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The impact of climate change on food crop productivity, food prices and food security in South Asia☆

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ABSTRACT

South Asia has been identified as one of the most vulnerable regions in the world to the impact of climate change. Empirical studies carried out in recent years using the partial equilibrium approach suggest that climate change-induced yield losses in agriculture are becoming a serious concern. In this study, we use a global dynamic computable general equilibrium model to examine the impact of changes in crop productivity due to climate change on food prices and food security in South Asia, focusing on five large countries in the region, namely, Bangladesh, India, Nepal, Pakistan and Sri Lanka. Our results suggest that there is likely to be a significant negative impact on food production and prices in all South Asian countries due to climate change-induced agricultural productivity changes. The results further suggest that countries in this region are likely to face problems of food security given that nearly half of the world's poor reside in this region and agriculture plays an important role in the gross domestic product (GDP) and employment generation in the region. The results support the need for policy analysts and policy makers in the region to develop climate change adaptation measures that address the likely negative consequences of climate change-induced agricultural productivity losses.

1. Introduction

Among researchers in the field of climate change, there is a clear consensus on two key issues. First, global climate change (GCC) is happening and it is occurring at an exceedingly fast rate. The earth's average temperature has increased approximately 0.8 °C since the early 20th century. This global warming has been accompanied, as predicted, by a steady increase in the number and severity of climate-related natural disasters, such as cyclonic storms, floods, droughts, and heatwaves. It is predicted that in the absence of active carbon mitigation, global surface temperatures are likely to rise a further 2.4–6.4 °C by the end of the 21st century (see e.g., Intergovernmental Panel on Climate Change (IPCC), 2007, 2013).

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Second, it has been recognised that agriculture (mainly food production) is heavily dependent on weather and climate. Excessive heat or insufficient water can interrupt crop growth and reduce yields; extreme events, especially floods and droughts, can destroy harvest; climate variation affects irrigation, soil quality and the natural communities that agriculture relies on; and moreover, increase in the sea level as a result of polar ice melting reduces the availability of arable land (Gornall et al., 2010). Therefore, climate change is expected to have an impact on food production, food prices, and potentially threaten food security. Food demand is predicted to increase by around 300% by the year 2080 because of higher population, higher income, and demand for bio-fuel; and this rise is likely to create an imbalance between food supply and demand without the effects of GCC (Cline, 2008, p. 27). If, as expected, there is a decline in food production due to GCC, it is likely that there will be further upward pressure on food prices, multiplying the existing threats to food security (Inter-Agency Standing Committee (IASC), 2010).

The likely negative impact of climate change on agriculture has important implications for developing countries because agriculture is the most important contributor to poverty reduction (Cervantes-Godoy and Dewbre, 2010). The recent experience of the global food crisis in 2007 and 2008 demonstrates that populations in developing countries, which are already food insecure and vulnerable to shortages, are likely to be the most seriously affected in the world as a result of a future food crisis, which is likely to be multiplied by GCC (Nelson et al., 2009).

South Asian countries have been identified as some of the most affected countries by GCC, although their contribution to greenhouse gas emissions has been shown to be low (World Bank, 2013). The World Bank report (2013, p. 106) noted that, "in the past few decades a warming trend has begun to emerge over South Asia, particularly in India, which appears to be consistent with the signal expected from human induced climate change". The observed warming in the region varies significantly between 0.016 °C and 1.0 °C (see Appendix 1, adapted from Sivakumar and Stefanski, 2011, p. 17). In recent decades South Asia has witnessed numerous extreme weather events which are consistent with the predicted effects of GCC (see e.g., Sheikh et al., 2014). For instance, in 1999 a severe cyclonic storm hit coastal areas of Pakistan and India and brought devastation to both countries; during the period 1998–2001 Pakistan faced the country's worst drought; in July 2001 a record of 620 mm of rain fell in Islamabad, Pakistan, causing catastrophic losses to life and property; and during July 2005, 944 mm of rain fell in Mumbai breaking the city's 24-h rainfall record.

Strong evidence further supports the link between productivity in agricultural sectors in South Asia and the increase in extreme weather conditions, such as more extreme and frequent droughts and floods. The World Bank (2010) noted that "domestic food prices have tracked the upsurge in global food prices, exacerbated by droughts" (p. 28). It further notes that erratic monsoon weather conditions in India during 2009 reduced production of the main crops and led to higher food prices in 2009. This Indian food price inflation also spread to several of its neighbours, including Bangladesh, Bhutan, Nepal, and Sri Lanka. Domestic demand in India also increased during this inflationary period and was exacerbated by the El Nino weather pattern in 2009 that brought food shortages due to the increased occurrence of floods. This episode of rising food prices in South Asia provides an excellent case study for demonstrating that the considerable economic vulnerability in South Asia is likely to experience as GCC continues. In addition to the influence of extreme weather patterns and other climate change effects on agriculture, as highlighted by the World Bank (2009), increases in temperature in South Asia have also produced a decline in crop yields.

South Asian countries are expected to remain among the most affected countries by GCC. In some parts of the region, summer temperatures are projected to increase by 3 °C–6 °C at a scenario of 4 °C global warming and by 2 °C at a scenario of 2 °C global warming by 2100 (see World Bank, 2013). If, as expected, food production is heavily disturbed by GCC, this could have severe negative impacts on the South Asian economies due to the crucial role that agriculture plays in the regional economy. Over 70% of people in South Asia (that is, roughly 1.1 billion) live in rural areas dominated by agriculture and these people account for about 75% of the poor in the region (World Bank, 2012, 2013). More importantly, agriculture contributes towards nearly 18% of the region's GDP and employs more than 50% of the population (World Bank, 2013, p. 125).

Although there is clear evidence that South Asia is highly vulnerable to GCC, there have been relatively few detailed studies carried out within a global modelling framework that have examined the effects of climate change on crop productivity in South Asia. For example, Nelson et al. (2009) attempted to assess the impact of climate on global crop production. They found that crop production in South Asia is likely to be severely affected by climate change. Hertel et al. (2010) applied a computable general equilibrium (CGE) model, Global Trade Policy Analysis Project (GTAP), to evaluate the welfare implications of climate-induced crop yield changes on a global scale. They showed that South Asia countries, such as India, Pakistan and Bangladesh, are likely to be negatively impacted with respect to their trade and economic efficiency. Similarly, Laborde (2011) attempted to evaluate an optimal trade policy option for the region in the context of the impact of climate change on agriculture. With the exception of the above studies, most of the published literature focuses on estimating productivity changes for various crops in the five large countries in the region (Bangladesh, India, Nepal, Pakistan and Sri Lanka). This has led to a dearth of comprehensive studies that have investigated crop productivity in these countries in the region.

Therefore, the main purpose of this paper is to examine the impact of climate change-induced productivity changes in food crops, focusing on food prices and food security in the five large South Asian countries. The rest of the paper is organised as follows: the next section provides an overview on the topic focusing on changes in productivity in food crop sectors in the region with the purpose of preparing reasonable and realistic productivity shocks to be introduced to a dynamic computable general equilibrium model, known as GDyn. Section 3 briefly outlines the dynamic modelling framework used in the study, and Section 4 discusses the results of productivity simulations. Section 5 of the paper will provide some concluding remarks.

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