Food security under a changing climate

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Introduction

Human beings have learned to live with climate variability on various timescales, from daily to decadal. However, the climate variability we are accustomed to is changing quickly, accompanied by a rise in global mean temperature due to increasing greenhouse-gas concentrations in the atmosphere. The poor in developing countries who already have difficulties in coping with current climate variability will be even more vulnerable. They are the ones who contribute the least to emissions of greenhouse gases, yet need to learn to cope with changing climate with few financial or technical resources.

This article first discusses the multiple aspects of food security in the light of climate change. The next part looks at impacts on crop production at different spatial scales. Adaptation to climate variability is most urgent for food security of smallholders, while climate prediction and longer-term climate-change-impact assessments constitute the basis for adaptation measures. This is discussed with an example of a study in Morocco and a focus on use of climate prediction and information. The article concludes with a discussion on adaptation and mitigation measures that are often mutually supportive in the agriculture sector.

Food security and climate change

Climate change affects livelihoods of poor and rich alike by impacting basic human needs, including food, clothing and shelter requirements. The four components of food security—food availability, food access, food utilization and food production system stability—are the heart of the mandate of the Food and Agriculture Organization of the United Nations (FAO). All four components are affected by climate (FAO, 2008(a)) but food availability is most intimately associated with climate and its changes, from crops to animal products, marine and aquaculture products and wood and non-wood products from forests. Even when production is sufficient, if a system of food allocation, whether it is through market or not, is negatively affected, food access is impaired and food security is compromised. Urbanization is rapidly taking place in many countries of the world, creating a category of urban poor who do not themselves farm and are very vulnerable to climate change.

Projections of increased pests and diseases due to climate change have an important implication for nutrition. New risks will affect crops, livestock, fish and humans. When human health is compromised, particularly that of women who prepare foods for household members, the capacity to utilize food effectively is dramatically lowered. Food safety may also be compromised with degraded hygiene in preparing food under limited freshwater availability or food-storage ability due to warmer climate. Malnutrition may also increase, due to shrinking food biodiversity and excessive dependence on a few staple foods.

The changes in climate variability have a direct implication on food production system stability. Increased frequency and intensity of extreme events such as drought and flood would be a great threat to stability, whether the impact is domestic or through the global food market. The frequency and magnitude of food emergencies might increase, resulting from complex interrelations between political conflicts and migration in a context of increased competition for limited resources.

Global impacts on potential agricultural production

Food availability and agricultural production under climate change are discussed in Chapter 5 “Food, fibre and forest products” of the second volume of the Fourth Assessment

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Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) and a number of other studies that have been published since then (e.g. Cline, 2007; Lobell et al., 2008).

In general, crop yields will increase in cold areas where low temperature currently limits crop growth. On the other hand, heat stress on crop and water availability will lead to a decrease in yields in warm environments. Globally, food production may increase but a net negative impact is expected if night temperatures increase and averages rise by more than a few degrees Celsius.

In addition to the potential negative impact on global food production, there is pressure from the projected increase in population in most developing countries. This is illustrated in a plot of net primary production of biomass, a biophysical indicator of potential agricultural production, from a recent FAO study which produced a typology of vulnerable countries to climate change (Figure 1). Net primary production per capita in 2030 was calculated from temperature, precipitation and population projections. From purely biophysical, geophysical and demographical factors, it appears that only parts of Europe, the Russian Federation and Japan may benefit from increased productivity due to warming in the next couple of decades.

Projections at the national scale have only limited relevance to food security of rural populations, however. While temperature increase is projected almost globally, the pattern of rainfall changes varies significantly from region to region and at sub-national level due to topography and proximity to water bodies. For the NPP projection shown in Figure 1, global climate model output on about 2.5° x 2.5° grid points were interpolated to each country’s area. Small countries sometimes fall within a single cell of model output and the results for these countries need to be interpreted with caution. It is probably meaningless to compare relative magnitude of changes with other small neighbouring countries.

Subnational impacts on crop production

To assess food security in the light of climate change for smaller countries and different populations within a country, fine spatial scale climate information is essential and the need is higher than ever. Any planning of adaptation measures to climate change requires finer spatial climate information that feeds into impact-assessment models, such as crop simulation. Good historical climate data are required for calibrating impact models along with future projections of climate to calculate future crop yields.

FAO recently conducted a study of the impacts of climate change on Moroccan crop production up to the end of this century under the framework of a World Bank climate change project (Gommes et al., 2009). The study covered six agro-ecological zones, 50 crops and two climate-change scenarios.
In a number of experiments, elevated carbon dioxide was shown to have a positive impact on plant growth and yield. It was found, however, that carbon dioxide fertilization will bring only marginal benefit to future Moroccan yield due to the water stress to which rainfed crops are exposed. On the other hand, there is still room in Moroccan agriculture for technological advances such as more efficient irrigation systems, improved crop varieties and more efficient fertilizer use. Agriculture may adapt, at a cost, by overcoming some of the negative climate change impacts.

Use of climate information for impact assessments

The Morocco study used statistically downscaled climate projections. With increasing computing power and progress in scientific research, regional climate models (RCM) are being used as a tool to provide fine spatial scale climate information. A dynamical regional model can produce projections of all climate variables that are physically, dynamically and hydrologically consistent with each other. When global climate models can do multi-decadal simulations at 100-km grid spacing, regional climate models can simulate at down to 10 km grid spacing and below. In this connection, the initiative by WMO to establish Regional Climate Centres (RCCs) for provision of a wide suite of regional-scale climate information is a welcome development.

In the course of the Morocco study, the interpretation of a finding required on many occasions a correct understanding of climate data and its propagating uncertainty into the crop model. In order to encourage appropriate use of climate data, the interactions between the climate science community and the impact application (physical and social) science community should be more actively promoted. Climate modellers need to better understand end-user needs regarding required variables, data format, temporal frequency, spatial scale, length of data period, etc. Above all, climate scientists are responsible for providing guidance on correctly using the data in applications and interpreting the results from impact models. The impact-study community, on the other hand, needs to ensure that climate data are used for what they were intended for and to understand the assumptions and uncertainty associated with the data accurately.

Vulnerable populations are concentrated in arid and semi-arid areas and projections of freshwater availability under climate change is a crucial variable for the assessment of agricultural production. As it turns out, global climate models do not necessarily agree on the projected direction of changes in precipitation in low to mid-latitudes which coincide with the area of arid climate, distribution of vulnerable people and rainfed agriculture. The Mediterranean region, including Morocco, is one of the few places where most models agree that precipitation will decrease in the future. When assessing food security in the regions where models do not have good ability in precipitation projection, extra caution should be paid in choosing climate models and their output to work with. It is possible to arrive at totally different conclusions on future rainfed agriculture with data from different climate models.

A similar point can be made for emission scenarios. A wide range of future projections is possible, depending on socio-economic development. The uncertainty needs to be recognized in the results derived from climate-model outputs by a crop model. Climate models are not meant to predict the future precisely but are rather designed to indicate the response of climate system given changes in forcing. A 20 per cent decrease in barley yield at a given location by 2030 is accurate only if the assumptions made in the emission scenario and a number of assumptions in climate and crop models are correct. Placing too much confidence in impact models might prevent the formulation of sound adaptation measures.

The IPCC data distribution centre offers a variety of projection data from a range of climate models and emission scenarios. Impact studies often do not have the resources to make use of all the available data, however. The cost lies in downsampling data to suitable spatial resolution. Most downsampling models (statistical model or regional climate model) are designed for using outputs from a couple of global climate models only. Computing resources are limited. When impact studies do not have the luxury of using multiple emission scenarios and global climate model outputs, one needs to carefully interpret the results from impact models. If the target area does not have good skill in precipitation, sensitivity studies may be preferred in order to see the impact of different magnitude of precipitation changes (from decrease to increase).

One of the biggest assumptions in the Morocco example is that current agricultural practices will remain unchanged in the future. We have little confidence for this assumption to hold until the end of century. What we are more interested in is the near future, perhaps up to 2030, in order to devise adaptation measures that are appropriate for local conditions and climate projections and to start implementing them. Since the climate change signal may be hidden in large climate variability, in near forthcoming decades, it may be worthwhile to make projections for 2100 and pattern-scale them back to 2030. The end-of-century projection of crop production itself should not be interpreted literally, however, as is clear if we think back to what agriculture looked like 100 years ago.

While the time horizon we should focus on in terms of food security
and climate adaptation is the next two decades, climate predictions on this timescale is both not well understood and limited. In this respect, the timing of this year’s theme of the World Climate Conference-3 is perfect. The climate science community has started to address this big challenge. Improved skills in decadal climate prediction, together with downscaling, will better inform impact assessments that constitute food security: crop simulation, watershed modelling, etc.

**Adaptation in the agriculture sector**

Regardless of international commitments to reduce greenhouse gases, a certain level of climate change cannot be avoided. Global mean temperature is expected to keep rising at least over the next few decades. Adapting to climate change is an urgent action needed particularly for developing countries. Joint activities by FAO and WMO in organizing international workshops in different regions such as the International Symposium on Climate Change and Food Security in South Asia (August 2008, Dhaka, Bangladesh) and the International Workshop on Adaptation to Climate Change in West African Agriculture (Ouagadougou, Burkina Faso, April 2009), are bringing together representatives of the National Meteorological and Hydrological Services (NMHSs), the agricultural ministries, and regional and international organizations to discuss strategies for regional climate change adaptation and develop appropriate recommendations for implementation in the vulnerable regions.

Impact studies discussed in previous sections inform decision-makers of vulnerable areas and sectors in order to plan adaptation measures. FAO assists subsistence farmers in building capacities to better adapt to climate change through the provision of technical help. To begin with, there is much to be done to reduce vulnerability to current climate variability. In this context, climate change adaptation has a strong linkage with disaster risk management.

**An ongoing FAO project in Bangladesh**

An ongoing FAO project in Bangladesh takes a comprehensive approach to livelihood adaptation. At the local level in the field, measures introduced are: better agronomic management, income diversification, strengthening extension services and testing recommended adaptation techniques. Farmers could adapt by changing planting dates and crop variety that suit better warmer and drier/wetter climate. Improved fertilizer use would increase per unit area yield. Efficient irrigation and watershed management would alleviate water stress that may be exacerbated under climate change.

**Mitigation—carbon sequestration**

Many adaptation options for agriculture provide mitigation benefit at the same time; they are readily available and can be adopted immediately. Agriculture and forestry sectors combined are responsible for one-third of total anthropogenic greenhouse-gas emissions and are the largest sources of methane and nitrous oxide emissions. Tapping great mitigation potential in these sectors is a key to achieving an ambitious greenhouse-gas-reduction target.

**Soil-carbon sequestration**

Soil-carbon sequestration has perhaps the biggest potential in terms of the amount of carbon dioxide. Global technical mitigation potential from agriculture is about 5.5 Gt C-eq per year by 2030. Soil-carbon sequestration can contribute about 89 per cent of this potential. We can expect a high return of reduced carbon for relatively low cost with managing land better across all climatic zones and a variety of land
use systems—cropping, grazing and forestry (FAO, 2008(b); FAO, 2009).

There are many management practices that can restore wastelands, soils and ecosystems to enhance soil organic carbon and improve soil quality and health. Such practices include organic agriculture, conservation tillage, mulching, cover crops, integrated nutrient management (including the use of manure and compost), agroforestry and improved management of pastures and rangelands. Improved nutrient management can also reduce nitrous oxide emissions, while contributing to soil carbon sequestration.

Sustainable land management practices that increase carbon in soil come with multiple benefits: improved soil fertility, enhanced above-ground biodiversity and increased soil water storage. Rural livelihoods will build resilience to climate change through enhanced/stabilized productivity, the provision of a range of ecosystem services, and reversing degradation and desertification.

**Conclusion**

Climate change affects smallholders in many ways but enhanced climate prediction and efficient use of climate information can guide all concerned with food security, from farmers to governments, to sound adaptation and mitigation measures. Agriculture has a significant potential to reduce greenhouse-gas emissions with multiple benefits for adaptation and rural development. Agriculture, however, has been insufficiently recognized as a major player in climate change negotiations so far.

FAO hosted a high-level conference on world food security in June 2008 to address the challenges of climate change and bioenergy. It was the first time that world leaders got together to discuss the specific issue of food and climate change. The countries present agreed that there was an urgent need to help developing countries to improve agricultural production, to increase investment in agriculture and to address the challenge through mitigation and adaptation measures.

The next two decades are the most crucial period to implement those measures, given ever increasing greenhouse-gas emissions and rapidly rising temperature. As the 15th session of the Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen, Denmark, nears, it is the right time for the international community to take action to tackle climate change while improving food security.

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**References**


