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Impacts and effects of government regulation on farmers' responses to drought: A case study of North China Plain

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Abstract: Frequent extreme weather events like drought, etc. in the context of climate change present huge challenges to agricultural production. To find out if farmers have taken measures against them and identify governments' impact on their response measures are the foundation of and key to further improving relevant policies and farmers' responsiveness. Taking the North China Plain as an example, the study analyzes farmers' responses to frequent climate change-induced drought, and assesses the impacts of governments' early-warning, policy support and other factors on farmers' responses based on questionnaire survey data and an econometric approach. The results show that: (1) Farmers are responsive to drought, and they are more likely to take measures as the degree of drought deepening. (2) Governments' regulation affects farmers' responses, although only part of its regulation measures has remarkable effects. Governments' early-warning messages can increase the possibility of farmers' responding to drought, however, only when they get the early-warning in all the processes including before, during, and after disasters can the effects be significant. Currently, as the primary channel through which early-warning information is released, television cannot change farmers' behaviors significantly. Early-warning is most effective when spread via two or more types of channels. In addition, governments' (especially town and village level institutions') policy support has certain impacts on farmers' responses to drought, yet with less prominent effects in disaster years than in normal years; to provide subsidies, as a regulation measure, can encourage farmers' initiative a lot in adopting response measures, but most of the farmers haven't got support from any institutions. Both the structure and strength of government regulation need to be improved. (3) Farmers with different conditions respond differently. Farmer households in irrigation areas, those whose farmland is lower fragmented, and those with numerous agricultural family members tend to take response measures. The study can provide scientific reference to the making of relevant regulation policies under the background of acidifications.

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1 Introduction

Drought disaster is considered as one of the major natural disasters threatening national grain security (UNDP, 2004; He *et al*., 2010). Especially under the background of climate change, the degree and frequency of all levels of drought disasters have still been increasing (IPCC, 2007; Dai, 2011; Li *et al*., 2003). As estimated by IPCC (2012), the total drought-attacked area all over the world will expand by 15%–44% by the end of this century (IPCC, 2012). In China, the area of crops affected by drought disasters has increased from 8% to 16% over the past 60 years, and drought-inundated area (where grain output has dropped over 30%) has also increased by nearly 12%. In 2000, the grain output lost in drought disaster reached 599.6 million tons, which amounted to about 13% of the total grain output of the year, causing huge economic and social losses (MWR, PRC, 2010). Many institutions and academics have pointed out that in a context where climate change is difficult to reverse, the issue of how to enhance the ability of all social groups to cope with risks by taking response measures is worth paying great attention to for policy makers (IPCC, 2007; Qin, 2014). Farmer households are the basic organizing unit of agricultural production (Weng, 2008), which is also a relatively fragile social group. To identify farmers' responses and the affecting factors of their responses, especially the impacts of government policies, is the foundation of and key to further improving relevant policies and farmers' responsiveness.

So far, there have been foreign and domestic studies focusing on the influences of climate change on agricultural production and farmers' livelihoods, most of which begin with discussing the influences and then further investigate farmers' response behaviors (Deressa *et al*., 2009) and future approaches to address climate change (Wang *et al*., 2014; Liu *et al*., 2012; Pan *et al*., 2010; Wang *et al*., 2010; Liu *et al*., 2010). Some academics have summarized possible measures for addressing disasters, including engineering ones like repairing or building new wells, irrigation and drainage ditches, water reservoirs, dams, etc., and non-engineering ones like adjusting the structure of crop planting, production factor input, intensity of irrigation and drainage, and dates for sowing seeds and harvesting, etc. (IPCC, 2007). To implement engineering measures is comparatively more complicated and relies on more capital and time investment, so their implementation is usually led by government departments or farmers' cooperative organizations. So far as farmers themselves are concerned, non-engineering measures are more preferable when responding to sudden natural disasters (Chen *et al*., 2014). Other academics and research institutions have evaluated the effects of response measures in dealing with disasters, and found that appropriate response measures can significantly help reduce the negative impact of drought disasters on agricultural production (Xiao *et al*., 2014; Falco *et al*., 2011; Holden *et al*., 2004). For instance, according to IPCC (2012), when temperature going up, response measures like changing crop varieties or adopting other field management modes, etc. can help reduce drought-induced loss by 10%–15% (IPCC, 2012). It is even possible for agricultural production to benefit from global warming if countermeasures are taken properly (Tian *et al*., 2014; Xiong *et al*., 2005). Then the question arises: who should take the actions? More and more scholars point out that in order to enhance the adaptability of agricultural sector, only relying on farmers' own initiatives in taking response measures is far from enough; related government departments

should also take actions (Pan *et al*., 2010; Ye *et al*., 2013; Cui *et al*., 2011). The functions of government support are mainly found in encouraging farmers to or help them reduce vulnerability, resume and even expand production (Zhou *et al*., 2012). For example, Carter *et al*. found that government actions like improving infrastructures etc. could help prevent farmer from falling into a vicious circle of poverty due to damages of disasters (Carter *et al*., 2007). International organizations also call on countries to incorporate climate change adaptation into their national development plan systems (World Bank, 2010). In recent years, Chinese government has responded to the international call actively and included the development and implementation of climate change adaptation strategies into national priority action plans. It not only issued *China's Policies and Actions for Addressing Climate Change* in 2008, but also took a step further and issued *Drought Control Regulation of the People's Republic of China* in 2009. Besides, *National Planning for Addressing Climate Change* (*2014–2020*) and other policy documents have also been worked out. These policies, on the one hand, have shown the determination and steps of Chinese government in addressing climate change; on the other hand, they also encourage farmers to fight against the disasters through providing them with early-warning information and practical support.

However, what is farmers' own attitude towards fighting disasters? Have corresponding policies been effective in encouraging them to take initiative in the face of disasters? These questions have not yet drawn much attention. Although there is no shortage of studies on affecting factors of farmers' response decision-making, most of them focus on natural and socio-economic factors and very few of them have touched upon policy factors (Chen *et al*., 2014; Falco *et al*., 2011; Wang *et al*., 2015; Wang *et al*., 2014). Micro empirical researches based on questionnaire survey data are particularly scarce. Non-engineering measures are more flexible, independent and reflect a better picture of farmers' attitudes and the effects of policy regulation. Therefore, based on farmer household questionnaire survey and through investigating the implementation of non-engineering measures by farmer households at North China Plain area, this study explores farmers' responses to the normalization of climate change-induced drought and affecting factors of their responses with a focus on the impact of government policy regulation on their responses. By doing this, the study hopes to further develop existing research on the impacts of climate change on agricultural production system theoretically, and provide scientific reference for improving corresponding policies after identifying farmers' responding behaviors and effects of government policy regulation. In the meantime, this study is also a micro empirical research on how human race should adjust our own behaviors in order to respond to resource and environmental changes. In other words, how to adjust farmers' and governments' behaviors so as to reduce the negative impacts or reinforce the positive impacts of natural factors on sustainable development of human race, which is also one of the challenges faced by geography in responding to climate changes.

2 Case study area and data sources

2.1 General introduction of the case study area

The North China Plain is located in the lower reaches of the Yellow River with most parts of it in the Warm Temperate Zone and having a semi-humid climate. It has a total area of 0.3

million km^2 and a total arable land area of 366 million mu (15 mu = 1 ha) among which paddy field, irrigated land and arid land taking up 3%, 54% and 43% respectively. As a major producing area for agricultural products like wheat, corns and apples, etc., the North China Plain holds a prominent position in agriculture with its average annual grain yield accounting for 30% of the national total (Yang *et al*., 2010). Agricultural production, however, is greatly affected by climate factors. In this area, three-year drought is a common phenomenon. Spring and summer drought is the worst, and continuous seasonal drought also occurs frequently (Lu *et al*., 2010). The arid tendency of this area is particularly obvious under the background of climate change, leaving the advantages of arable land resource not brought into full play (Fei *et al*., 2007). According to related literature, from 1960 to 2009, the frequency of drought in the North China Plain reached 46.79%, with an average disaster-stricken area in disaster year accounting for as much as 28% of the total national disaster-stricken area (Lu *et al*., 2010). In recent years, the temperature in this area has been rising continuously with the temperature rise much larger than the national average value 0.76°C/100a, which makes the aridification process even worse (Tu *et al*., 1999; Li *et al*., 2004; Zou *et al*., 2010). The direct economic losses caused by drought exceed 100 billion yuan every year (Huang *et al*., 2006). Over the past three decades, this area has also shown apparent trends in decreasing rainfall and falling ground water levels. The amount of precipitation has decreased by 3128.7×10^8 m^3 accumulatively and ground water resources decreased 594.5×10^8 m^3 correspondingly (Zhang *et al*., 2011). How to deal with the increasingly severe drought is the major challenge faced by the North China Plain (Ma *et al*., 2006; Liu *et al*., 2004).

It should be noted that the North China Plain is an ecologically fragile area where drought occurs frequently, so there is actually no such thing as a 'normal year' in a strict sense. To be precise, 'disaster years' refer to those with disasters severer in degree. Therefore, in this area, farmers usually need to take field management measures to ensure grain production benefits even in the 'normal years'.

2.2 Data sources

The research data are mainly drawn from field questionnaire surveys conducted in Hebei, Henan and Shandong provinces, supplemented by reference material and statistical yearbook data. As important components of the North China Plain, these three provinces have long histories of agricultural production and a large population of which farmers take up a very large proportion. These three provinces are thus typical and representative of the North China Plain area. That is the reason why they are taken as the investigation provinces. Based on the overall development states of each area, four types of questionnaires aimed at counties, towns, villages and farmer households respectively are designed. Specifically, county-level questionnaire covers economic development, agricultural production and disaster situation of each county. Town-level questionnaire involves 267 indexes under 6 large categories: jurisdictions, socio-economic development, disaster prevention facilities construction, disaster situation, and aid and assistance provision. Village-level questionnaire concerns 1911 indexes under 22 categories such as socio-economic development, crop yields, impacts of disasters, public service facilities construction, responding measures that have been taken to

been taken to address disasters and so on. Farmer household questionnaire covers 2626 indexes under 9 large and 39 medium categories including essential features of the family, farmland conditions, production inputs, impacts of disasters, disaster prevention measures, knowledge about climate change, awareness of disaster prevention, government policy implementation, etc. Survey sites (Figure 1) and interviewees were selected through stratified sampling and random sampling. Eventually among the questionnaire surveys that have been done, valid and relevant questionnaires to the study include 54 village-level questionnaires and 540 farmer household questionnaires.

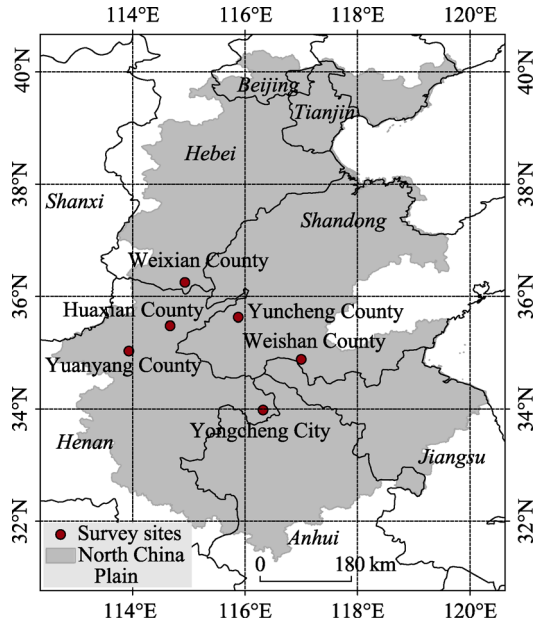

Figure 1 Location of the North China Plain and the survey sites

2.3 Data analysis methods

First of all, a descriptive statistical analysis method is employed for a general analysis of the questionnaire data. The analysis provides a general picture of farmer households' responding behaviors and government regulation measures, including farmer households' attitudes in taking responding measures and types of the measures taken in different years, presence of government policy regulation and its specific forms, etc. Secondly, the analysis of variance based on calculation of the values of F statistic is conducted to investigate the differences of farmer households' responding behaviors in disaster years and in normal years and with different policy regulation measures. Binary logistic regression analysis is also used to build a model for further exploring major affecting factors of farmer households' responses and the degree of their effects, especially the effects of policy factors. When building this model, 'whether farmer households' take responding measures or not' is taken as the dependent variable and are set as binary dummy variables 'take' (=1) and 'not to take' (=0). Detailed structure of this model is as follows:

$$\begin{cases} \ln\dfrac{p}{1-p} = \alpha + \sum_{k=1}^{k} \beta_k x_k \\ P(y \mid x_1, x_2, \cdots, x_k) = \dfrac{\exp\left(\alpha + \sum_{k=1}^{k} \beta_k x_k\right)}{1 + \exp\left(\alpha + \sum_{k=1}^{k} \beta_k x_k\right)} \end{cases}$$

where $p = P(y \mid x_1, x_2, \cdots, x_k)$ indicates the frequency of farmer households' "taking" or "not taking" responding measures with independent variables x_1, x_2, …, x_k. x_k stands for the factors affecting farmer households' selection of responding measures. Following the principles of ensuring data availability and avoiding colinearity of factors, the analysis tries to ensure the validity of this regression model by taking as many factors as possible into consideration. In the meantime, it also tries to verify the effectiveness of policy factors on the premise that other variables are controlled. By combining existing researches and field investigation, internal factors, external factors and policy measures are selected (internal and external factors are set as control variables). In this analysis, internal factors mainly include attributes of farmer households, their land and family features, e.g. age and education level of the head of household, size of the family, land structure, social connections, etc. External factors mainly refer to climate conditions, physical geographic conditions and development state of the villages where the farmer households live in, including disaster, topographical and irrigation conditions, etc. Policy measures refer to the measures that are implemented by governments, including whether disaster early-warning information is provided, early-warning channels, whether disaster relief activities are organized, whether material, financial, technical or labor supports are provided, etc. k stands for the total number of variables, α is a constant, and β_k is the partial regression coefficient.

3 Results and discussion

3.1 Analysis of farmer households' responding behaviors to drought and their attitudes

Taking responding measures or not is the major behavior of farmer households in front of drought, reflecting their attitudes in responding to drought disasters. The statistical analysis shows a positive attitude of farmer households. Most of the respondent farmer households choose to take actions, and as the degree of drought disasters deepening, the possibility of farmer households taking actions increases. In the 540 farmer household samples, 75.37% of them choose to take responding measures in normal years, and 82.78% of them choose to do so in disaster years (Table 1).

The types of measures that farmer households take can further reflect the degrees of their recognition of disasters. An analysis of the types of measures that farmer households have taken in different years show that, along with the deepening of severity of disasters, the degree of farmer households' recognition of drought and their input cost both increase. In normal years, only 144 of the 407 farmer households who choose to take responding actions take multiple (two or more) measures, accounting for 35.38% of the total; while in disaster years, the percentage reaches 58.61%. There are even farmer households who have taken 5

Table 1 Farmer households' responding measures

Number of measures taken		Normal years		Disaster years	
		Number of farmer households taking measures	Percentage (%)	Number of farmer households taking measures	Percentage (%)
Number of farmer households not taking measures		**133**	**24.63**	**93**	**17.22**
Number of farmer households taking measures, among whom:		**407**	**75.37**	**447**	**82.78**
	1 measure	263	48.70	185	34.26
	2 measures	112	20.74	112	20.74
	3 measures	29	5.37	95	17.59
	4 measures	3	0.56	42	7.78
	5 measures	0	0.00	13	2.41
Total		**540**	100.00	**540**	100.00
Variance analysis	F value		9.011		
	Sig.		0.003		

different types of measures in disaster years in order to reduce the negative impacts of drought on agricultural production. Furthermore, the result of the variance analysis is significant ($P=0.003<0.05$), meaning farmer households' behaviors in taking responding measures vary considerably in normal and disaster years. Farmers' responding behaviors are significantly affected by the degrees of drought disasters. These provide further verification of farmer households' positive attitude in addressing drought disasters.

3.2 Governments' early-warning and farmer households' responding behaviors

Providing early-warning information is one of the commonly used measures for governments in addressing disasters. Governments get information about possible or ongoing natural disasters through meteorological monitoring, and then pass the information to farmer households via various media, reminding them to make preparations so as to reduce potential losses. In order to obtain detailed information about governments' early-warning, the questionnaire has designed two separate scenarios–pre-disaster warning, and early warning amid and after disasters. For different years, the interviewees have been asked "have you received any related disaster prevention information before/during or after the disaster?" If the interviewees answered "Yes", then inquire further by asking "through what media and from which institutes or whom did you obtain the information?"

3.2.1 Channels for releasing governments' early-warning information

In both normal and disaster years, channels for releasing governments' early warning information are basically the same for pre-disaster warning or early-warning amid and after disasters. Major channels include short mobile messages, meetings, issuing documents, broadcasting, television, and informing farmer households face to face, etc., among which television is most commonly used followed by broadcasting (Figure 2). For pre-disaster warning, 78.45% and 77.01% of the farmer households have received the information on TV in normal and disaster years respectively; 12.71% and 14.56% from radio broadcasts. The

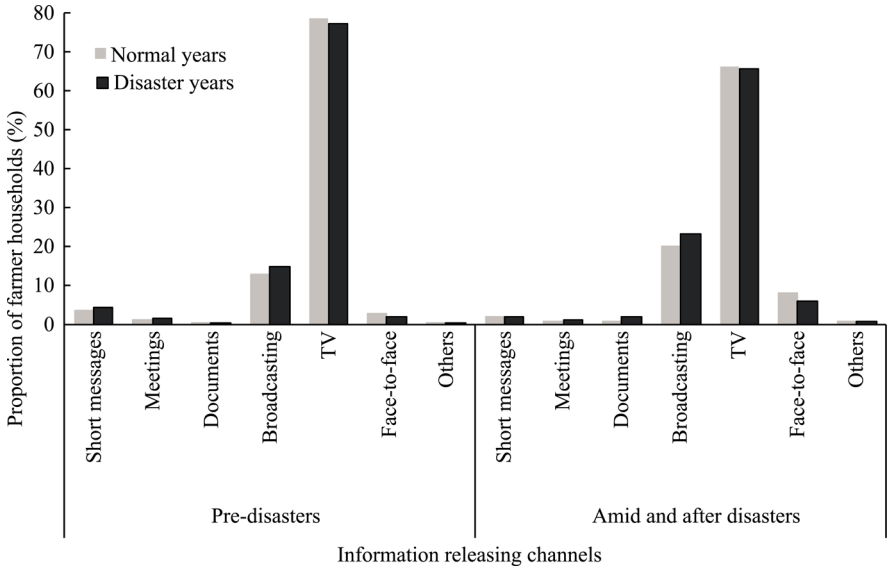

Figure 2 Major channels for releasing early-warning information

percentages of farmer households getting informed through other channels are extremely low. So far as early-warning during and after disasters is concerned, TV is still the most important media for releasing information, though the percentages of farmer households obtaining information in this manner are lower compared with pre-disaster warning, which are 66.30% and 65.44% in normal and disaster years respectively. The percentages for radio broadcasting increase, which are 20.11% and 23.16% respectively. In addition, the proportions of farmer households obtaining early-warning information through short messages during and after disasters are smaller than those before the disasters. The proportions of farmer households being informed through documents or face to face increase compared with pre-disaster warning, especially for face-to-face informing. These findings reveal that as the severity degree of drought disaster deepening, the governments also attach increasing importance to releasing the early-warming information and in more direct and formal ways.

3.2.2 Farmer households' access to early-warning information

Generally speaking, the farmer households who have access to early-warning information are the minority no matter in normal or disaster years, but the more severe the disaster is, the more likely for them to get governments' early-warning information. For pre-disaster warning, only 155 of the 447 relevant and valid farmer household samples have accessed to the information in normal years, accounting for 34.68% of the total; the percentage rose to 43.16% in disaster years, still lower than half the valid samples though. The situation for early-warning during and after disasters is basically the same (Table 2). Furthermore, statistical analysis also shows that although governments are able to release early-warning information through multiple channels simultaneously, the proportions of farmer households who have obtained the information from multiple (two and more) channels are all very small no matter before, during and after the disasters. In normal and disaster years, there are only 23 and 36 farmer households respectively who have obtained pre-disaster information from multiple channels, accounting for 14.84% and 16.29% respectively of the total number of

Table 2 Farmer households' access to early-warning information

Got information or not		Pre-disaster				Amid- and post-disaster			
		Normal years		Disaster years		Normal years		Disaster years	
		Number of farmer households	Percentage (%)	Number of farmer households	Percentage (%)	Number of farmer households	Percentage (%)	Number of farmer households	Percentage (%)
No		**292**	**65.32**	**291**	**56.84**	**282**	**63.66**	**286**	**55.75**
Yes		**155**	**34.68**	**221**	**43.16**	**161**	**36.34**	**227**	**44.25**
Number of channels	1	132	29.53	185	36.13	140	31.60	188	36.65
	2	21	4.70	33	6.45	19	4.29	34	6.63
	3	1	0.22	2	0.39	1	0.23	4	0.78
	4	1	0.22	1	0.20	1	0.23	1	0.19
Total		**447**	**100**	**512**	**100**	**443**	**100**	**513**	**100**

samples; the percentages are 13.04% (21 farmer households) and 17.18% (39 farmer households) respectively for amid-and post-disaster warning. It shows that the way of announcing early-warning information through multiple channels has not been widely adopted by the governments.

3.2.3 Governments' early-warning and farmer households' selection of responding measures

Whether and when governments provide early-warning information affect farmer households' responses to drought to a certain degree (Figure 3). When farmer households receive governments' early-warning information before the disaster (Scenario 1), the proportion of those who choose to take actions is 82.58% in normal years and 85.97% in disaster years, 7.58% and 4.18% higher respectively than when they are not informed. When they get the warning messages during or after disasters (Scenario 2), the percentages of those who take actions are 82.61% in normal years and 87.22% in disaster years, 7.79% and 6.80% higher respectively than when they are not informed. When they get informed at every stage–before, during and after disasters (Scenario 3), the proportions are 84.62% in normal years and 88.02% in disaster years, being 9.47% and 6.57% higher respectively than when they haven't got the information.

Furthermore, after comparing the proportions of farmer households who choose to take responding measures under the three scenarios, the authors find: the percentage of farmer households taking actions is higher if governments provide early-warning information at every stage (before, during and after disaster). It means that farmers are most likely to take responding measures when they get all the pre-warning, amid-disaster and post-disaster warning messages.

3.3 Governments' policy supports and farmer household's responding behaviors

Apart from indirectly helping farmers deal with drought disasters through providing early-warning and enhance their sensitivity to extreme weather events, governments can also intervene in farmers' responding behaviors directly through policy measures like technological, material, financial and labor supports. In order to learn in detail about governments' policy supports, the questionnaire asks, "Have you ever got any government support when disasters occur?" If the interviewee answers "Yes", then inquires further, "What kind of supports are

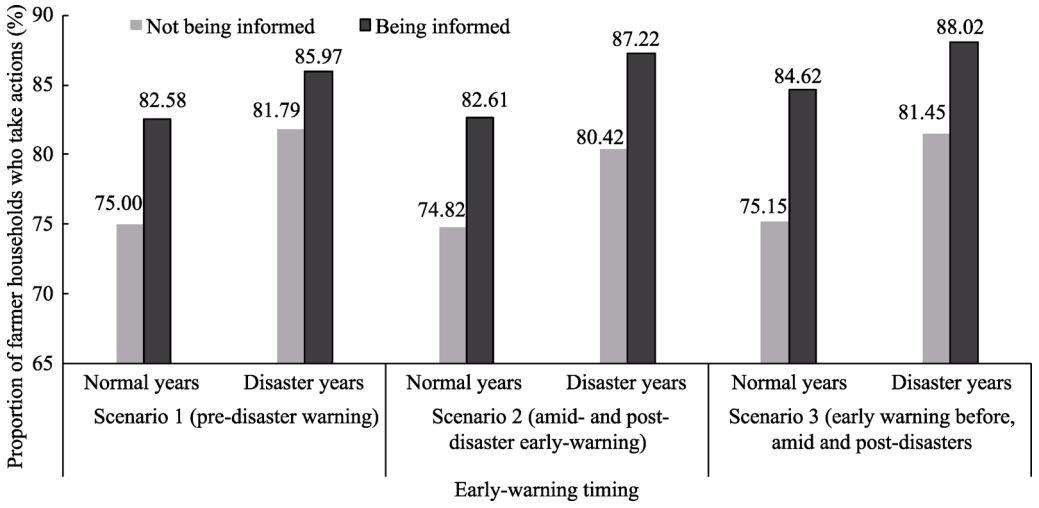

Figure 3 Relationship between early-warning and farmer households' responding measures

they?" "By whom were the supports provided?", etc.

3.3.1 Status quo of policy support

Statistics show that the institutions providing supports for farmer households include village, town and upper-level governments in a hierarchical order, but the majority of farmer households have never been given any policy support by any government sectors, even in years of severe drought disasters. In the 535 valid questionnaires for normal years, only 129 farmer households have ever received policy supports, accounting for 24% of the total; in the 534 valid questionnaires for disaster years, only 131 households have been supported by government policies, taking up 25% of the total (Table 3). An analysis of the structure of government sectors providing policy supports shows that above-town-level institutions give the most supports, claiming 46% and 44.6% of the total volume of supports respectively in normal and disaster years. Generally speaking, however, government policy supports cover a very small part of farmer households, and whether governments provide policy support or not is not affected by the severity level of drought disasters.

Table 3 Supports by different levels of government institutions

Being supported	Normal years		Disaster years	
	Number of samples	Proportion (%)	Number of samples	Proportion (%)
No	**406**	**76**	**403**	**75**
Yes, by:	**129**	**24**	**131**	**25**
Village	32	23.40	37	26.60
Town	39	28.50	37	26.60
Upper-level institutions	63	46.00	62	44.60
Others	3	2.20	3	2.20
Total number of supports	137	100	139	100
Total number of samples	**535**	**100**	**534**	**100**

3.3.2 Forms of policy supports

The supports provided by governments mainly include technical guidance, financial subsidies, material subsidies, labor support and other forms of supports. In normal years, financial subsidies are the most common form of supports provided by different levels of institutions, accounting for 45.95% of the total, followed by material subsidies, which take up 35.81% of the total, including fertilizer, pesticide, seed, farmyard manure subsidies and other input factor subsidies for agricultural production. Besides, 8.78% of farmer households have received technical guidance, and 8.11% have got labor supports. This indicates that governments tend to support farm households in more convenient and rapid ways by providing funds and materials. In the long run, however, compared with technical guidance, financial and material subsidies will not be able to enhance farmer households' perception of natural disasters significantly, so that will not help them strengthen their ability to deal with disasters. Therefore, the forms and structures of governments' policy supports are in need of further improvement. It is also the case for disaster years and needs not to be repeated here (Figure 4).

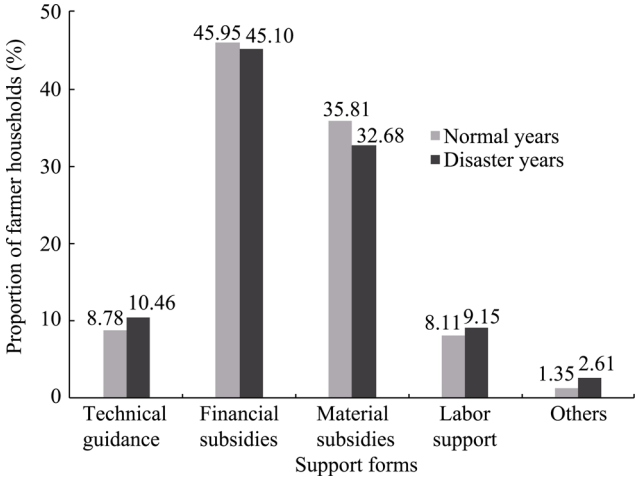

Figure 4 Forms of government policy supports (multiple choices)

3.3.3 Government policy supports and farmer households' selection of responding measures

Generally speaking, when drought disasters occur, government policy supports can encourage farmer households to take actions to a certain degree, but the effects are rather limited, especially in disaster years. Statistics show that if no government supports are given, the share of farmer households taking responding measures is 72.17% in normal years and 81.39% in disaster years; if farmer households have got government supports, then the proportions increase 12.9 and 5.47 percentage points respectively, reaching 85.07% in normal years and 86.86% in disaster years (Table 4). This shows that a larger proportion of farmer households will take responding measures with government supports than without any supports in both normal and disaster years, but the impacts of policy supports on farmer households' initiative in taking responding measures are very limited in disaster years. Furthermore, by comparing farmer households' responses when not being given any supports with the respective situation when they are given labor supports, technical guidance, financial subsidies and material subsidies, the authors find that the proportions of farmer households taking actions are 23.24%, 16.34%, 9.37% and 8.68% higher when being supported in respective forms. This indicates that labor supports have the greatest impacts on farmer households' selection of responding measures, successively followed by technical guidance, financial subsidies and material subsidies.

3.4 Affecting factors of farmer households' responses

To identify the affecting factors of farmer households' responses is the key to enhance their

Table 4 Forms of government supports and corresponding share of farmer households taking actions

Being supported	Share of farmer households taking actions (%)	
	Normal years	Disaster years
No	72.17	81.39
Yes	85.07	86.86
Technical guidance	100.00	87.50
Financial subsidies	85.29	86.96
Material subsidies	83.02	88.00
Labor support	100.00	100.00

response capacities. The simple statistical analysis above cannot control the influences of other factors, e.g. farmer households' own personal attributes, socio-economic conditions, etc. (Chen *et al*., 2014; Wang *et al*., 2015), on farmer households' decision-making. Therefore, in order to further explore the impacts of policies and other factors on farmer households' responding behaviors based on the analysis above, the study, setting farmer households' responses as the dependent variable, establishes logistic regression models for farmer households' responding measures. In order to deepen the understanding on the effects of policy regulation factors and avoid the co-linearity of factors as well, the study builds three models based on different indexes of policy factors to probe into the impacts of policy regulation factors on farmer households' responding behaviors step by step. Model 1 evaluates the effects of policy factors from an overall perspective (whether farmer households have received early-warning information or policy supports). Model 2 is established based on the regression results of Model 1, focusing on identifying the impacts of early-warning timing and government structures on farmer households' responses. Model 3 is constructed on the basis of Model 1 and Model 2, further exploring the regulation effects of different information releasing channels and policy support forms (Table 5).

The regression shows that all of the prediction accuracies of the three models are above 78%, which has been a remarkable result for regression analyses of complicated and socio-economic issues. Most of the variable symbols are consistent with theoretical expectations with the significant levels being above 90%. Affecting factors of farmer households' responses include their physical capital (farmland conditions) and social capital (family member/s is/are village cadre/s or not), physical geography conditions of the village (within irrigation area or not), external intervention (disaster prevention activities organized by the village, government early-warning information and practical supports), and weather conditions. Detailed results are as follows:

First of all, from the perspective of internal and external affecting factors of farmer households' responses, the larger farmland areas the farmer households possess, the smaller chances there will be for them to take responding measures. The reason lies in farmers' conception of 'fairness'. In the process of agricultural production, if farmer households choose to take actions when their farmland is stricken with natural disasters, they will try their best to take care of their whole land; if they choose not to take actions, then they will not take actions on a single part of their land. For individual farmer household, the larger farmland area they have, the more restricted they will be by factors like explicit costs of agricultural materials and implicit costs of labor forces, which will thus discourage them from taking

Table 5 The regression models of farmer households' responses (Dependent variable: taking measures=1, not taking measures=0)

Independent variables	Model 1		Model 2		Model 3	
	Coefficients	Exp (B)	Coefficients	Exp (B)	Coefficients	Exp (B)
Internal factors						
Total number of family members	–0.063	0.939	–0.061	0.941	–0.062	0.940
Age of household head	–0.01	0.99	–0.01	0.99	–0.012	0.988
Education level of household head	0.028	1.028	0.026	1.026	0.018	1.018
Farmland area of the household (mu)	–0.051**	0.951	–0.049**	0.953	–0.040*	0.961
Farmland fragmentation level (mu/piece)	–0.119**	0.888	–0.119**	0.887	–0.082	0.922
Total value of house (ten thousand yuan)	0.004	1.004	0.004	1.004	0.006	1.006
Joined cooperation organization (Yes=1, No=0)	0.221	1.247	0.184	1.202	0.023	1.023
Family member is/are village cadre/s (Yes=1, No=0)	–0.329*	0.719	–0.344*	0.709	–0.523**	0.593
External factors						
Topography (plain=1, others=0)	19.523	3.012	19.595	3.236	19.538	3.056
Inirrigation area (Yes=1, No=0)	0.727***	2.07	0.699***	2.012	0.809***	2.246
Average underground water level (m)	0.001	1.001	0.002	1.002	0.003	1.003
Policy factors						
Received early-warning information (Yes=1, No=0)	0.412**	1.51				
Only received pre-disaster warning			0.076	1.079		
Only received post-disaster warning			0.216	1.241		
Received both pre- and post-warning			0.615***	1.85		
Only received warning via TV					–0.342	0.711
Only received warning via one channel apart from TV					0.499	1.646
Received warning via two or more channels					0.491**	1.633
The village organizes disaster prevention activities (Yes=1, No=0)	0.326*	1.386	0.321*	1.379	0.223	1.250
Received government supports (Yes=1, No=0)	0.374*	1.454				
Supported by town-level or lower levels of institutions			0.667**	1.949		
Only technical guidance					0.197	1.218
Only financial subsidies					2.057**	7.821
Only material subsidies					0.019	1.019
Only labor supports					0.744	2.105
Two or more types of supports					1.100	3.003
Supported by above-town level institutions			0.308	1.361		
Disaster years (Yes=1, No=0)	0.410**	1.507	0.412**	1.51	0.426**	1.532
Constants	1.025	2.786	1.043	2.838	1.400**	4.057
Accuracy of prediction	79.10%		79.20%		78.80%	
Degrees of freedom	15		18		21	
Number of samples	1070		1070		936	

Notes: *, ** and *** indicate significance at confidence level 0.1, 0.05 and 0.01 respectively.

responding measures. Likewise, the greater the degree of fragmentation of their farmland is, the less likely they will take actions. That is, there exists a negative correlation between the degree of farmland fragmentation and farmer households' initiative in taking responding measures under the scale effect. Moreover, the more immediate family members the farmer households have who work in village, town or upper levels of governments, the less likely they will take measures, i.e. the greater share the non-agricultural family members account for, the smaller chances there will be for them to take actions. The reason is that as the share of non-agricultural family members in a farmer household increases, its dependency on agricultural production decreases, and the likelihood for it to take actions when disaster occurs will also decrease as a result. Besides, "whether within irrigation area or not" is also a significant affecting factor of farmer households' responses. According to the occurrence rate shown by Exp (B), farmer households within irrigation areas is 1.07 times more likely to take responding measures than those outside irrigation areas, which means that farmer households' responses to drought disasters are also affected by external physical geographical environment. Lastly, farmer households are 0.5 times more likely to take actions in disaster years than in normal years, meaning the severer the disaster is, the more likely it is for farmer households to take responding measures.

Secondly, from the perspective of policy regulation factors, both government early-warning information and policy supports have significant impacts to a certain degree on farmer households' responses. Model 1 shows that the farmer households who have received government early-warning information are 0.51 times more likely to take measures than those who have not obtained any information. Then Model 2 further shows that no matter the early-warning information is provided before, during or after disasters, they are able to increase the likelihood of farmer households taking actions, but only when the information are provided at all the stages. i.e. before, during and after disasters can they affect farmer households' responding behaviors significantly, the coefficient of the marginal effect reaching 1.85. This indicates that governments' early-warning information can enhance farmer households' initiative in taking responding measures, and the longer the early-warning period can be, the more remarkable its effects will achieve. If the villages organize disaster prevention and mitigation activities, then the farmer households live there are 1.39 times as likely to take measures as when the villages do not organize these activities, indicating that village activities play a positive role in encouraging farmer households' responses. The farmer households who have been supported by the governments are 0.45 times more likely to take actions than those who have not been supported, and according to the results of Model 2, the supporting measures taken by town or lower levels of institutions have the most significant effects. Moreover, all the 4 types of government supports (in Model 3)–technical guidance, financial subsidies, material subsidies and manpower support are positively correlated with farmer households' responding behaviors, among which financial subsidies have the most significant effect. This shows that government supports are likely to encourage farmer households' initiative in taking responding measures regardless of their forms of which financial subsidies having the most significant effect.

4 Conclusions and suggestions

How to adopt effective measures to address increasingly frequent drought disasters is of

great concern to both academics and policy makers. To identify the behaviors of farmer households as the main actor in agricultural production in response to drought disasters and the affecting factors of their behaviors, especially the effects of policy factor regulation, is of great practical value to further improving corresponding policies and enhancing farmer households' ability to deal with disasters. Based on empirical research data, this study finds that the farmer households in the North China Plain hold positive attitudes in responding to drought disasters. They can adjust their own responding policies flexibly in accordance with the different severity levels of disasters so as to reduce their negative effects on agricultural production. The higher the severity level is, the more likely they will take measures. Apart from the severity level of disasters, farmer households' responding behaviors are also under the combined influence of multiple factors such as their own family attributes, the physical geographical conditions of the villages where they live and so on. For instances, the degree of farmland fragmentation, being within or outside irrigation area, the proportion of non-agricultural family members in a household, etc., all have significant impacts on farmer households' behaviors in addressing drought disasters.

Government policy factors can promote farmer households' initiative in taking actions to a certain degree, albeit not all regulation measures have significant effects. Other researchers' studies have also proved this conclusion (Deressa *et al*., 2009; Wang *et al*., 2015). So far as early-warning factor is concerned, governments' early-warning can encourage farmer households to take responding measures in both normal and disaster years. The effects, however, are only remarkable when the warning messages are received in every stage of disasters. Although TV is the most commonly used information-releasing channel, its functions are limited. The results are more satisfactory when multiple channels are employed. The reason may be that early-warning information is actually a complicated potential regulation measure, the final effects of which are under the combined influence of multiple factors like the duration of information dissemination, media, recipients' personal attributes, and their confidence in the accuracy of the information. That is why only when the information is perceived by farmer households for several times can they finally trigger farmer households' practical actions. Through investigation the authors find that the major factors restricting farmer households' behaviors include shortage of money, labor forces and technical information. Therefore, when governments (especially town or lower levels of governments) provide them with direct material, technical, labor and financial supports, their enthusiasm in taking responding actions will become greater. The result of providing financial subsidies is particularly remarkable. The effects of policy supports, however, are less obvious in disaster years than in normal years, for the reason that the force and reliability of government support are still not strong enough to compensate the losses caused by disasters. The severity degree of disasters is comparatively more likely to influence the behaviors of rational farmer households and encourage them to take actions on their own initiative. Furthermore, at present, policy supports only cover 25% of the farmer households in this area, which is definitely very limited. In general, there is still room for improvement in the channels for information dissemination and the force and range of policy supports.

Based on the conclusions and discussion above, the study offers the following suggestions for improving the effects of policy regulation: 1) Increase the force and duration of early warning for disasters. Early-warning information should be disseminated via multiple chan-

nels simultaneously. Pre-disaster warning should be tracked until the impacts of disasters have been relieved. For instance, apart from TV, computer and other commonly used communication media, posters and propaganda campaign are also useful forms for publicizing climate change and disaster prevention knowledge on a long-term basis, which could help improve farmers' scientific literacy and perception of disasters. When disasters occur, the function of information dissemination should be reinforced continuously after early-warning information has been released. 2) Strengthen town- and village-level institutions' supports for farmers in fighting droughts and choose appropriate forms of supports according to specific needs of farmers. Improve the quality of labor force by organizing regular production and disaster prevention trainings so as to offset household labor shortage in combating drought. Assign technical staff to work in the villages and provide regular one-to-one guidance for major farmers. Set experience exchange and technique sharing platforms for farmers, encouraging them to share their production and disaster prevention experiences. Enhance the collective capacities of villages in dealing with disasters and village cadres' service consciousness. 3) Adjust thinking on and measures of policy regulation. Gradually set up a smooth cyclical disaster management pattern by constructing a security network for drought disasters that involves various levels of government sectors, private sectors, meteorological disaster monitoring institutions, disaster risk assessing institutions, non-governmental organizations, academic research institutions and the media, etc. Taking disaster reduction as the common goal, all parties of the network should cooperate following the cyclical network model of monitoring–making prevention plan in advance–early-stage warning–impact assessing–emergency response–summarizing and feedback–monitoring. Introduce social capital and market force, especially agricultural insurance market, into agricultural disaster prevention and mitigation activities to relieve the heavy burden of governments in addressing agricultural disasters gradually.

It should be noted that the research data are available only until 2012, so it does not cover the impacts of modern factors and new land policies on farmer households' responses to disasters during the last 4 years. Follow-up research should study further on informatization factors, the application of mechanization in agricultural production, land rights policy, improvement of land market, and new characteristics of farmers' responses to disasters in the new era. Moreover, this study mainly concerns farmer households' responses to climate-change-induced drought disasters in the North China Plain where is typical of severe drought disaster area in China. However, in the context of climate change, natural disasters like flood, pests and diseases, Xerothermic wind disaster, etc. are also on the rise, so the impacts of other extreme weather events on farmers' responses also need to be studied in later research. Climate change issues are complicated and cannot be resolved in the short run, and farmers' response is a dynamic development process. Therefore, with the deepening of human knowledge in climate change issues and effects of new policies, long-term dynamic monitoring research and continuous testing on the effects of policies can be conducted in the future.

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