Introduction

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CLIMATE CHANGE, AGRICULTURE, FOOD DEMAND AND LAND USE

Interactions between agriculture, climate and patterns of land use are complex. Agriculture is a major user of the land, and patterns of land use are shaped through climatic conditions. The characteristics of agriculture in any location are largely determined by climatic factors. Evidence is amassing that increases in atmospheric concentrations of greenhouse gasses (GHG) like carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) cause increases in global temperature. The Intergovernmental Panel on Climate Change (IPCC) projects that the build-up of atmospheric GHGs will cause a moderate increase in temperature and altered patterns of precipitation are projected for large parts of the world. Accompanying changes in agricultural productivity are to be expected. In addition agriculture may play a role in managing the future GHG concentrations by switching land use from crops to forests, trees or biofuels and by managing energy use, rice lands, cattle and manures among other things. Thus agriculture is affected by both sides of the climate change issue and will feel influences on production patterns and land use.

There is an ongoing dialogue about agriculture as potentially manipulatable source or sink of greenhouse gas emissions. Major changes in agriculture, regional climate and land use patterns are foreseen in the next couple of decades. Society needs to be prepared to implement measures that contribute to transform agriculture in an environmentally effective, economically viable and socially acceptable manner.

Food demand will also influence future patterns of land use. Global population is projected to increase to about 9 billion by 2050. Global income per capita is likely to increase by a factor of three and more by 2050, and the share of animal calories in diet is projected to increase from about 15% today to about a third in 2050. Such changes increase the demand for food and put pressures on the available land resources.

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Experience is needed based on cross-disciplinary science and policy-science interactions to explore the way land use may aid in addressing the climate change and food demand influenced future.

KEY OBJECTIVES AND ORGANISATION OF THE BOOK

The objective of the book is threefold:

- establish linkages between land use and climate change;
- establish linkages between land use and greenhouse gas emissions control; and
- explore linkages with future patterns of food demand.

The perspective of the book is beyond the year 2015. The individual contributions draw on the experiences from cross-disciplinary approaches, and the interactions between policy and science. In this approach, the volume aims to identify existing gaps in scientific understanding. The book is divided into 4 parts.

Part 1 sets the scene and provides an overview of the key issues addressed in this book. The main interrelations between climate and societal factors as the influence land use change are explored. Chapter 2, by Peter Verburg and Jan Peter Lesschen, provides a discussion of different modelling approaches and the main challenges that are faced in exploring the interactions between land use policies, agriculture and the environment. A wide range of models of land use change is available. The authors argue in favour of a strong involvement of policy makers in the land use modelling process. Also, models could strongly support policy formulation. Chapter 3 identifies and explores important drivers and relationships of agricultural land use change under alternative scenarios of future development. Frank Ewert and his co-authors address linkages at the European scale between land use and agricultural productivity as affected by technological advances, climate change and atmospheric CO_2 concentrations. Agricultural land use changes are particularly sensitive to economic development, and technology development is a strong driver of productivity and land use change. Chapter 4, by Helmut Geist and his co-authors, aims to strengthen our understanding of the main driving forces, key actors and processes of agricultural change and land use patterns. The variety of key factors influencing land use transitions at the forest and dryland margins is explored. Also, a method is proposed for assessing the trade-offs and to draw implications for land use policies.

Part 2 looks at future forces shaping land use decisions and its sensitivity to climate change related issues. Chapter 5 offers an assessment of agricultural production systems in the coming decades and their implications for emissions of greenhouse gases. Lex Bouwman and his colleagues project a strong increase of global methane emissions, mainly in developing countries. Also, the projected concentration of agricultural activities will induce a further intensification of production. Chapter 6 examines main trends in agricultural land use in Central America over the past couple of decades, and how they point in the coming decades to changes in production patterns, patterns of agricultural land and forest

cover. In this chapter, David Carr and his co-authors, notify strong intensification of agricultural production. Regional production to meet the demands of a growing population and international markets requires focus on sustainable development strategies. Such strategies require coping sustainability in agriculture and the trade-offs between intensification of labour, land and capital with extensification and reduction of forest cover. Chapter 7, by Hermann Lotze-Campen and his co-authors, puts agriculture as a crucial link between human society and the biosphere. In order to understand their interactions, they argue that an in-depth understanding of the links between food (both production and consumption), land use and climate change is indispensable. A grid-based global vegetation model is coupled with a non-spatial economic optimisation model, and applied for Germany. Neeraj Sharma, in Chapter 8, presents a perspective on the challenges that India faces in terms of population and economic growth. Here, land use patterns are likely to be decided by these factors in the coming decades.

Part 3 explores patterns of land use and the agricultural role in climate change mitigation. Edward Smeets and his co-authors, in Chapter 9, offer a methodology of global technical bioenergy production potential in 2050. A bottom-up approach is adopted and some results are presented as well. They conclude that the technical potential to increase crop yields and increase efficiency of animal production is sufficiently large to meet food demand and reduce the area needed for food production. Climate change mitigation policies promoting the production and use of bioenergy can have a major impact on global land use. The largest bioenergy potential comes from developing countries (e.g. sub-Saharan Africa, the Caribbean and Latin America). Chapter 10, by Harry Aiking and his co-authors, explore the land use implications of a transition from the consumption of meat to Novel Protein Foods (NPFs). The acceptance by the consumers is a crucial factor for a successful implementation. A switch to more NPFs by the wealthy part of society would be insufficient to overcome the projected increasing demand of meat in developing countries. NPFs could only offer a partial solution for reducing emissions to the environment. New tools are made operational in Chapter 11, to measure progress and identify indicators describing the process of change. Jan Ros and his co-authors, identify some options to reduce greenhouse gas emissions over time. They focus on agriculture in the fan meadow areas, food production and consumption, biomass and greenhouse production as a supply source of energy. The options are explored in close consultation with stakeholders and the conflicting viewpoints in society are addressed. Sanderine Nonhebel, in Chapter 12, identifies options to reduce emissions related to the production and consumption of food. The chain from food production to the consumer offers largest potential to decrease greenhouse gas emissions. However, a shift to organic production may increase emissions of CH_4 and N_2O. She also highlighted the reduction potential associated with intensive production methods relative to extensive production methods adopted with the production of milk. Chapter 13, by Heng-Chi Lee et al., explore management and land use practices to reduce greenhouse gas emissions in the agriculture and forestry sectors that offset fossil fuel emissions and enhance carbon sequestration. They argue that agricultural and forest carbon sequestration provides more time to find long-term technological solutions that halt the increasing ambient greenhouse gas concentrations. Also, power plant feedstock

biofuels are likely to be an important long-term strategy under high greenhouse gas emission prices. Marie Boehm and her co-authors, in Chapter 14, explore possible changes in agriculture over the next decades. Farmers will still have to adapt to climate change. Innovation and experimentation at the farm level would be important to move from understanding to action. Management for mitigation and adaptation includes good land management, conservation of resources as well as careful management of the carbon and nitrogen cycles.

Finally, part 4 identifies policy and social responses to the new perspectives on future land use patterns. Wilfrid Legg, in Chapter 15, concentrates on the policy efforts to enhance the environmental dimension of sustainable agriculture in cost effective and efficient ways. He argues too little is yet known on the cause-effect linkages between policy measures and environmental outcomes. However, the policies may have been effective, but there have been trade-offs and in some case even inefficiencies. Murry Fulton and co-authors - in Chapter 16 - focus on institutional and organizational changes needed over the next 50-75 years to manage greenhouse gas emissions. The ability of the agricultural sector to respond to the new environment will depend on the new technologies that are developed, the institutional structures that are in place, and the manner in which the sector is organized. Finally, Chapter 17 reviews the different performance standards that are currently being used to evaluate a farmer's impact on the environment. Also, the appropriateness of legal rules for greenhouse gas mitigation in agriculture is evaluated. Patricia Farnese, in this Chapter, argues that it is desirable to adopt a range of policies aimed at bringing about the same outcome to ensure that farmers fully understand the performance standard they must satisfy in order to avoid liability.