Climate Change and Agriculture: from Challenges to Solutions

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1. Introduction

Land is the subject of increasing tension between objectives critical for the sustainable future of the planet: i) providing food, fibre and bioenergy, ii) conserving biodiversity and ecosystem services; and iii) contributing to climate-change mitigation. The debate over future paths for food, fibre and bioenergy production is complicated by increasing anthropogenic pressures, directly but also indirectly *via* climate change and its implications for food security, biogeochemical cycles, biodiversity and land-based production systems. Land-based food production will have to meet the nutritional demands of a global population that is projected to grow to at least 9 and potentially 11 billion by 2100. Food and nutritional security is a central element of the UN Sustainable Development Goals[i] adopted in 2015. Future socioeconomic and demographic changes are projected to increase the global demand for crops and livestock by 60-110% by 2050 fuelling a projected 50% increase in water demand and environmental impacts through land conversion, loss of natural habitats and increased use of fertilizers and pesticides. At the same time, land-based activities are major sources and sinks of greenhouse gases (GHGs). The agriculture sector is already affected by climate change, with significant global negative impacts on wheat and maize yields being observed over the last decades. The global food systems would be severely threatened under high-end global warming scenarios.

2. Exploring solutions

Emphasis has recently been put on solutions based on reinforcing ecosystem services as part of climate-change adaptation and mitigation strategies (e.g., reforestation or afforestation), including in agricultural systems (e.g. soil carbon sequestration and climate smart agriculture), but the contributions of these solutions to resolving tensions on land management at multiple scales is not well quantified. Land-based 'solutions' could bring a strong contribution to reduce GHG emissions and increase ecosystem carbon storage as necessary conditions to meet the climate targets that the international community has set at the Paris Agreement on climate change[ii] of the UN Framework Convention on Climate Change (UNFCCC). These solutions include a massive use of bioenergy coupled with carbon capture and storage (BECCS), large-scale afforestation, and soil carbon sequestration (4 per 1000 initiative: soils for food security and climate[iii]).

In addition to the sheer complexity of the processes involved, a major difficulty in articulating the different objectives of food, fibre, bioenergy provision, biodiversity enhancement and climate-change mitigation is that the 'solutions' relevant to each objective tend to be designed and analysed in separate scientific and policy communities. For example, the Integrated Assessment Models used for IPCC scenarios, which point to BECCS as critical for meeting a 2°C climate target, are based on rather coarse insights about food systems, let alone biodiversity.

The agriculture, forestry and land use sector contributes to 24% of global anthropogenic greenhouse gas (GHG) emissions, with livestock alone estimated to contribute about 14.5% of total human induced emissions when a supply chain approach is considered. Globally, GHG emissions from agriculture could be reduced by 20-30% if less efficient producers would adopt the best practices of their peers, in the same production system and region. Technologies and practices that help reduce emissions exist but are not yet widely used. Those that improve efficiency and plant and animal health also have productivity co-benefits. In addition, the agriculture sector could benefit from carbon offset programs that represent potential additional income for farmers.

Forward-looking scenarios of plausible agricultural sector developments were developed based on the new IPCC scenario framework (Shared Socioeconomic Pathways, SSPs). The results in terms of agricultural market developments, land and water use, and GHG emissions going until 2050 highlight the role that demand driven and supply driven changes in the sector could play both for greenhouse gas mitigation and for adaptation to climate change.

To ensure global food and nutritional security, several targets should be reached simultaneously: sustainably increasing production without expanding agricultural land, increasing resilience to climatic hazards while reducing GHG emissions intensity, providing nutritious food and enhancing a stable access to food for all. Moreover, this will need to be achieved in the face of increased demands of land, bioenergy and water from other sectors. By adopting in each region best available practices, GHG emissions from the agricultural sector could be reduced by about 20%. The technical mitigation potential of agriculture by 2030 is estimated at almost six billion tons of CO_2 equivalents per year and there would be an equivalent potential from reductions in food wastes and losses and from transitions towards healthier diets. Increasing global top soil organic matter at a rate of 4 per 1000 each year would allow for a doubling of the current land carbon sink, with mostly positive impacts on soil fertility and on land resilience to climatic hazards.

To make further progress, a reduced complexity (AgRIPE, Agricultural Representative Identities and Pathways of Emission) model has been developed, calibrated over 1961-2010, and tested for assessing the solution space providing global food security and GHG mitigation compatible with the 2°C global warming target. First results will be presented showing evidence that 6 options (GHG emission abatement, soil carbon sequestration, yield increases, livestock efficiency gains, changes in diets, reductions in food wastes) need to be combined in variable ways depending upon the SSP, dietary trends, demands on bioenergy, climate change and land degradation impacts on yields and soil carbon. In particular, a strong agricultural soil carbon sequestration is always necessary to keep agricultural emissions in line with the 2°C global warming target.

3. Conclusions

Climate change and the rise in atmospheric CO_2 will reorganize food systems and alter agricultural productivity, with impacts on food security, land use and greenhouse gas emissions, as well as biodiversity and ecosystem services. Understanding the solution space for global food systems under climate change during the course of this century is a critical challenge that needs to be increasingly researched to reduce uncertainties and provide policy targets both at global and at regional scales.

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[i] http://www.un.org/sustainabledevelopment/sustainable-development-goals/
[ii] https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf
[iii] http://newsroom.unfccc.int/lpaa/agriculture/join-the-41000-initiative-soils-for-food-security-and-climate