Setting the agenda

Climate change adaptation and mitigation for food systems in the developing world

Working Paper No. 29

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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CLIMATE CHANGE AGRICULTURE AND FOOD SECURITY

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Abstract

New agricultural development pathways are required to meet climate change adaptation and mitigation needs in the food systems of low-income countries. A research and policy agenda is provided to indicate where innovation and new knowledge are needed. Adaptation requires identifying suitable crop varieties and livestock breeds, as well as building resilient farming and natural resources systems, institutions for famine and crop failure relief, and mechanisms for rapid learning by farmers. Mitigation requires transitioning to 'low climate impact' agriculture that reduces emissions while achieving food security, economic well-being and sustainability. Efficient interventions, incentives for large-scale shifts in practices, and monitoring systems are required. Integrated assessments of adaptation and mitigation are needed to better understand the synergies and trade-offs among outcomes.

Keywords

Climate change; agriculture; adaptation; mitigation; research.

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Introduction

Recent analysis indicates that global food systems are failing and need a radical redesign to meet the needs of future population (Godfray et al. 2011, Foresight 2011). Climate change requires that food systems both adapt to new climates and mitigate impacts on the climate. Yet low-income countries also need to increase food production and meet economic development goals, and to do so in sustainable ways. To work towards these multiple goals, new knowledge and policy will be necessary to support innovation, identify feasible options, and monitor impacts. Toward this end, we provide a research and policy agenda for agriculture and climate change in developing countries, produced collaboratively by the climate change and agricultural development scientific communities. The agenda reflects priorities for achieving climate change mitigation and adaptation as well as current gaps in knowledge.[1]

Adaptation policy and research needs

Adapting farming systems to a variable and changing climate is already a necessity for many farmers in developing countries. Climate change scenarios to 2030 and beyond indicate that agricultural production will decrease and become more variable, especially in the tropics and subtropics (Lobell et al. 2008, Funk and Brown 2099). Sub-Saharan Africa is especially vulnerable due to the range of projected impacts, multiple stresses and low adaptive capacity (IPCC 2007, Ericksen et al. 2011). Agricultural adaptation will require resilient farming systems (Reynolds and Ortiz 2010). The following paragraphs outline the priority actions and specific research needs to support adaptation.

Vulnerable farming systems: Better modelling is needed to show how climate change will affect farming to identify vulnerable populations. Improvements should include better

1 The priorities identified here are based on the outcomes of a meeting of the Climate Change, Agriculture and Food Security Research Program (CCAFS) of the Consultative Group for International Agricultural Research (CGIAR) and Earth Systems Science Partnership (ESSP), held 4-6 December, 2010, in Playa del Carmen, Mexico. The participants in this workshop represent major scientific programs in climate change from the Earth System Science Partnership and the CGIAR. This summary can therefore be considered a synthesis of current thinking on climate change research priorities in agriculture.

predictions on seasonal to decadal scales, use of suites of models to capture uncertainty, testing the sensitivity of different farming systems and understanding the interactions between climate and other drivers affecting farm productivity (Ericksen et al. 2011). Policy makers will need new tools and decision-making frameworks to assess the implications of vulnerability and target areas for intervention. Understanding the conditions of vulnerable farmers provides the context necessary for developing further options.

Crop varieties and livestock: Adapted farming systems will require use of crop varieties and livestock breeds better suited to predicted future climates and uncertainty. Assessing the capacity of existing crops and livestock to adapt to these conditions will be as important as developing new varieties and breeds. Specific crops traits such as resistance to heat and cold, or climate extremes such as droughts and floods, will be needed in many places. Developing new strategies to breed to cope with uncertainty and rapid change and help farmers access adapted varieties or breeds will increase farmers' options (Fedoroff 2010, Delmer 2005, Wassmann et al. 2009a,b, McCartney and Smakhtin 2010). Harmonizing national seed laws and regulations to allow regions to share varieties will support more rapid and efficient adaptation (Langyinto et al. 2010). Analysis of intellectual property rights and technology transfer would help guide the design of more adaptive policies.

Resilient crop and natural resource management systems and livelihood strategies: Research also is needed on how management practices can best cushion the impacts of the changing climate and sustain the natural resource base. Crops will be less resilient where soils are degraded and no longer have adequate water-holding capacity to buffer against drought and heat stress. Management practices can reduce climate impacts by, for example, conserving rainwater, managing floods or buffering temperatures (Hobbs and Govaerts 2010). Improving the resolution of spatial models to better link weather forecasting and climate modelling should provide better information for both breeding and management.

Adapted farming systems will be insufficient, however, if not supported by ecologically and economically resilient household livelihood strategies and larger economies (Hobbs and Govaerts 2010). A better understanding is needed of the roles of agroecosystem and livelihood diversity in adaptation, the coping mechanisms of the rural poor, and the impacts of enabling conditions such as health and education services, infrastructure for agricultural inputs and markets, food and fuel prices or trade policies.

Adaptive institutions: Assuming that some crop or livestock failure is inevitable, research on effective micro-insurance and micro-finance mechanisms and indicators to anticipate famines and inform relief efforts will be important. In some areas rural employment schemes and guaranteed access to food will be desirable, so understanding how to make these systems accessible and efficient should be a priority.

Learning and knowledge dissemination: Given the time lag between the development, dissemination and adoption of interventions, mechanisms will be required to support farmers' learning and adaptation. Adaptation options are frequently information intensive (e.g. seasonal forecasts), both for farmers and information providers. Improved capacity and institutional arrangements for rapid learning and collaboration among farmers and the institutions supporting them will be needed (Armitage et al. 2009).

Summary of adaptation policy and research needs

- Identify the most vulnerable farming systems and the conditions that vulnerable farmers face;
- Identify and develop crop varieties and livestock breeds suited to an array of future climates and vulnerable populations' needs;
- Improve crop and natural resource management systems to increase the resilience and sustainability of food production and livelihood strategies;
- Strengthen institutions that help farmers cope with crop failure or famine through, for example, improved climate information, advance famine warning systems, or insurance mechanisms linked to climate; and
- Enhance mechanisms for farmers' rapid learning and access to the knowledge and material associated with adaptation.

Mitigation policy and research needs

Agriculture and associated land use change contribute about one-third of global anthropogenic emissions, and emissions from agriculture are expected to increase most rapidly in developing countries (Smith et al. 2007, Lambin and Geist 2006).[2] Unacceptable levels of climate change are likely to continue if agricultural emissions are not reduced (Wyn Jones et al. 2010). Yet developing countries cannot compromise food security and economic development. The following paragraphs outline the priority actions and specific research that can balance these multiple aims.

Scaling low climate impact agriculture: From a policy perspective, it will be necessary to identify 'low climate impact' development pathways (development options that minimize the increase of emissions) to meet a balance of multiple objectives, including food security, rural development, energy production, management of forested and degraded landscapes, and adaptation to climate change. Scenarios of different agricultural pathways should be tested to identify how to minimize climate impacts while meeting other aims.

High impact agricultural mitigation options: To make technical decisions, basic data on the feasibility and impacts of on-farm mitigation options are necessary (Mann et al. 2009, Mosier et al. 2004). Research should explore how to improve management practices, crops, and livestock to minimize emissions per unit yield and reduce the expansion of agriculture into carbon-rich forests and grasslands (Burney et al. 2010, DeFries and Rosenzweig 2010). Accounting for emissions from all greenhouse gas emissions (carbon dioxide, methane, and nitrous oxide) will be needed to assess interactions among practices and reduce leakage.

Economic analysis will support investment and policy by showing which aspects of agriculture (e.g., fertilizer management, soil carbon sequestration, agroforestry, livestock management, water management, fossil fuel use) and regions of the world provide the largest net benefits. Analysis across the forest, agriculture, and aquaculture sectors should guide where mitigation can have the biggest impact.

[2] Global agricultural emissions are 5.1-6.1 gigatons $CO_2e\ yr^{-1}$, and the economically viable potential for mitigation at future carbon prices of USD 20-100 is estimated to be ~1500-4300 megatons $CO_2e\ yr^{-1}$ (Smith et al. 2008)

Incentives and institutions for low climate impact agriculture: Smallholder farmers will need incentives and institutional support to adopt mitigation practices, especially to overcome high establishment and transaction costs (De Pinto et al. 2010, Shames et al. 2011). Identifying practices that provide direct gains to farmers will be more sustainable and attractive. For example, improved fertilizer efficiency improves yields and reduces emissions (Norse et al. 2011). Alternative incentive arrangements should be explored, including payments for ecological services, policy compliance mechanisms, and technical assistance and quality control requirements in food supply chains (Herrero et al 2010). Mitigation costs can be reduced by increasing the efficiency of financial incentives by, for example, tailoring the size of payments according to the characteristics of the target group, providing incentives to larger groups of farmers, or bundling ecological services to reduce transaction costs. Testing the impacts of mitigation on food security and household wellbeing should be a priority, and trade-offs such as the impacts of afforestation on water resources should be assessed (Perez et al. 2007). Understanding who benefits and who loses from mitigation, and how to align mitigation with livelihood needs, will inform how to improve impacts for smallholders (Boyd et al. 2007, Tschakert 2007). Testing safeguards such as participation requirements or financial buffers will be important to enable poor farmers—including women—to benefit.

Low cost MRV protocols: Better emissions baselines and estimates of mitigation potentials can guide policy. Improved data about farming activities (e.g., number of livestock, amount of fertilizer used, area of land use, burning practices) are needed to support this analysis (Brown et al. 2011). Low-cost, comparable protocols and tools for greenhouse gas MRV are needed. This will require building data management infrastructure, strengthening capacities, and building better links between the global climate science community and practitioners.

Summary of mitigation policy and research needs

- Identify low climate impact pathways through improved management of agricultural emissions and carbon sequestration on farmers' fields at significant scales;
- Invest in mitigation interventions that will have the largest impact in agriculture and across landscapes and food systems;
- Develop incentives and institutional arrangements for the transition to a 'low climate impact' agriculture that balances multiple needs; and
- Develop simple, low cost protocols and tools for measurement, reporting, and verification (MRV).

Managing outcomes

Synergies and trade-offs among food security, net emissions, and livelihoods

Developing climate-resilient food systems in developing nations requires integrative assessment to understand better the synergies and trade-offs among desirable outcomes. This will require tools and decision-support frameworks. Tracking the drivers of regional food supply and demand, including population growth, increased income, rural-urban migration, growing preference for fish, meat and dairy, and modernization and concentration of food industries will show where interventions may be useful. Understanding the emergent properties of these impacts at different scales will be needed to understand trade-offs across scales, such as meeting national needs for biodiversity, but local needs for food. Measuring outcomes will require multi-scale indicators to capture effects on farms, households, communities and food systems.

Adaptation and mitigation measures in agriculture should be synergistic whenever possible. Understanding where synergies are possible can guide policy. Many adaptation measures have positive impacts on mitigation by diversifying systems, improving nitrogen and water use efficiencies, or improving soil carbon storage (Smith and Olesen 2010, Wassmann et al.

2009b, McCartney and Smakhtin 2010). Trees on farms, for example, diversify products, improve ecological functions of soils and sequester carbon (Verchot et al. 2007), although competition for nutrients and water must be managed. Understanding farmers' perspectives on feasibility and trade-offs of options, in addition to other constraints and opportunities, can help indicate expected local impacts and implementability.

Not all adaptation is synergistic with mitigation, however; increasing agricultural production often increases total emissions. Current trends in many developing countries are towards more intensive livestock management and increased fertiliser use. Identifying sustainable approaches to agricultural intensification and better managing the linkages between agricultural land, forests, degraded areas and water systems can support environmental health and the sustainability of agricultural inputs (Tilman et al. 2002). Where agriculture increases emissions, approaches for offsetting the new emissions through carbon sequestration in the soil or above ground biomass should be explored. Analysis should identify how to improve adaptive capacities for food, energy and water across landscapes and regions in ways that reduce net emissions and provide food security in the long run. For example, should biomass residues be used to feed livestock, increase soil organic matter or generate energy? Understanding and improving governance mechanisms from the international to local level can indicate how to support fair and just decisions about these trade-offs.

Conclusions

Adapting food systems and reducing their impact on the climate will be a necessity in the coming decades. New agricultural development pathways are needed to minimize impacts on climate change, as well as achieve increased food security, economic development and environmental sustainability. In this paper we have identified priorities for action and research to support development of these new pathways (Figure 1). Many countries are already actively seeking ways to achieve the multiple aims required of future food systems. As part of an agenda to address climate change, Mexico is actively promoting conservation agriculture, Niger is supporting expansion of agroforestry, and Ghana is exploring how to manage cocoa intensification to reduce pressure on carbon rich forests.

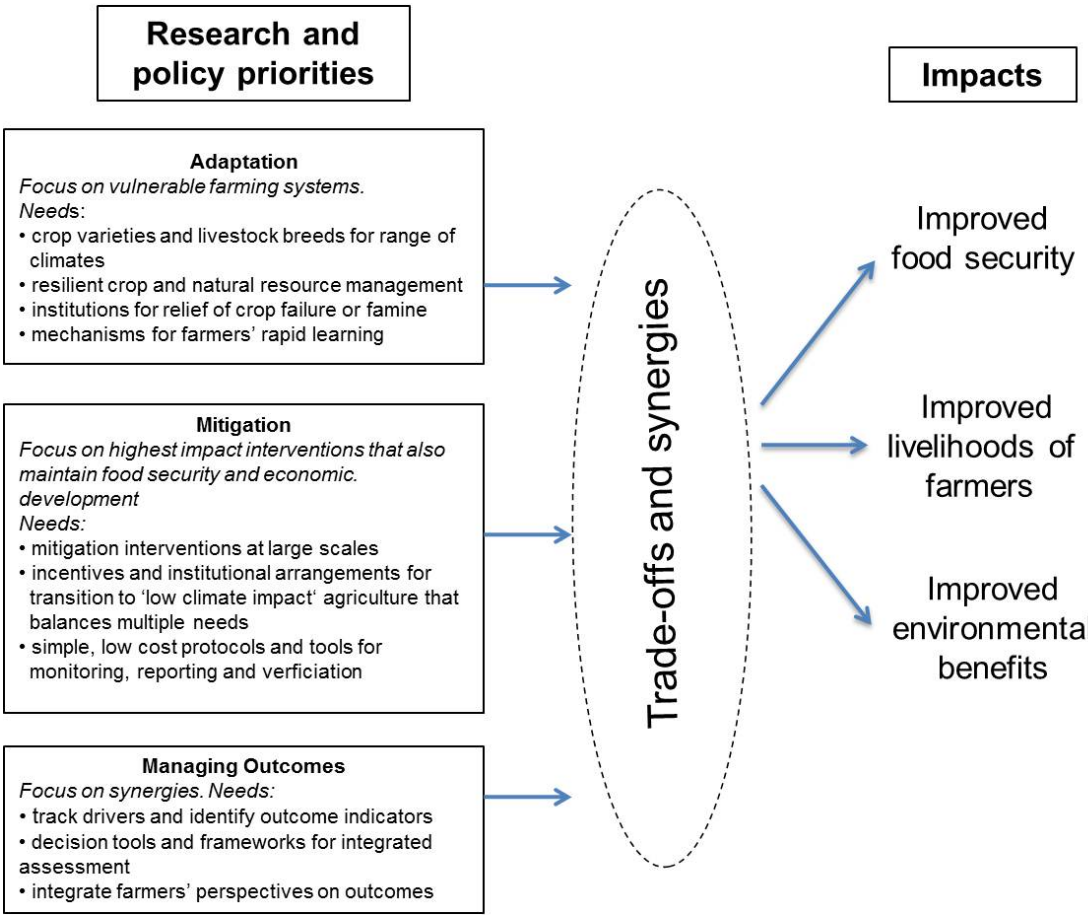

Figure 1 Research and policy priorities for climate change adaptation and mitigation in agriculture

International action needed

- Allocate fast-track financing to support capacity building and action toward agricultural adaptation and mitigation,
- Include food security in international climate agreements
- Ensure that REDD+ and other forest conservation efforts address agricultural drivers and support sustainable, low climate impact agricultural strategies
- Include agriculture and landscape approaches in mitigation finance mechanisms, such as the Clean Development Mechanism
- Create safeguards to rural livelihoods and food security, and
- Represent the interests of smallholder farmers and low-income countries in decisions about agricultural climate change adaptation and mitigation.

To move forward, national policy and research will be essential, and must be complemented by international action. Prioritizing research, national policy, and international governance for climate change adaptation and mitigation will support the necessary transition to a resilient, climate-friendly food system capable of meeting the long-term food needs of the developing world.

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