Economic Tools and Methods for the Analysis of Global Change Impacts on Agriculture and Food Security

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Introduction

Eras of rapid shifts in agriculture have been recorded throughout history. Some of them have been caused by the development of new techniques, tools or species, or simply by shifts in demand patterns. Other disruptive forces have a natural origin, such as large-scale volcano eruptions or non-anthropogenic climate change. Yet the present era is facing a series of changes that will not only affect agriculture but many other aspects of human life. Among them, anthropogenic climate change has attracted great attention. A consensus has been formed over the forecast that greenhouse gas emissions will affect climate patterns at a global level. Some of these changes have already been reported.

Agriculture is, at different levels, sensitive to climate. This implies that most of the expected impacts of climate change will directly affect agriculture and, therefore, food security. Changes in temperatures are probably the impacts most often associated with climate change and would directly affect agriculture, just as potential changes in precipitation patterns particularly. Both impacts would influence water availability and, therefore, agriculture. Precipitation patterns are expected to turn many agricultural areas drier overall but with more concentrated rainfall. Many plant species could be affected by this. Moreover, concentrated rainfall patterns could accelerate soil erosion, also affecting plantations. Temperatures are expected to increase due to the greenhouse effect. This would increase water evaporation, reducing the amount to be collected by plants.

Climate-related extreme events could also affect crops. Events such as floods, draught or frosts can damage crops by directly affecting them and seriously damaging production, or in a more indirect way, such as the aforementioned case of soil erosion caused by flooding events. Yet different regions' agriculture will benefit from climate change. Areas too cold to provide adequate environment to several crops will likely offer an improved context for plant species developed in different geographical contexts. This effect will hardly compensate for the losses caused in agricultural systems in other parts of the world, which could affect sectors highly dependent on agriculture, such as cotton and biofuels. Probably most important, these impacts could have a direct effect over food security. Recent projections

estimate that global wheat production could be reduced between a 4.1 and a 6.4% by a temperature increase of 1° (Liu et al. 2016).

Food security, which following definitions used by FAO (2007, 2008), could be associated with the capacity of all members of society which are either able to obtain food on their own means or are able to rely on social networks to ensure their access to adequate food supply, i.e. food able to provide the necessary nutrients for a lifestyle. In 2017, 52 countries were considered to have at least "serious" levels of hunger according to the Global Hunger Index (Von Grebmer et al. 2017). While most of the recent history has witnessed mostly decreasing hunger levels, the situation may worsen if agricultural output is affected by changing climatic conditions in the long term.

Unequal distribution of resources is a matter closely related to both climate change and food security. Research on climate change draws a map where poorer countries could bear the heavier burden of impacts. This has several implications. First, that poorer farmers will suffer more from climate change. Second, that farmers situated in poorer countries will be able to receive social support from their state or communities. Third, that migratory movements might be necessary in order to reallocate farmers no longer able to reach survival rates. Last, and taking into account, that poorer regions are often the most unequal, and it can be deduced that inequalities will grow both within and throughout national borders. Hunger and poverty have an intuitively strong correlation, both at the micro- and macro-levels, though poor individuals in rich countries often have secured an access to food supplies ensured by the state.

The present book addresses these matters by providing a series of tools aimed at improving the capacity of agriculture systems to optimise their performance under meteorological and climatological uncertainties.

Content is structured into two parts: *Microeconomic Modelling: Risk management, Adaptation Measures and Stake-Holders' Perception and Macroeconomic* and *Complexity Modelling: Global Challenges and Multi-agent Interactions in Mitigation and Adaptation Policy Analysis*.

Part I opens by describing the methodologies carried out in the context of Spain with the aim of studying different policy scenarios' impacts over production, efficiency and distribution. The second study, Chap. 2, uses species distribution models to assess changes in the Nicaraguan agrarian system. Chapter 3 uses a Ricardian approach to study inequality and poverty in rural Mexico. Next, Chap. 4 describes cost-loss approaches towards valuating weather information in agriculture. Ending this first section, Chap. 5 goes into the topic of participatory approaches developed for Sub-Saharan Africa, in order to analyse behaviour in adaptive strategies.

The first chapter of Part II, Chap. 6, uses computable general equilibrium (CGE) models focused towards policy analysis in Spain. Similarly, the analysis taken in Chap. 7 is based in CGE, which is applied in this case to the study of the impacts that an extended draught could cause in Mexico. Following this, Chap. 8 deals with the potential costs and benefits of adaptation, by describing a series of studies performed at varying scales and depicting their methodologies. Chapter 9

compares two methodologies, statistical and simulation models, studying impacts of climate change over Tanzanian agricultural output. Finally, Chap. 10 addresses the Nicaraguan case in order to design a tool for prioritising efforts in adaptation to climate change.

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