The perspective of climate change impacts on agriculture and the environment

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Abstract

Climate change will impact upon all economic sectors with agriculture and forestry being one of the sectors most intensively affected. The resources needed for ensuring sustainable agricultural production, including soils, water, genetic resources and biodiversity, will also be impacted. It is crucial to start preparing for adaptation, in order to reduce the negative effects and take advantage of the potential benefits. To this end, a better understanding of the baseline situation and the challenges ahead is needed. This paper presents a discussion on which data and information may be necessary and whether agriculture statistics could give a response to this challenge.

The paper focuses on three aspects. Firstly, the impacts of climate change on agriculture and the challenges of adaptation strategies. Secondly, the efficiency of water use by agriculture in the face of growing water scarcities and the data needs for the application of market based instruments. And finally, the data needs for assessing the environmental consequences of the growth of bioenergy.

Introduction

Climate change is one of the biggest challenges we will face in the future. The effects of climate change can already be observed and are projected to become more pronounced, in terms of impacts on natural ecosystems, biodiversity, human health and water resources as well as on many economic sectors such as forestry, agriculture, tourism and the insurance industry. Climate change will have profound effects on the way we go about our daily lives.

The latest Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) projects that global average temperatures in 2100 will be between 1.8 and 4.0 °C higher than the 1980–2000 average. Sea levels are projected to rise 0.18/0.59 metres by 2100, based on observed rates of ice flow from Greenland and Antarctica. More frequent and intense extreme weather events, including drought and flooding, are also expected.

Climate change effects may be perceptible in different degrees, at different times and with a varying intensity, depending on the region and sector of the economy. Predicting future impacts is, therefore, difficult, but this inherent complexity must not prevent immediate attempts to do so, together with an understanding of the magnitude of uncertainty.

Agriculture and forestry production will be hit directly by climate change. The resources and ecosystem services needed to ensure a sustainable agriculture sector will also be affected: soils, water, pollination, nutrient cycling, genetic resources and biodiversity. Adaptation strategies must therefore be introduced to reduce negative effects and exploit potential positive ones.

According to recent assessments by the EEA, European Commission, OECD, the World Wide Fund for Nature, IUCN, and various UN bodies for Europe, in many regions there may be an increase in irrigated area and water abstraction for irrigation. In the northern temperate region, agro-climatic zones are likely to move northwards as a result of climate change. In the southern areas, current crop areas may be abandoned due to low availability of water. Although increases in precipitation projected for some countries are likely to be beneficial for agriculture, the higher risk of flooding events involve higher risk of direct economic losses and destruction of the production capacity.

As a result, the way we tackle environmental issues related to agriculture will also have to be approached from the perspective of climate change impacts.

With all these considerations in mind, this paper discusses requirements for data and information on the agriculture sector with respect to climate change impacts and adaptations. Thus, in the following paragraphs more questions than answers are to be found.

1. Adapting agriculture to climate change[1]

Policy makers have to anticipate how climate change will affect the way we live and prepare for the changes identified. This was the strong message conveyed by Commissioner for the environment of the EU last July 2007, at the presentation of the Commission Green paper on adaptation to climate change (COM, 2007). Our understanding of climate change effects have to be continuingly improved, but the bottom line is that we understand the problems we are facing today well enough.

This appears to be particularly important in the case of agriculture, as one of the sectors that will be hit by climate change due to its dependence on climatic conditions and on the use of natural resources. Additionally many rural areas, in particular mountain areas, show high vulnerability. But at the same time the agriculture sector has been adapting itself to different climate conditions over centuries, as weather has always played the role of friend and foe for farmers.

Ideally, agriculture statistics should be capable of providing information on past experiences of impacts and adaptation. This information should become the baseline for action and a necessary input to validate models, prepare plausible scenarios and perform risk assessments.

The objective is to improve understanding of the impacts of and responses to climate change. In this regard, a non-exhaustive list of areas that need further research and extended knowledge is suggested below:

- information on the direct impacts of climate change on agriculture production, as a result of higher temperatures and increased CO_2 concentrations: altering phenology, crop yields, cattle breeding, changes in crop quality (e.g. biochemical composition and biomass accumulation). Ideally, data should be available for different crops, groups of crops and farming systems;

[1] The paper is not intended to be a comprehensive overview of all climate change adaptation issues for the agriculture sector. It will only point out some of the most relevant issues and the related need for improved data and information. Implications in significant fields such as forestry, soils, biodiversity or global food security cannot be approached in detail within the limits of this paper.

- information and improved data on the secondary effects of climate change (Olesen 2006): occurrence of pests and diseases (changes in spatial-temporal patterns); effects of extreme events; and environmental side-effects. Among the latter, for instance, changes in nutrient leaching and water quality, the loss of biodiversity associated with farmlands, and the interaction between climate change and soils with respect to carbon content dynamics and erosion;

- describing the limits that the agriculture sector can cope with, in terms of temperature, water stress, crop suitability or resistance to pests and diseases, without further stressing the environment (e. g. a greater use of pesticides) or the natural resources (water for irrigation);

- strengthening our predictive capacity and improved forecasting. This will be crucial to anticipate effects and prepare responses, in particular face to extreme events: early warning systems, protective infrastructures…

- improvements to the models and scenario tools in the following aspects: focusing on the medium and short term; more flexibility to integrate policy changes, price variations, new regulations, farm management changes or extreme weather events; a better downscaling and improvement in representing extreme events; and finally, continuous validation against real data;

- better knowledge of farm management practices. A substantial piece of information is lacking on the different responses by farmers to policy developments and market pressures. This information is basic not only for adaptation but also for mitigation strategies e.g. on farm management of nitrogen fertilizers and manure. There is a clear need for improving the estimates of methane and nitrous oxide released to air, and a range of agricultural pollutants released to water, and how they vary in different farming systems;

- to assess the adaptative capacity of the sector, it is necessary to identify and get a better understanding of the adaptation strategies applied in the past (mostly autonomous and private): shifts in crops, yields, varietals, geographic move of production, etc. Water requirements and growing demand for irrigation are outstanding issues in adaptation; some comments will be presented later;

- vulnerability of rural areas. There is a lot to be done regarding the definition and identification of the most vulnerable areas and sub-sectors with respect to climate change. This should be done, and as far as possible, at the most precise geographic level. Vulnerability maps, together with a better knowledge of current responses, will be the basis for future risk management strategies;

- regarding data and information needs, identifying the optimal spatial scale: coherent and comparable information at regional or local level is still lacking. Many of these gaps have to be frequently filled by means of case studies, which can only reflect fragmented pictures;

- and last but not least, one of the biggest challenges is to establish how to define the prices of the resources ecosystem services needed for sustainable agriculture. Discussions on pricing in the context of a world carbon market, the next steps in the post-Kyoto process around the use of biomass and biofuels, and the ways in which the Clean Development Mechanism and agriculture could be used to support sustainble food production are all critical to this.

There is a clear need for research on the vulnerability of society and ecosystems to climate change impacts, in particular for agriculture. Better databases on frequency, intensity and effects of extreme events and on national adaptation practises, including responses to climate variability, would facilitate the development of effective adaptation strategies.

The overall question could be summarised as follow: How can we improve our understanding of climate change effects (in the past and in the future) with the help of existing agriculture statistics? And which improvements in terms of new data needs, arise from the point of view of adaptation to climate change? But even if we can answer these questions, an additional challenge arises: are the information systems able to give quick, simple, usable answers to the needs of decision-makers for adaptation? It seems clear that it will be necessary to improve the sharing of databases and to facilitate their use.

2. Efficiency in agriculture water use

The impact of climate change on water resources will become a critical issue. Even if emissions of greenhouse gases were stabilised today, increases in temperature and the associated impacts, including water availability and flooding will continue for many decades to come (EEA 2007a).

There is recent evidence of major drought and flood episodes all over the world. Europe continues to experience notable climate variability, with catastrophic effects. The 2007 summer has brought persistent and torrential rains in many parts of northern Europe, especially in England, and extreme dryness and hot temperatures have led to devastating fires in Greece.

Opinion is divided as to whether these events represent a significant trend or simply reflect natural climate variability. In any case, climate-change models project more frequent and intense droughts, heat waves and floods.

Agriculture appears a very vulnerable sector with respect to extreme climate events. On the one hand, water scarcity and droughts will lead to a reduction in yields, increase water demand for irrigation and, subsequently, increased tensions among competitive users and between regions. On the other hand, floods can destroy the productive capacity of agriculture and forestry and may trigger or worsen soil erosion process. These impacts convey direct socioeconomic losses. But they also imply cascading effects on biodiversity loss, water quality and desertification.

Water shortages and droughts are currently a major environmentally policy theme in Europe. A recent communication from the European Commission on water scarcity and droughts (COM 2007) highlights a number of actions to be applied under an integrated approach. Among them, is the need for improved knowledge and data collection: reliable information on the extent and impacts of water scarcity and droughts is indispensable for decision making at all levels.

How can we assess if a drought has occurred as a consequence of a dramatic fall in raining or because the misuse and mismanagement of the resource, or whether it is a combined result out of both of them?

Agriculture statistics can provide with a sound set of data and information, as agriculture is one of the biggest water consumers and irrigation, either supporting or substituting rainfall, is present in almost every country.

However, the environmental assessment of agriculture’s impacts on water resources is not always an easy task. There are still shortages of data on various key variables concerning water resource management (EEA, 2005). In particular, there is a critical scarcity of information describing actual water use by agriculture, especially at a regional scale. In addition, where such information does exists, there is, typically, little or no attempt to integrate this with information describing water usage by other sectors, nor the means to link this data to observed impacts upon groundwater levels and river flows. The issue is also exacerbated by a lack of data of sufficient temporal resolution; the most adverse impacts upon water resources are realized seasonally, and cannot be fully explained using annual totals or averages. A better quality of integrated data (both spatially and temporally) is clearly necessary to monitor trends in the use of water resources, which, ultimately, would lead to a better targeting of measures to ensure water savings and efficient use.

A further challenge arises with respect to accounting for the water used by agriculture. Water/agriculture authorities and management units are frequently different from those involved in the collection and exploitation of data. Additionally, the geographical breakdown of data and information brings about problems when dealing with river basins across different administrative regions or across national borders; techniques to re-aggregate data from an administrative scale to a river basin or hydrological scale are desirable.

These data requirements reinforce the need for shared information systems and common definitions to ensure data consistency. As well as close cooperation and collaboration among all the institutions involved in water resources management. The Water Information System for Europe (WISE), developed by the European Environment Agency, provides an ideal platform to integrate and disseminate information related to water. WISE simplifies the access to data and information and helps to visualize water related issues on a European scale, by means of thematic maps as the one shown below:

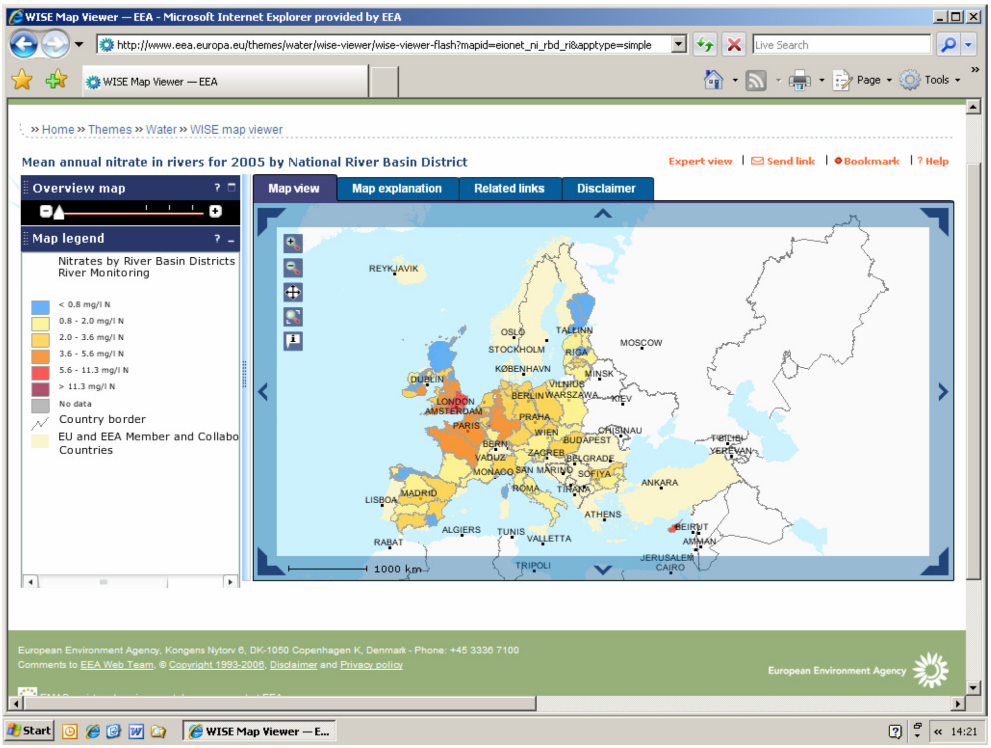

Figure 1. Mean annual nitrate concentration (mg/L N) in rivers for 2005 by National River Basin District. Source: WISE http://water.europe.eu

To a great extent, adaptation strategies in agriculture will mean finding ways to use water more efficiently. Efficiency has to do with an appropriate selection of crops, irrigation technologies, modernizing infrastructures (e.g. irrigation equipment) and issues such as the application of wastewater to agricultural land, in order to save resources and avoid water losses. But efficiency in water use is also influenced by agriculture subsidies and with market-based instruments, mainly water pricing.

There are strong implications in terms of policy-making, in order to make choices or define the best combination of policy instruments with a view to improve water efficiency. The discussion needs to be backed by a solid set of data and information. Among these, socioeconomic data on the agriculture sector are to be seen not only as context indicators but also as crucial variables for the implementation of environmental instruments and assessing their efficacy.

Can we assess the effectiveness of policy instruments with current data? The key questions are:

- how have agriculture subsidies boosted the intensification of agriculture and a higher non-sustainable use of inputs, in particular of water?

- how does water pricing influence water consumption? What is the elasticity-price of water consumption in agriculture? It is possible to distinguish between crops in terms of their answer to different levels of water pricing?

- what is the performance of other policy instruments, such as incentive payments to reduce water consumption, water taxing or better technical education to farmers?

- is it possible to isolate the drivers and the underlying causes? For instance, can we assess whether a reduction in water use is driven by a policy measure (e.g. agro-environmental measures in EU rural development policy) or by socio-economic factors (e.g. lower prices of crops).

- which are the socioeconomic effects of water pricing on agriculture, both at the farm level (running costs, gross margin) and at macro level (economic accounts for agriculture: gross added value, productivity).

- what is the status of water metering systems? Market-based instruments will only make sense if water metering systems are extended and fully implemented. Agriculture uses are not always sufficiently registered as it would be desirable.

Water scarcity and droughts have to be addressed as an essential environmental issue. Climate change will exacerbate current problems, in particular for agriculture. A move towards water efficiency and water savings is essential to cope with the future challenges.

3. New developments in bioenergy

One of the main strategies facing climate change is reducing greenhouse gases. The EU has committed itself to cut greenhouse gases by 20% by 2020 compared with 1990 levels (Presidency conclusions 8/9 March 2007). The discussions in the upcoming Conference of the Parties in Bali may lead to even higher targets, depending on the range of measures to be considered and the role of developing economies such as Brazil, China and India.

Agriculture activities release to the atmosphere around 9% of total GHG emissions (EEA 2007b), from various sources such as livestock production, mineral fertilizing, crop residues or certain farm management practices (manure application). But at the same time, the agriculture and forestry sectors can make a positive contribution through the production of bioenergy. The EU has set a quantified objective of a minimum 10% biofuels in total EU transport fuel (petrol, diesel) by 2020. But this target is subject to the condition of bioenergy production being sustainable.

In this regard, new requirements for data and information arise. Can we obtain information from current agriculture statistics on the following issues?:

- different final uses of the same crop (e.g. maize to food, animal feed or bioenergy)

- impacts on commodity markets: fluctuations of prices, shifting of trade flows or even threatens to food security.

- statistics on the extent and type of bioenergy crops needed to be grown in the future and their possible sources.

- rates of conversion of land use groups (e.g. arable, permanent grass, permanent trees, pastures, forests, non-agriculture land…) into biomass cropping.

- trends in intensification of bioenergy production: can the use of inputs (fertilizers, pesticides) and natural resources (water) be distinguish between food/feed and fuels?

- the impact of a growth in bioenergy crops upon soil and water quality. To adequately quantify these impacts requires monitoring of soil and water resources at an appropriate spatial and temporal scale. For example, localized impacts of bioenergy crops upon water quality could be significant, but hidden when monitoring focuses only on larger rivers that include multiple pollution sources (e.g. discharges from urban land) and their associated policies.

- can the potential loss of biodiversity (both terrestrial and aquatic) be attributed to different biomass uses?

Better, detailed information on bioenergy crops is necessary to identify the relative weight of biomass production and how it is turning towards different uses. These trends will reveal the potential imbalances and pressures to natural resources. A simplistic visualization could be presented as follows:

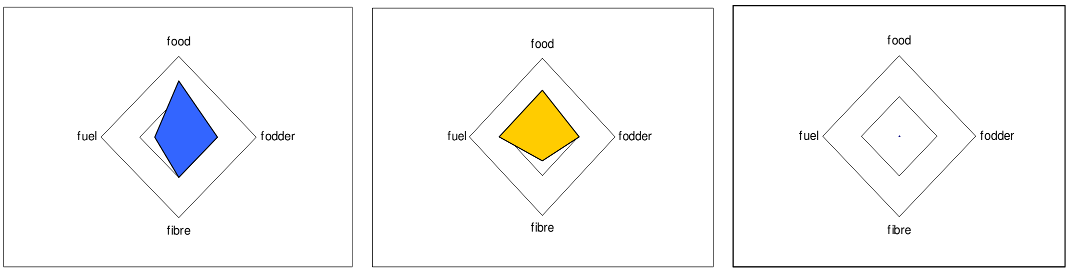

Figure 2. Past? Now? Future?

Summing up, the way agri-forestry production moves towards different uses will obviously have different impacts on the environment, on land use changes and on socioeconomic aspects such as relative prices, input requirements and international trade balances. And ultimately, it will influence decision making in the fields of agriculture, energy and trade policies around the world.

Final comments

Agriculture statistics can provide decisoin-makers with long series of data and thorough information, over a wide range of issues related to land use, crops, forestry, inputs, labor force, rural population, economic performance or international trade.

The overall questions that we try to answer may sound quite familiar: how do agriculture activities affect the state of the environment? are policy instruments effective in protecting the environment? The difference now is that the scenario in which these need to be answered has changed, as climate change is fundamentally altering the way we are able to tackle environmental problems.

Are agriculture statistics and agriculture information systems at regional, national and global scale, ready for this challenge? How can they help to give quick and effective responses to the new developments derived from climate change and which improvements might be needed? The answers are nor easy not clear. Some key ideas could contribute to the discussion:

- information on the past is needed to prepare the future
- there are gaps in data, but also potentialities in existing information
- flexibility is needed to integrate new developments in policy, markets or climate
- integrated approaches: water/socioeconomic, energy/agriculture
- breakdown of data and assessments: management units, (bio)geographical regions, farming systems
- information has to be available, accessible, understandable and easy to use
- new opportunities from information technologies and communication tools and
- collaboration and coordination among institutions and countries.

As a final remark, the biggest challenge for statistics is to move from showing facts to telling us stories:

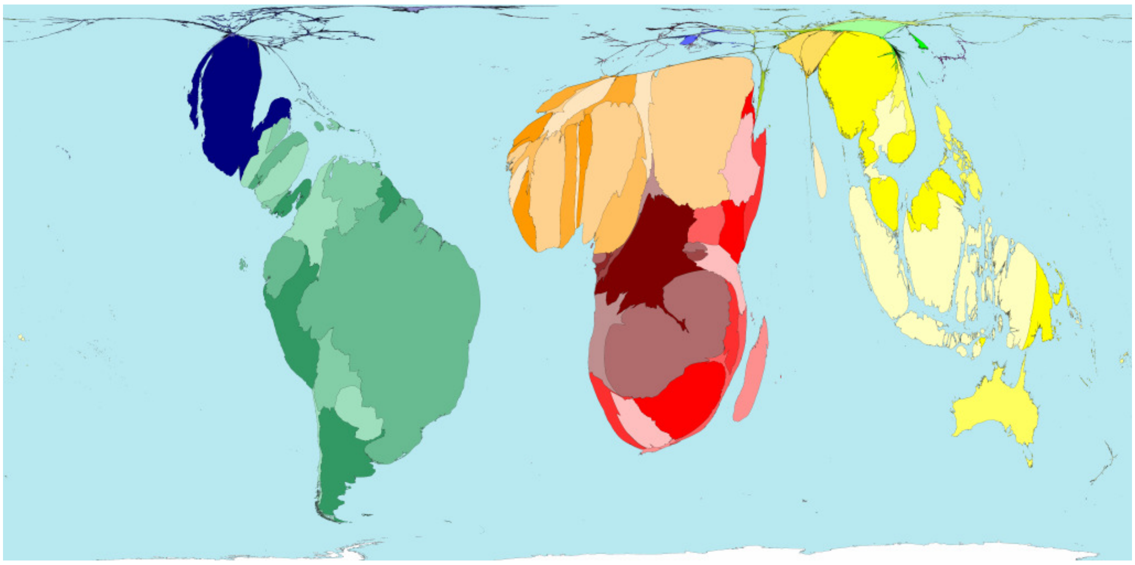

Figure 3. World forest loss. Source: www.worldmapper.com

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