Climate Change, Water and Agriculture: Challenges and Adaptation Strategies

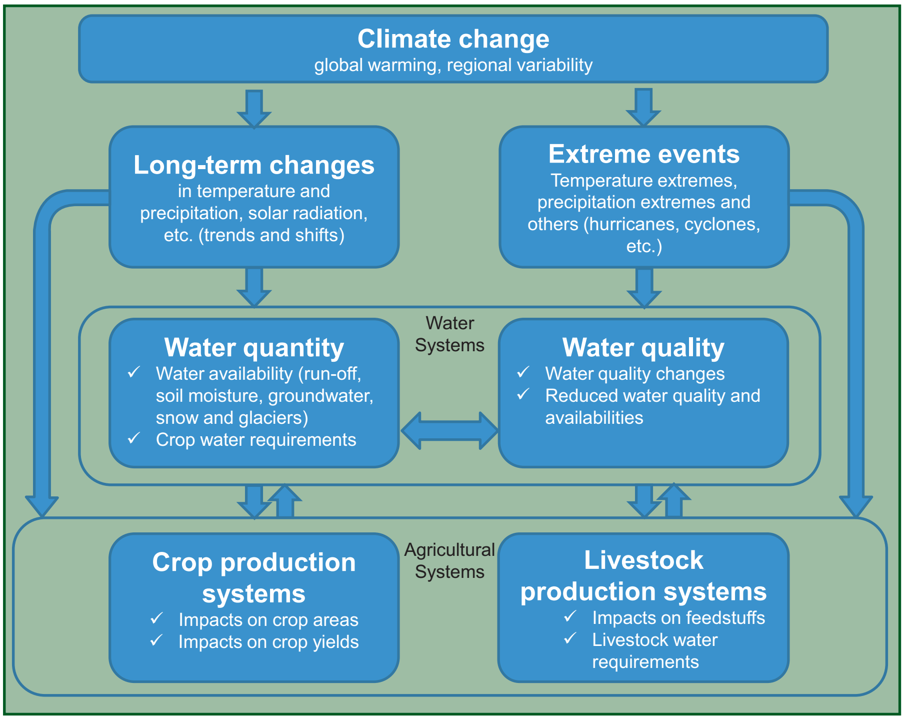
Changement climatique, eau et agriculture : défis et stratégies d'adaptation

Klimawandel, Wasser und Landwirtschaft: Herausforderungen und Anpassungsstrategien

Julien Hardelin and Jussi Lankoski

Agriculture is one of the most exposed and vulnerable economic sectors to climate change. In the complex interactions between climate change and agriculture, the issue of water is particularly important. Climate change is likely to affect water resources in several ways, notably through changes in precipitation patterns; direct and indirect impacts on water quality; and increases in the frequency and severity of extreme events such as floods and droughts. Climate change impacts on the water cycle will have consequences for agricultural production in most regions of the world, with potential implications for agricultural markets and other water users and uses (urban, energy, industry and ecosystems). There is a need to define adaptation strategies for water management in agriculture. On the basis of the recent work undertaken by OECD in this area (OECD, 2014), we identify and discuss three main dimensions for a comprehensive adaptation strategy for agricultural water management.

Figure 1: Main linkages between climate change, the water cycle and farming systems



Source: OECD (2014).

Impacts

Figure 1 summarises the principal channels through which climate change may affect farming systems through changes in water systems. In the long run, climate change is projected to affect both the supply of water and the demand for water in agriculture: water supply can be impacted directly – through changes in rainfall patterns – and indirectly – through changes in water supply sources such as surface water, groundwater and snow and glaciers that play a major role in water storage in certain regions. Climate change can also affect water demand directly through changes in crop water requirements driven by climatic variables such as temperature, humidity and wind speed; and indirectly through the adaptation responses of farmers to climate change in crop and livestock systems.

Several regions of the world are expected to experience increasing water stress due to the combination of rising water demand due to economic development, and reduced and more uncertain water supply due to climate change. However, water-related impacts of climate change are likely to vary substantially across countries and regions. Increases in precipitation are projected at high latitudes and at mid-latitude wet areas, while decreases in summer precipitation are more likely in mid-latitude and sub-tropical dry areas (IPCC, 2013). For example, Southern Europe and some regions of Central and Eastern Europe are likely to experience water stress due to changes in precipitation and it has been estimated that by 2050 crop yields could decrease between 15 and 25 per cent in Spain and Greece, and between 5 and 15 per cent in the south-west of France and Italy (EEA, 2012).

> “Bien que les impacts du changement climatique liés à l’eau soient incertains et très divers, des réponses sans regret, telles qu’une meilleure efficacité de l’utilisation de l’eau, existent en matière d’adaptation.”

Water-related impacts of climate change would not be limited to crop yields. Climate change could also affect livestock productivity and health, through changes in the quantity and quality of feedstuffs, and water needs of livestock due to heat stress. Projections from climate models suggest an overall acceleration of the water cycle, involving more frequent extreme water events such as droughts and floods (OECD, 2013b). Finally, climate change could affect water quality, although expected impacts are difficult to assess and highly uncertain: an increased incidence of floods could increase sediment loads, including the content of nutrients and chemicals, while droughts may contribute to increased concentrations of pollutants in water bodies. Indirectly, changes in cropping patterns and land use associated with mitigation and adaptation responses (e.g. afforestation of agricultural land for mitigation or adoption of irrigation for climate change adaptation) could also have significant implications for water quality. In spite of substantial progress in climate change projections, there are still significant knowledge gaps regarding these types of impacts, especially the implications for livestock and water quality.

Projections from climate models suggest an overall acceleration of the water cycle, involving more frequent extreme water events such as droughts and floods.
***Source*: Simazoran@Thinkstock**

Adaptation strategies for water management in agriculture

Although there is broad agreement among academic and policy circles on the necessity for adaptation to climate change in agriculture, the exact role of government and appropriate types of government intervention are debated. In the area of water management, public policies are already in place in most countries to deal with market failures associated with negative externalities (impacts on wider society) such as: nutrient pollution of surface and groundwater; over and inefficient use of water due to common property resource characteristics; or incomplete insurance and financial instruments for dealing with droughts and floods. The question is how such policies will be able to cope with the changing climate, and drive farmers’ on-farm adaptation choices in a direction which more effectively aligns farm profit with wider social welfare and greater resilience for agriculture.

A common issue in any adaptation problem is the timing of adaptation

An increased incidence of droughts may contribute to increased concentrations of pollutants in water bodies.

responses, and how to deal with uncertainty in assessing the costs and benefits of adaptation strategies. This is especially the case for water, for which the implications of climate projections are highly uncertain, especially at the local level. In such a context, decision makers have to rely on an adaptive learning approach that progressively incorporates new information and knowledge. It is important to find strategies that improve the adaptive capacities of agricultural and water systems, i.e. the ability to adapt to change as more information becomes available and knowledge increases.

Table 1: Water cost recovery in agriculture in OECD countries

		Operation and maintenance cost recovery	
		Less than100 per cent	100 per cent
Investment costs recovery	Less than 100 per cent	Spain, Greece, Hungary, Ireland, Italy, Mexico, Netherlands, Poland, Portugal Switzerland, Turkey, Korea	Australia, Canada, United States, France, Japan
	100 per cent		Austria, Denmark, Finland, New Zealand, United Kingdom, Sweden

Source: OECD (2010).

Given long-term projected changes in temperature and precipitation patterns, an increased incidence of extreme water events and rising demand for water by other users, the following strategic dimensions for agricultural water management appear to be of particular importance in order to foster the adaptive capacities of agricultural and water systems to climate change.

> "Obwohl die Auswirkungen des Klimawandels im Bereich Wasser unsicher und sehr variabel ausfallen, gibt es Anpassungs-strategien wie z.B. die Erhöhung der Wassernutzungseffizienz, die in jedem Fall zielführend sind."

The *first strategic dimension* is to foster an enabling environment for the development of on-farm adaptive capacities in agricultural water management. On-farm adaptation is usually defined in terms of technical changes in agricultural management practices such as: adoption of drought-resistant crop varieties, change in sowing dates, increased irrigation efficiency, adoption of irrigation in previously non-irrigated areas and changes in crop rotations. On-farm adaptation practices can reduce the vulnerability of farms to climate change; however adoption may be slowed by a lack of awareness, knowledge, or behavioural bias. Government policies targeted to innovation, education and the provision of advisory and extension services have a role to play in fostering an enabling environment for on-farm adaptation response.

A *second strategic dimension* for adaptation is water policy. Farmers' adaptation decisions take place in a broad policy and market environment that includes environmental regulations. A lack of incentives to improve agricultural water management due to under-pricing of water in agriculture, over-allocation of water rights or the use of irrigation subsidies is still pervasive in many OECD countries, and this tends to impede the development of a more water-productive agriculture. Table 1 shows that only a few OECD countries have full cost recovery for the investment, operation and maintenance costs involved in supplying water to agriculture. Adapting agricultural water management to climate change at the watershed level requires that signals of water scarcity be provided to users to induce efficient allocation. This requires developing flexible and robust systems able to allocate water in the short run – to cope with intra-seasonal volatility of water supply – and in the long run – to ensure a structural balance between water supply and demand.

Water allocation systems that allow either price or quantity to vary in response to changes in water availability are desirable, both under the existing climate and to provide adaptive capacity with climate change. Economic instruments such as water pricing and tradable water quotas have the potential to combine short-run flexibility in the allocation of water resources with long-run incentives for efficient water management. A prerequisite is the development of technical equipment and infrastructure to measure water flows and stocks in watersheds. The Australian experience in developing water markets in agriculture over the last two decades is an interesting illustration of such potential. Australian farmers can trade water allocations in short-run markets to cope with seasonal water shortage, and permanent water entitlements in long-run markets. The government intervenes in the markets through a buy-back of water rights to ensure minimum environmental flows i.e. minimum river flows that ensure the well-functioning of biodiversity and ecosystems. There is substantial evidence that water markets have allowed Australia to reduce the costs of droughts for farmers, and have fostered significant gains in terms of efficiency and water productivity in agriculture (Kirby *et al.*, 2014). Irrigation application rates in Australia have decreased from an average of 8.7 megalitres per hectare of agricultural land in 1990–92 to 3.6

Climate change impacts on the water cycle will have consequences for agricultural production in most regions of the world.

megalitres per hectare on average for the period 2008–10 (OECD, 2013a).

A *third strategic dimension* for adaptation is risk management policy for water-related extreme events such as droughts and floods. Projected increases in the frequency and severity of these events imply that consideration be given to the provision of insurance and compensation systems for the resulting production risks. While private insurance products are already available for certain types of risk in agriculture, this is not the case for catastrophic risks that have low probabilities but can generate large losses due to the scope and severity of effects. A specific challenge arises with non-stationary climate which increases *uncertainty* about such risks and makes them more difficult to assess with sufficient accuracy. Ensuring insurance coverage against catastrophic weather risks is a key issue for agricultural adaptation to climate change.

In practice, in several OECD countries, catastrophic risks – especially droughts – are managed through public–private partnerships, involving different forms of government support such as insurance premium subsidies or public reinsurance of last resort. While this can expand the number of farmers insured, such interventions may also have unintended consequences in terms of risk allocation and production incentives. With a well-functioning insurance market, a fair pricing of risks, i.e. insurance premiums that reflect the actuarial cost of risk, farmers are provided with proper price signals to adapt their risk management strategies to their individual risk profiles, while at the same time being covered against production risks. If risks are underpriced through free of charge *ex-post ad hoc* compensation or insurance premium subsidies, this can reduce the vulnerability of farms to the impact of climate change in the short run, but can provide perverse incentives that encourage behaviours which increase risk exposure in the longer run. Such incentives should be carefully considered when assessing the costs and benefits of public interventions for dealing with catastrophic risks associated with climate change.

> “Although water-related impacts of climate change are uncertain and highly variable, no-regret adaptation responses, such as improving water use efficiency, exist.”

Several experiments are currently being undertaken around the world to develop innovative approaches to the management of climatic risks through mechanisms such as index-based insurance products. Weather index insurance consists of providing indemnifications (compensation for losses) on the basis of the value of a weather index (temperature, rainfall, etc.) rather than individual losses. This offers potential cost savings due to reduced monitoring and verification costs at farm level, as well as reducing the moral hazard problem. Another possibility is area-yield insurance, with indemnities based on the aggregate yield of a geographical area.

Weather index insurance products have been or are being tested in several countries such as Ethiopia (rainfall index), India (rainfall, temperature and humidity indices) and Mexico (drought-indexed insurance) (Carter *et al.*, 2014). The relative performances of these innovative tools compared to traditional individual insurance schemes can depend on the degree of uncertainty regarding weather risks, an important issue given the projected impacts of climate change. Recent analysis shows that in circumstances of uncertainty, the policy choice between different types of insurance (individual, area-yield and weather index) depends on the risk profile of different farmers and locations (Anton *et al.,* 2013). In general, area-yield insurance performs better across countries and scenarios; however it can be very costly under extreme climate change scenarios while weather-index insurance would be less costly in those cases (Anton *et al.*, 2013).

Policy implications

Building on these ongoing policy experiences to improve agricultural insurance schemes can foster the development of innovation in this area. With this aim, the *Platform for Agricultural Risk Management* has been recently created as part of the International Fund for Agriculture Development (IFAD), following recommendations by the G20 development group. The platform objective is, ‘facilitating matching between agricultural risk management and existing tools, sharing the

Ensuring insurance coverage against catastrophic weather risks such as droughts is a key issue for agricultural adaptation to climate change.
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experiences of different organizations and practitioners' (OECD, 2014).

Finally, the adaptation strategies outlined above must be pursued within a framework of overall coherence of agricultural policies. In particular, open international trade is important to reflect potential changes in comparative advantage associated with a changing climate; this can also reduce commodity price risk by pooling production shocks at a large geographical scale. Finally, well-functioning competitive commodity storage markets have the capacity to smooth price shocks over time. Governments could have a role in providing an enabling environment in this area.

A second important dimension of policy coherence is the linkage between adaptation and mitigation. Climate change mitigation practices may have either positive or negative effects on agricultural water resources and water quality. Taking synergies and trade-offs into account can improve the efficacy and efficiency of policy instruments. For example, the conversion of cropland to forest to promote soil carbon sequestration is likely to improve surface water quality through a reduction of sediment, nutrient and pesticide run-off but may have a negative effect on water quantity, as permanent land cover consumes water throughout the year. A major challenge is the lack of knowledge on these interactions. In this area, as in others cited above, the further accumulation of knowledge is fundamental to guide adaptation strategies.

Disclaimer

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Julien Hardelin and Jussi Lankoski, Organisation for Economic Co-operation and Development (OECD), Paris.
Email: julien.hardelin@oecd.org; jussi.lankoski@oecd.org

Summary

Climate Change, Water and Agriculture: Challenges and Adaptation Strategies

Climate change is expected to have numerous and complex impacts on water resources, with consequences for agricultural production through changes in crop water requirements; the availability and quality of water; and increases in the frequency and severity of extreme weather events such as droughts and floods. Although there is substantial uncertainty about the magnitude of impacts, especially at the local level, this does not call for inaction. On the basis of the recent work undertaken by OECD in this area, we identify and discuss three main dimensions for a comprehensive adaptation strategy for agricultural water management: i) creating an enabling environment to foster on-farm adaptive capacities through policies targeted at innovation, education, and advisory and extension services; ii) improving agricultural water management through the development of flexible and robust instruments, such as water pricing and water markets, to deal with both short-run water shortages and long-run water stress; iii) developing and improving risk management tools for droughts and floods to ensure that the true cost of risks is signalled to farmers while at the same time improving the efficiency of risk allocation. We highlight the importance of policy coherence in recognising the linkages between climate change adaptation and mitigation.

Changement climatique, eau et agriculture : défis et stratégies d'adaptation

Le changement climatique devrait avoir des impacts nombreux et complexes sur les ressources en eau, avec des conséquences sur la production agricole par le biais : du changement des besoins en eau des cultures; de la disponibilité et de la qualité de l'eau; et de la hausse de la fréquence et de la sévérité des phénomènes météorologiques extrêmes comme les sécheresses et les inondations. Les incertitudes fondamentales sur l'ampleur des impacts, en particulier au niveau local, ne justifient pas l'inaction. Sur la base de récents travaux entrepris dans ce domaine par l'OCDE, nous identifions et examinons trois dimensions principales d'une stratégie globale d'adaptation pour la gestion de l'eau en agriculture: i) créer un environnement favorable au renforcement des capacités d'adaptation au niveau de l'exploitation, à l'aide de politiques ciblant l'innovation, l'éducation et les services de conseil et de vulgarisation; ii) aménager la gestion de l'eau en agriculture par le développement d'instruments flexibles et robustes comme la tarification de l'eau et la création de marchés de l'eau, afin de gérer à la fois les déficits de court terme et le stress hydrique de long terme; iii) développer et améliorer les outils de gestion du risque de sécheresses et d'inondations pour s'assurer que les agriculteurs perçoivent le coût réel des risques tout en améliorant en parallèle l'efficacité de la répartition des risques. Nous soulignons l'importance de la cohérence des politiques en reconnaissant les liens entre l'adaptation au changement climatique et son atténuation.

Klimawandel, Wasser und Landwirtschaft: Herausforderungen und Anpassungsstrategien

Der Klimawandel wird voraussichtlich zahlreiche und komplexe Auswirkungen auf die Wasserressourcen haben und aufgrund von Mengenänderungen im Pflanzenwasserbedarf, der Wasserverfügbarkeit und -qualität sowie der Zunahme der Häufigkeit und Schwere von Wetterextremen wie Flut- und Dürrekatastrophen Folgen für die Agrarproduktion nach sich ziehen. Obwohl insbesondere auf kommunaler Ebene große Unsicherheit über das Ausmaß der Auswirkungen herrscht, bedeutet dies nicht, dass kein Handlungsbedarf besteht. Auf der Grundlage der jüngsten Studie der OECD in diesem Bereich identifizieren und diskutieren wir die drei Hauptgrößen für eine umfassende Anpassungsstrategie für das landwirtschaftliche Wassermanagement: i) Ein unterstützendes Umfeld, um die Anpassungsfähigkeiten vor Ort durch auf Innovation, Bildung und das landwirtschaftliche Beratungssystem ausgerichtete Politikmaßnahmen zu fördern; ii) ein besseres landwirtschaftliches Wassermanagement durch die Entwicklung flexibler und robuster Politikinstrumente, z.B. Wasserpreisbildung und Wassermärkte, um sowohl mit kurzfristiger Wasserknappheit als auch mit langfristigem Wasserstress umzugehen; iii) bessere Werkzeuge zum Risikomanagement für Flut- und Dürrekatastrophen, um den Landwirten die realen Kosten der Risiken vor Augen zu führen und dabei gleichzeitig die Effizienz der Risikoallokation zu erhöhen. Wir betonen, wie wichtig Politikkohärenz beim Verständnis des Zusammenhangs zwischen der Anpassung an den Klimawandel und dessen Abmilderung ist.