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RESEARCH ARTICLE

Crop Diversification in Coping with Extreme Weather Events in China

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Abstract

Apart from the long-term effects of climate change, the frequency and severity of extreme weather events have been increasing. Given the risks posed by climate change, particularly the changes in extreme weather events, the question of how to adapt to these changes and mitigate their negative impacts has received great attention from policy makers. The overall goals of this study are to examine whether farmers adapt to extreme weather events through crop diversification and which factors influence farmers' decisions on crop diversification against extreme weather events in China. To limit the scope of this study, we focus on drought and flood events only. Based on a unique large-scale household survey in nine provinces, this study finds that farmers respond to extreme weather events by increasing crop diversification. Their decision to diversify crops is significantly influenced by their experiences of extreme weather events in the previous year. Such results are understandable because farmers' behaviors are normally based on their expectations. Moreover, household characteristics also affect farmers' decisions on crop diversification strategy, and their effects differ by farmers' age and gender. This paper concludes with several policy implications.

Key words: adaptation, extreme weather event, climate change, crop diversification, farmer

INTRODUCTION

The world, including China, has experienced and will continue to experience long-term climate change. In the past 100 yr (1906 to 2005), the global average surface temperature has increased by 0.74°C (IPCC 2007). Similar to the global trend, China has also experienced a warming trend. From 1951 to 2009, the average annual temperature rose by 1.38°C (ECSNCCA 2011). By the end of the 21st century, the global air surface temperature will have increased by 1.8 to 4°C, and China's temperature will increase by 2.5-4.6°C (IPCC 2007; ECSNCCA 2011). Additionally, precipitation changes have presented obvious regional trends. On the global scale, precipitation has tended to increase in the high-latitude regions of the northern hemisphere and in the tropical regions, while in the semi-tropical regions, precipitation decreased over the past several decades (IPCC 2007; Dai 2011). In China, drier regions in the northeast have received less precipitation in summer and autumn, while the wetter regions in the south have experienced more rainfall during both summer and winter (Piao *et al*. 2010).

Apart from long-term climate change, the frequency and severity of extreme weather events (e.g., drought and flood) have also increased. Since the 1950s, the

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occurrence of extreme weather events in the world has presented an increased trend, and, on average, the annual economic losses resulting from these events reached US$67 billion (Guha-Sapir *et al*. 2004). The total area suffering from drought throughout the world is forecasted to expand by 15 to 44% by the end of the 21st century (IPCC 2012). In China, the annual average crop area suffering from drought increased from 11.6 to 25.1 million ha, with an increase of 116% from the 1950s to the beginning of this century (Ministry of Water Resources 2010). During the same period, the annual average crop area suffering from flooding increased by more than 50%, from 7.4 to 11.2 million ha.

Importantly, although there is some uncertainty about the long-term impacts of climate change, the potential negative impacts of extreme weather events cannot be ignored. Depending on regional conditions and other factors, long-term climate change may have mixed effects on agriculture. For example, increased temperature has shown to be harmful to rain-fed farms, but beneficial to irrigated farms in China (Wang *et al*. 2009). If the CO_2 fertilization effect could be realized, the negative impacts of climate change on agriculture would become positive (Xiong *et al*. 2009). However, increasingly severe extreme weather events can result in massive socio-economic losses in China. For example, in the past 60 yr, drought caused an annual grain production loss of more than 27 milliont in China (Ministry of Water Resources 2010). In the drought year of 2000, China suffered a loss of 60 million t of its grain harvest, and 28 million people and 22 million heads of livestock had difficulty obtaining drinking water (Ministry of Water Resources 2010). The great flood of 1998 inundated 21 million ha of land and destroyed five million houses in the Yangtze Basin, causing an economic loss of over US$20 billion (Zong and Chen 2000).

Given the risks posed by climate change, the question of how to mitigate the negative impacts has received a great deal of attention from policy makers. The international community has called for incorporating climate change adaptation into national development plans (IPCC 2007; World Bank 2010). This is especially urgent and important for farmers who have been suffering from increasingly extreme events in developing countries (Mendelsohn *et al*. 2006; Seo and Mendelsohn 2008). In recent years, China's government has also given top priority to formulating and implementing adaptation policy (NDRC 2007, 2012). A national plan responding to climate change was issued in 2007, which was followed by a series of publications of white papers on national policies and actions against climate change.

In recent years, exploring suitable adaptation measures has become an important research topic. According to their nature and attributes, adaptation measures can differ along several dimensions such as intent (spontaneous versus planned), timing (reactive, concurrent or anticipatory), duration (short versus long term), spatial extent (localized or widespread), and agent responsibility (e.g., government, producers, etc.) (Bradshaw *et al*. 2004). Smit and Skinner (2002) systematically summarized the major adaptation measures adopted in the agricultural sector. According to their summary, there are several categories of adaptations at the farm level, including the modification of resource management, improving farm management, purchasing crop insurance, and the diversification of production activities. They indicated that diversification has the potential to reduce exposure to climate-related risks and increase the flexibility of farm production to changing climatic conditions.

Even though crop diversification has been recognized as an effective adaptation option for farmers for risk mitigation (Gebrehiwot and van der Veen 2013), little empirical analysis has been conducted to determine how extreme weather events influence farmers' decisions on diversifying their crops. From a literature review, we find that crop diversification has often been examined as a tool to stabilize crop revenue and farm income (Zentner *et al*. 2002; Orindi and Eriksen 2005; Chen 2007). Many scholars have analyzed the influence of farm and farmers' characteristics on crop diversification (Pope and Prescott 1980; Mishra and El-Osta 2002; Culas and Mahendrarajah 2005; McNamara and Weiss 2005). However, to our knowledge, there is little empirical study that has quantified the relationship between the occurrence of extreme weather events and farmers' crop diversification behavior.

Given the severity of extreme weather events and