

decision to rent can be influenced by farmer characteristics. To check the potential endogeneity of rented land in the model, the Durbin-Wu-Haussmann test for endogeneity is performed.

5. Estimation results and discussion

5.1. Main results

Table 7 reports the marginal effects of the parameter estimates obtained from the ordered probit regression model. Predicted probabilities are not significant for *Contracted Land* when it is not interacted with the flood variable. However, the significantly positive marginal effects associated with the interaction term in columns (2), (3) and (4) suggest that, compared to those with rented land, farmers with contracted land are more responsive in a year with severe disasters than in a normal year. Particularly, farmers prefer to adopt a middle or higher level of adaptation measures, that is to change crop variety (flood tolerant), and/or adopting any of the other two or several measures. This is in contrast to the general finding in the existing literature. As has been demonstrated in Bryan et al. (2009), a large percentage of farmers surveyed in Ethiopia and South Africa for the analysis had not made any adjustments in response to extreme weather events. Similarly, Bryan et al. (2013) claim that many households surveyed in their study in Kenya had made only small adjustments to their farming practices in response to climate change. Further, according to Di Falco, Veronesi, and Yesuf (2011), current climate variables had no impact on the probability of adaptation.

The results imply that the presence of contracted land, compared to rented land, increases the predicted probability of implementing measures in response to flood. For instance, compared to those with rented land, farmers endowed with contracted land are three per cent more likely to carry out middle level adaptation measures (column 2). Farmers are over 2 per cent more likely to adopt the higher or highest level adaptation measures than those on rented land (columns 3 and 4). At the same time, the predicted probabilities are negative and statistically significant for low level adaptation (column 1). In other words, farmers with contracted land are less likely to adapt at the lowest level than those with rented land. Our observation of this result is that farmers with contracted land are more likely to do nothing rather than to do a little bit. The estimates in column 1 overall support the hypothesis of this study that farm households with contracted land are more likely to implement adaptation measures on that land in response to extreme weather events.

The estimated coefficients in Table 7 for age, late rice, middle and best plot quality, provision of information, and social capital are positive and statistically significant for middle level, higher level and highest level adaptation measures. They are negatively and significantly related to low level adaptation.

As expected and in line with previous empirical findings in the literature, for instance Maddison (2007), provision of information is positively and significantly related to the decision to adapt.

Table 7
Climate adaptation and land rights in Guangdong Province in China: Model Estimates.

	Ordered Probit Marginal effects Dependent Variable: Adaptation (0 = no adaptation, 1 = low level adaptation, 2 = middle level adaptation, 3 = higher level adaptation and 4 = highest level adaptation)			
	Predicted probability of low level adaptation (1)	Predicted probability of middle level adaptation (2)	Predicted probability of higher level adaptation (3)	Predicted probability of highest level adaptation (4)
Main variables				
Contracted Land	−0.0011	0.0149	0.0097	0.0091
	(0.0008)	(0.0120)	(0.0076)	(0.0070)
Interaction term: Contracted Land × Flood	−0.0037 **	0.0313***	0.0220***	0.0218***
	(0.0016)	(0.0096)	(0.0071)	(0.0073)
Control variables				
Household Characteristics				
Age of household head	−0.0002**	0.0019***	0.0013***	0.0012***
	(0.0001)	(0.0006)	(0.0004)	(0.0004)
Education of household head	−0.0002	0.0022	0.0015	0.0014
	(0.0002)	(0.0017)	(0.0012)	(0.0011)
Household size	0.0006***	−0.0072***	−0.0048***	−0.0046***
	(0.0002)	(0.0018)	(0.0018)	(0.0011)
Wealth per capita	4.74e−08	−5.19e−07	−3.47e−07	−3.33e−07
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Plot Characteristics				
Land area	−4.92e−06	0.0000	0.0000	0.0000
	(0.0000)	(0.0001)	(0.0001)	(0.0001)
Best plot quality	−0.0069*	0.0378***	0.0295**	0.0312**
	(0.0039)	(0.0127)	(0.0118)	(0.0137)
Middle plot quality	−0.0019**	0.0405***	0.0251***	0.0232***
	(0.0010)	(0.0146)	(0.0085)	(0.0076)
Landform	−0.0003	0.0031	0.0021	0.0020
	(0.0008)	(0.0089)	(0.0060)	(0.0057)
Institutional Factors and Social Capital				
Provision of disaster related information	−0.0029**	0.0283***	0.0193***	0.0188***
	(0.0012)	(0.0088)	(0.0061)	(0.0061)
Social capital	−0.0053***	0.0584***	0.0390***	0.0375***
	(0.0016)	(0.0083)	(0.0057)	(0.0054)
Other variables				
Late rice	−0.0021**	0.0237***	0.0157***	0.0151***
	(0.0009)	(0.0088)	(0.0059)	(0.0056)
No of obs	1890			
Prob > Chi2	0.0000			
Pseudo R2	0.0259			
Marginal effects Y = Pr (Dep variable) (predicted outcome)	0.1567	0.3187	0.08797	0.05444

Notes: Standard errors are given in the parentheses. Reported standard errors are normal standard errors. Significantly different from 0 at *90%, **95%, ***99%.

Access to early warning information enhances farmers' climate-related knowledge and improves the ability to adapt in advance. The higher the level of social capital, the greater will be the farmers' willingness to adopt new farm management measures. Our interpretation is that farmers with greater levels of social capital have wider networks and greater access to information which enhances their knowledge and also improves their ability to adapt.

Plot characteristics also play a part in the adaptation decision. Moderate and higher-quality plots are positively associated with degree of adaptation, compared to lower quality plots. The benefits of adaptation are greater with higher quality plots of land and this association drives farmer decision making.

Degree of adaptation also increases with age. Older farmers have more experience of the consequence of extreme weather events which prompts them to take a higher level of adaptation.

Household size also plays a role. There is a general belief that bigger households have more labour resources to use in farming activities which may contribute to a decision to take additional actions related to adaptation. However, this study finds that the coefficient for household size is negative and significant. An explanation is suggested by Gbetibouo (2009) who argued that bigger households may divert their labour inputs towards off-farm activities to increase total household income, negatively affecting farming activities.

Other variables include education, wealth, land area, or land form. We do not find statistically significant evidence that these variables affect the adaptation behaviour of farmers in our study sample.

5.2. Discussion

Studies of changes in land tenure arrangements generally examine the impact on investment decisions. We add to this literature by finding a contribution of land tenure arrangements to management decision-making. Relative to renters, who also act in the context of extreme weather events which we examine, owners do more. Our results show that the difference is statistically significant.

It might have been thought that changes in land tenure arrangements would have little effect on management decision-making. This situation might arise because the returns to management decisions are received in a relatively short period so that arrangements in which land was either rented or owned would not affect the future return to the effort made to implement the management changes. However, we find that these arrangements do matter. In explanation, we propose that our results indicate that there is not only a forward-looking aspect to the interaction of land tenure and decision-making, but there is also a backward-looking dimension. We speculate that owners do more because they are more familiar with the land which they farm in a number of dimensions. For example, they are more aware of the areas of land quality and the way that different pieces of land will respond to changes in management practices. Owners earn a higher return to any management effort or change for this reason, and as a consequence they are more likely to make those changes.

6. Conclusions and policy implications

Based on a survey of rice farm households in Guangdong Province in China, this study investigates the association between land tenure and farmers' adaptation behaviour in response to flood disasters. Our main result is that farmers with contracted land are more likely to implement adaptation measures in response to a weather disaster than those who have rented their land from the collective and from other farmers. This supports the main hypothesis of the study that the nature of property rights matters, in this case for management decisions. The traditional analysis of the impact of property rights has concentrated on investment decisions: our contribution here relates to management practices. This consequence is significance since in the context of climate it is another channel through which agricultural productivity would improve.

Other key drivers of adaptation decisions related to management practices are the farmer's age, the quality of the plot of land, access to information through its public provision and through networks associated with social capital. We do not find statistically significant evidence to suggest that farmer education or wealth, the total farm land area and the form of the land affect the adaptation behaviour of farmers in this respect.

The findings from this study have important policy implications. Our results highlight the importance of the security of land rights. In the case of China, while privatization of land may not be necessary at the moment, any institutional interventions to develop the existing framework of property rights can significantly improve the likelihood of the implementation of adaptation measures. Relevant actions could include increasing the contract length beyond the 30 years which is the current situation. This institutional change is likely according to be relatively important. For example numerous extension and awareness programs are already carried out by local governments to encourage farmers to implement adaptation measures related to climate change, but farmers may not do so simply because they do not own the land or they do not have sufficiently secure land rights. The problem is not the design of those programs but the context of land tenure in which they are applied.

Another example of the effect of land rights on uptake of adaptation measures is that policies to correct market failures, such as the development of credit markets to support farmers' climate adaptation investments, would not generate the effects expected in the absence of secure land rights. Some villages have already established various credit and banking facilities, but the inability to use their land as collateral would inhibit farmers' access to credit from these banks.

In conclusion, this study contributes to the existing literature in three other ways. First, it estimates the association between farmer adaptation and land tenure by distinguishing between farmers' responses in normal years and in the years with extreme weather events using the same sample of households. Existing studies do not make this distinction (Lobell, 2014). Second, while the focus of most studies is on farmers' behaviour in response to climate events on average, we estimate farmers' behaviour in response to a specific form of weather event, which in this study is a flood. Third, land tenure is interacted with an indicator of the presence of a disaster information to correctly capture the association between land tenure and adaptation decisions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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