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Enhancing food security: Food crop portfolio choice in response to climatic risk in India

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ABSTRACT

Food security is highly sensitive to climate risks in rainfed areas, particularly in South Asia where agriculture is highly dependent on rainfall. About 56% of India's land mass is agricultural land, and only 43% is net cultivated area; 60% of India's total cropped area is still rain-fed and therefore dependent on the monsoon. Changes in climatic variables such as rainfall can have an adverse impact on output and income, food prices and human health, and the food security. This study considers the combination of food crop choices as one of the *ex-ante* risk management strategies and examines farm households' food crop portfolio choices as a response to climatic risk in semi-arid tropics of India. Unlike in other countries, intercropping and mixed cropping are prevalent among Indian farmers. Taking this into consideration and data from Indian farms findings show that farmers in semi-arid tropics of India are growing less risky food crop portfolio. Secondly, we find that in the presence of climatic risk, farmers tend to choose less risky crops and as a result less risky food crop portfolios. Finally, in the presence of climatic risk wealthy farmers and farmers with more cash on hand are more likely to choose relatively riskier food crop portfolio.

1. Introduction

Agriculture is sensitive to both short-term changes in weather and to seasonal, annual and longer-term variations in climate. Climatic risk,[1] or variability in weather, is one of the important factors affecting agricultural production and land allocation (Lobell and Field, 2007; Stige et al., 2006; Tao et al., 2008). Heal and Millner (2014) note that climate change and variability has a serious problem that requires immediate attention. Further, Iizumi et al. (2014) discuss the climate variability and climate change have an adverse impact on global food production and food security. Finally, Tadesse et al. (2014) concluded that a reduction in yield and increased variability from extreme weather events is likely to increase the long-term mean and volatility of staple food prices. As a result, weather-induced changes in agriculture affect the food security and the livelihood of farm households[2] because they are likely to affect both farm income received by poor rural farm households and food prices paid by households in general (Burke and Lobell, 2010; Morton, 2007). The impact of climate change on agricultural production can adversely affect global food security in four ways: food availability, food accessibility, food utilization and food system stability. High variation in environmental factors such as temperature and rainfall, for example, can negatively affect crop growth, although certain crops may be positively affected by changes in these environmental factors. Therefore, changes in climatic variables can have a negative impact on output and income, and the food security (Greg et al., 2011).

In a recent study Campbell et al., (2016) note that extensive work addresses the impact of climate change on crop yields, but urgency is needed in dealing with the consequences of climate change on farmers' adaptation strategies. In the anticipation of different degrees of climatic and production risks, rural farm households might choose to diversify their crops by growing less profitable but less risky crops

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[1] In this study variability in rainfall is used as a proxy for climatic risk. Note that several studies have used weather extremes as a proxy for climatic risk (see Gbegbelegbe et al., 2014). The rainfall pattern in South Asia is influenced by large-scale intra-seasonal and inter-annual climate variability.

[2] Most rural households in developing and low-income countries depend, to a significant extent, on agriculture for their livelihood. Additionally, small farm households represent not only a significant proportion of the rural population but also contribute a significant share of the total agricultural output (Mishra et al., 2015).

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(Benin et al., 2004) to hedge risk rather than undertaking investments for higher expected returns. To cope with fluctuating climatic, farm households engage in several risk management strategies. These include food crop choice mix (or crop diversification), off-farm work and weather insurance—available in only a few developing countries. As a self-insurance mechanism, in the presence of pervasive risk, is likely to be taken by farm households.[3]

In a recent review article Iizumi and Ramankutty (2015) argue that climate and weather influence cropping area, intensity and yield in different ways; farmers need to develop strategies to deal with extreme climatic changes. Several studies have discussed the nature of crop riskiness and its relation to climatic and market uncertainties (Lamb, 2002; Haile, 2007). However, previous studies have several limitations. First, most of the studies are based on subjective assessment of the riskiness associated with the crops under study. Second, existing studies deal only with major crops while ignoring the nature of intercropping and mixed cropping. Third, existing studies have failed to include soil information (soil productivity) and food crop portfolio choices. Take the case of India and in particular the rain-fed semi-arid tropics region of India, where water is one of the most limiting resources for crop growth. Rainfall is usually low and highly variable, and crops often are subjected to drought, particularly on light-textured soils with low moisture-holding capacity. Rainfall is one of the key climatic variables that affect both the spatial and temporal patterns of water availability. The farmer's choice of adaptations and adjustments ultimately is influenced by the risk-generating agro-climatic circumstances. Hence, the patterns of farming practices are differentiated on the basis of characteristics of climatic risk. To this end, Indian agriculture thrives on intercropping and mixed cropping (Willey, 1990).

To the best of our knowledge, none of the previous studies has investigated the impact of climatic risk on farmers' food crop portfolio choices[4] in South Asia. There are several differences in the nature of crops grown and in the structure of farms and farm households between sub-Saharan Africa (e.g., Ethiopia)[5] and semi-arid tropical regions in South Asia (e.g., India), which is the focus of this study. For instance, cash crops and crops such as coffee, pulses, oil seeds, teff, and corn are the major components of Ethiopian agriculture. However, in South Asia, and in the sub-tropical region of India in particular, cereal crops such as rice and wheat are staple crops, and the intercropping of legumes and mixed cropping with corn, potato, sugar cane and oil seeds on the same plot are common occurrences. It should be noted that intercropping and mixed cropping are common features of subsistence farming in India. Finally, our empirical analysis includes information on the farm soil type or average soil fertility of the farm. Recall that soil type plays a major role in production agriculture because certain soil types might be suited only for a particular crop.

The objective of this study is twofold. The first is to investigate how food crop choices make up food crop portfolios in rural Indian farm households, based on riskiness. The second is to assess the impact of climatic risk on crop portfolio choices. This study uses farm and household-level panel data for five years 2008–2012) collected by the International Crop Research Institute for Semi-arid Tropics (ICRISAT) from 18 different villages in the semi-arid tropical region of India. Two aspects are important in the household-level crop choice decision. The first is the riskiness of each crop, and the second is the household's management of crop riskiness by choosing appropriate crops in its food crop portfolio. Farmers' responses to climatic risk through adjustments in their food crop portfolios might help in understanding farmers' behavior in mitigating the non-systematic component of risk through crop diversification. Additionally, diversification through food crop portfolios provides insights for both private and public sectors, including policymakers, in designing public policies such as crop insurance programs and in quantifying risk premiums.

2. Background

2.1. Role of weather in Indian agriculture

India – located to the southeast of the Eurasian countries – is a fast-growing country. Its population is growing by 2% a year (the current population is 1.24 billion people). However, about 59% of the population still lives in rural communities, and the majority of rural households are directly dependent on agriculture for their livelihood. Agriculture is an important sector of the economy, which accounts for around 14% of GDP and 11% of the country's exports. Although there has been substantial growth in food grain production, there is also significant variability in weather. Variability in rainfall is regarded as the primary cause of yearly fluctuations in crop yields (Kumar et al., 2014); more relevant when considering food grain production on an aggregate scale. More subtle variations in weather during critical phases of crop development cab also have a substantial impact on crop yields. Additionally, cultivated areas are subject to a broader range of influences, including changes in agricultural commodity prices, costs of input, and availability of irrigation. Finally, climate may have indirect and possibly lagged influences on harvested and cultivated areas (Khanal et al., 2016). Monsoon season (starts in late June or July) and Indian agriculture highly depends on the southwest monsoon. Southwest monsoon is critical to the '*Kharif*' (growing season from June to September) crops, which accounts for more than 50% of the food grain production and more than 65% of the oilseeds production in the country. Variability in southwest monsoon over India has a strong impact on the variability if aggregate Kharif foodgrain production (Gadgil, 1996; Webster et al., 1998). Finally, the '*Rabi*' growing season starts after season summer monsoon season and continues to the following spring or early summer. Note, that rainfall occurring at the end of the monsoon season provides stored soil moisture and irrigation water for '*rabi*' crops, which is seeded post-monsoon season (October-November). Therefore, summer monsoon is responsible for both '*Kharif*' and '*Rabi*' crop production in India. The northeast (winter monsoon) contributes substantial rainfall in much of rainfall in states like Tamil Nadu and Andhra Pradesh, permitting rainfed crop production during '*rabi*' season.

2.2. Crop management—climate a driving factor

The agriculture sector represents 23% of India's Gross Domestic Product (GDP), plays a crucial role in the country's development and continues to occupy a prominent place in the national economy. Additionally, about 59% of the population still lives in rural areas and heavily depends on agriculture for employment and livelihood (Tripathi and Mishra, 2017). Nonetheless, 60% of the total cropped area in India is still rainfed and depends relatively on the uncertainties of monsoon (Kumar et al., (2014). Agriculture is sensitive to short-term changes in climate and to seasonal, annual and longer-term variations in climate.[6] Climatic variability in the sense of inter-season or intra-season fluctuations for agriculturally relevant weather conditions is a major source of instability in farming (Dash and Hunt 2007). However, in subsistence-oriented societies, like India, most of the formal means of combating instability and risk are not readily available. (This might

[3] Previous studies have found that rural farm households in the low-income countries are likely to behave sub-optimally under such risks rather than as profit-maximizing agents (Rosenzweig and Binswanger, 1993; Yesuf and Bluffstone, 2009).

[4] Measured by risk-based crop portfolio index.

[5] Bazabih and Di Falco (2012) study uses Ethiopia data. However, their study differs in several ways from the present study. We will discuss those differences in the literature review section.

[6] Dash and Hunt (2007) concluded that changes in climate for agriculture and effects on human health are likely to be serious and vary significantly across the regions in India.