Chapter 1

Addressing water risks in agriculture

Trends and projections suggest that agriculture will face increasing water risks in many regions which could affect agriculture production and markets as well as international trade and food security. This chapter presents evidence on future water risks for agriculture and introduces the hotspot approach as a means to assess and respond to these risks.

Key messages

Due to a combination of climatic constraints, current water uses, and rising competition for water, agriculture in many regions is projected to face multiple water risks that could negatively affect local, regional and global food production and food security. Water shortages, excessive water and water quality deterioration are projected to increase in some regions and will have an impact on agriculture production.

Agriculture both contributes to and faces such risks. Water is essential to agriculture production, yet in many countries this sector is a large and inefficient user of water. It is also a large polluter of surface and groundwater.

The use of a targeted approach, e.g. focusing actions on particular areas, to future agriculture water risks could help better cope with these challenges, while saving public resources. As outlined in this chapter, the report assesses and proposes policy responses to mitigate the effects of acute future water risks in localised productive agriculture regions, i.e. "hotspots", for agro-food systems and markets.

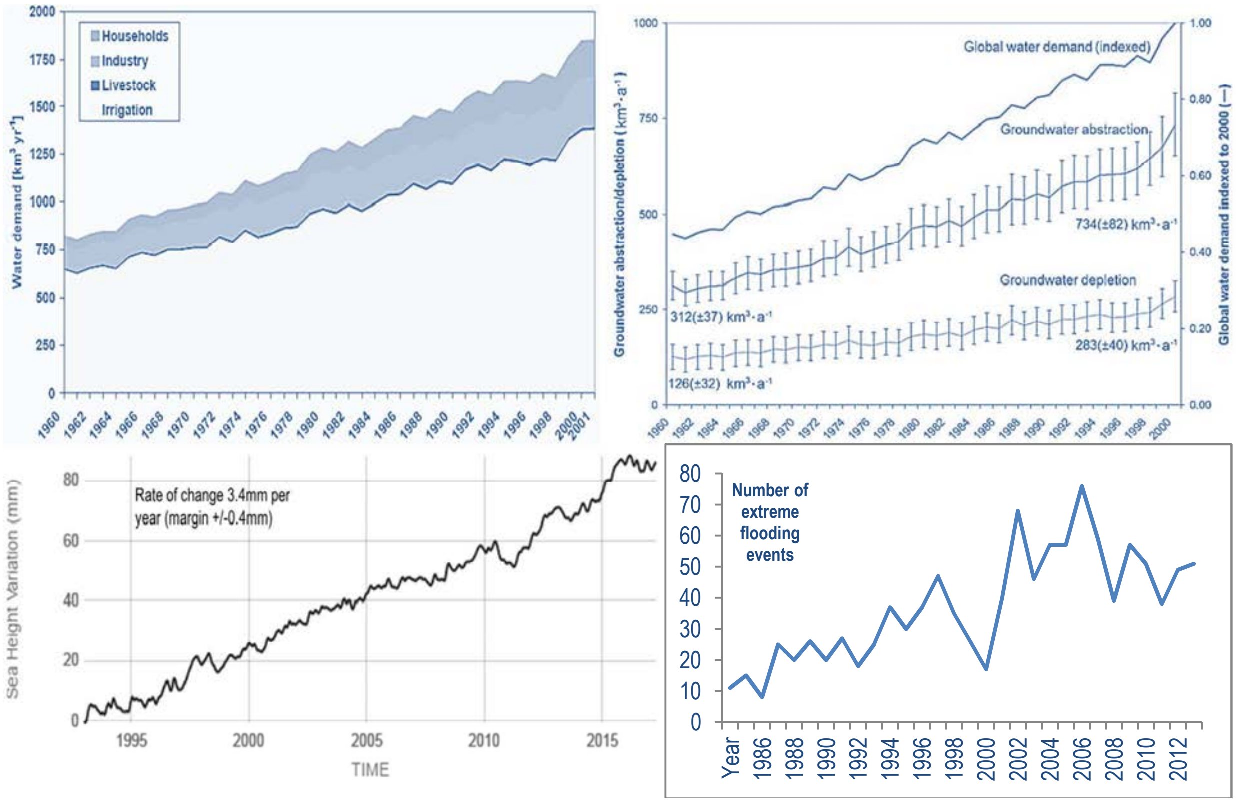
1.1. Past and recent trends demonstrate the growing importance of water risks

Recent studies show increasingly high trends in water risks.[1] Global assessments report increasing risks of shortages and flooding (Sadoff et al., 2015). The global rise in overall water demand and increased groundwater use (top of Figure 1.1) have contributed to rising tensions between the use of freshwater supply and dealing with regional water scarcity. Concurrently, average sea levels have continued to rise and extreme flooding events are more frequent (bottom of Figure 1.1), trends which are partially attributed to climate change (Jimenez-Cisneros et al., 2014).

Figure 1.1. Worrying water trends

Top left: Global water demand (1960-2000), Top right: Groundwater abstraction and depletion (1980-2000)

Bottom left: sea level rise (1993-2015), Bottom right: frequency of extreme flooding events (1983-2012)



Source: Derived from Wada et al. (2011); Wada et al. (2010); NASA Goddard Space Flight Center (2017), https://climate.nasa.gov;; "Global Active Archive of Large Flood Events", Dartmouth Flood Observatory, University of Colorado, http://floodobservatory.colorado.edu/Archives/index.html.

The annual number of disasters triggered by weather-related natural hazards more than doubled from the 1980s to the first decade of the 2000s (FAO, 2015). Droughts and related heatwaves are more frequent in many regions (OECD, 2014a). In 2015, droughts were particularly severe in southern Brazil, southwestern United States and northern Chile, and severe droughts started in southern Africa and Thailand. Trend observations from the Dartmouth Flood Observatory suggest that extreme floods have also become more frequent, with their impact also increasing over time.

Extreme weather events previously considered as seasonal occurrences such as storms and cyclones, have become more frequent and severe in many regions of the world (Herring et al., 2015). For instance, the number of storms in the Eastern North Atlantic increased by 200% during between December and March 2014; cyclones in the Bay of Bengal have become significantly more frequent in the northern part of the Bay and stronger than normal after the regular monsoon period. Extreme rain events like the one observed in 2014 in the French Cevennes are three times more likely today. Above average yearly maximum rainfall are being seen in the Jakarta area where they are twice as likely to occur today as in the past.

The agriculture sector is bearing a large part of the losses and damages associated with these water-related extreme events (OECD, 2016). The Food and Agriculture Organization (FAO) has estimated that 30% of all damages caused by 140 weather-related natural disasters between 2003 and 2013 in developing countries were borne by agriculture (FAO, 2015). Agriculture accounts for 84% of the economic impact of droughts (Ibid.). Droughts, cyclones, floods and cold waves have led to agriculture crop and livestock production losses worth USD 80 billion. In OECD countries, droughts have been particularly damaging for agriculture, leading to reductions in crop yields and farm revenues, or to large increases in crop insurance compensation (OECD, 2016). More generally, Lesk et al. (2016) estimate that severe droughts and extreme heat events between 2000 and 2007 were responsible for crop losses equivalent to 6% of global cereal production.

1.2. Water risk projections depict a bleak future for agriculture in many regions

There is increasing concern about the availability of usable water resources in the medium and long term. In its 2015 ten-year risk-landscaping exercise, the World Economic Forum (WEF) identified water crises as potentially having the single greatest impact on economies in the medium term (WEF, 2015). The fifth assessment report of the Inter-government Panel on Climate Change (IPCC) emphasised the central role of water risks, noting that significant water effects have been attributed to climate change in many regions (Pachauri et al., 2014). Business-as-usual scenarios, such as those used in the OECD Environmental Outlook, combining climate impacts on supply and demand projections up to 2050, also foresee pressure on the quantity of fresh water and deteriorating water quality. The Environmental Outlook projections attributed its highest risk ratings to (i) quantitative water stresses for more than 40% of the population, (ii) flood risk to nearly 20% of the world's population, (iii) groundwater depletion in many regions, and (iv) expected decrease in the quality of surface water, especially in non-OECD countries (OECD, 2012a).

Regional and country analyses confirm these assessments (OECD, 2014a). On the quantitative side, existing evidence suggests that the water cycle will accelerate with more frequent episodes of strong precipitations in high latitudes and fewer in lower latitudes (Buckle and Mactavish, 2013; OECD, 2014a).[2] For example, Southern Europe is expected to face a significant reduction in the availability of surface water (Forzieri et al., 2014), coupled with increased seasonal variations in precipitation (more intense in winter), resulting in negative groundwater recharge overall (MEDDE, 2012). Australia will be increasingly vulnerable to rises in sea level (OECD, 2014a), while flooding costs in Europe could increase five-fold by 2050 (Jongman et al., 2014). By 2030, baseline scenarios find flood risks doubling in urban or rural areas, with the greatest risks in Asia (Sadoff et al., 2015). Long-term water management decisions upstream may also result in exacerbated regional water risks downstream in other countries, with significant economic, environmental and social consequences (Orr et al., 2012).

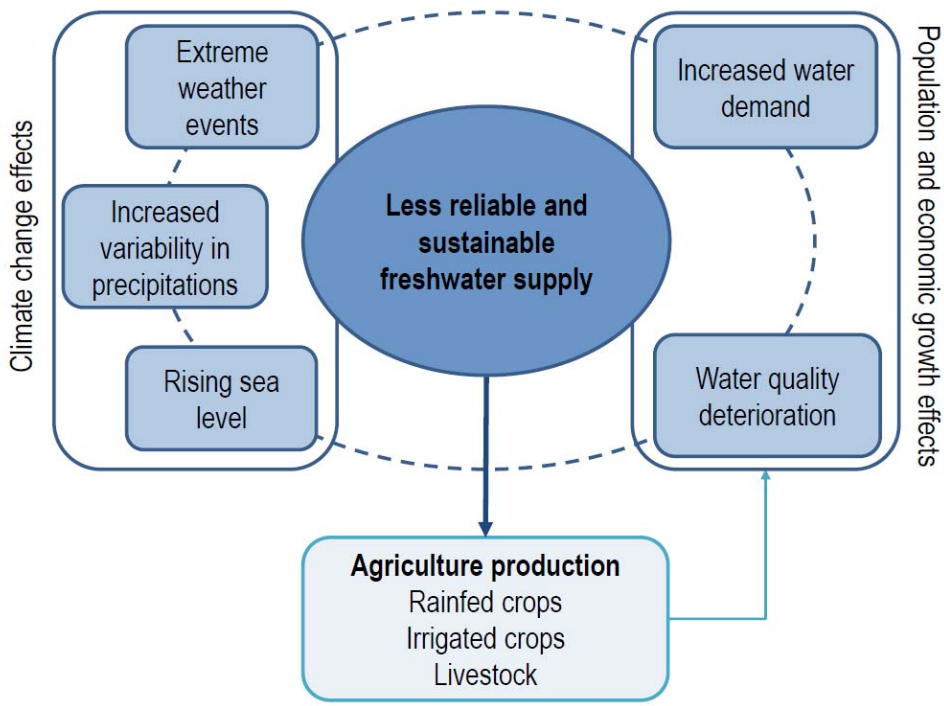
Water quality is projected to deteriorate in multiple regions due to human activity and climatic factors. Increased discharge of nitrogen and phosphorus from agriculture and other sectors resulting in eutrophication are projected particularly in parts of Sub-Saharan Africa, India and Southeast Asia (IFPRI and Veolia, 2015). These changes will be exacerbated under a drier climate.[3] Climate change-induced sea level rises will increase the risk of saline intrusion in coastal aquifers (Jiménez Cisneros et al., 2014), affecting the quality of groundwater in multiple regions, including Japan, Mexico and the Netherlands (OECD, 2015). Dryland salinity is expected to expand over the next few decades in Australia because of changes in precipitation patterns (Hart et al., 2003).

These water risks are expected to strongly impact agriculture, a highly water-dependent sector (UNEP, 2016). Agriculture accounts for approximately 70% of the world's water withdrawals and 85% of global freshwater consumption (Pfister and Bayer, 2013). Roughly 80% of cultivated land across the globe is exclusively rainfed, accounting for 60% of the world's crop production (FAO, 2009). The remaining

20% obtains water from irrigation systems to meet all or some portion of crop-water demand, contributing to 40% of global crop production.

All types of agriculture activities could be affected (Figure 1.2). Rainfed agriculture will face changes in precipitation patterns, potentially increasing frequency of extreme events due to climate change (Box 1.1). Irrigated agriculture will face similar types of variability in water supply and demand, with an increase in water demand and competition from other sectors, and water quality challenges threatening its viability (HLPE, 2015).[4] Groundwater depletion in some semi-arid areas may affect the productivity potential of major cropping systems and their resilience to climate change (OECD, 2015). It is expected that declines in water quality, due in part to irrigation-induced salinity and soil erosion, will affect freshwater availability for agriculture (OECD, 2012b). Rising seawater levels will affect coastal croplands and deltas (ADB, 2011), and droughts and floods will affect livestock productivity (OECD, 2014a).

Figure 1.2. Agriculture production is projected to face a combination of water risks



Note: Arrows represent the main impacts of water risks on agriculture and of agriculture on water risks.

Source: Author's own work.

Box 1.1 Water risks for agriculture under climate change

Climate change will have multiple impacts on the water cycle for agriculture. Three variables are critical to agriculture: higher temperatures, future precipitation patterns and their distribution throughout the year, and the incidence of extreme weather events. The main consequences of changes in water resources for agriculture production include:

- Increased crop evapotranspiration due to rising temperatures (up to a maximum heat threshold), which may increase crop demand for water.
- Increased water shortages, particularly during the spring and summer months with increased water requirements for irrigation. This will be especially difficult in areas already suffering from water stress.
- Reduced snowpack, affecting the seasonal flow of surface water for irrigators.
- Expansion of crop irrigation calendars raises irrigation requirements.
- Increased risk of flooding due to the expected concentration of rainfall during the winter months.
- Reduced water quality due to higher water temperatures and lower levels of water runoff in some regions, imposing further stress in irrigated areas. Other factors include increased sediment, excessive nutrient, and pollutant loadings from heavy rainfall.
- Increase in sea levels affecting agriculture production in low-lying coastal areas.

Source: OECD (2014a), Iglesias and Garrote (2015), Fischer et al. (2007).

As a key agriculture input, the availability of usable water will have an impact on production at the local level as well as on markets and consumers on a much wider scale. Multiple studies have shown that irrigated crop yields are significantly higher than those from rainfed agriculture (Hertel and Liu, 2016; WWAP, 2012). It also generates more value, for instance in the United States, in 2012, the average value of farm products by irrigated farmers was about 3.9 times the average value for non-irrigated farms (Schaible and Aillery, 2016). This could have both local and global repercussions, affecting local production, which relies on irrigation, and broader agriculture markets and consumers. In particular, water risks related to climate change will contribute to exert pressure on agriculture markets by increasing commodity prices (Ignaciuk and Mason D'Croz, 2014; Ignaciuk et al., 2015). For instance, Sadoff et al. (2015) estimated that ensuring "full water security" for irrigated agriculture[5] would decrease the probability of global wheat production falling below 650 million tonnes per year from 83% to 38%, and the probability that the price of rice could exceed USD 400 per tonne from 21% to 0.7%. Overall, water security for irrigation could generate welfare benefits of USD 94 billion (Ibid.).

Water quality could also impact agriculture significantly in a number of ways (OECD/Ringler, 2011; OECD, 2014a). Reduced water quality can decrease plant growth and increase livestock contamination, thus affecting agriculture productivity (OECD, 2013b). Salinity may affect up to 20% of irrigated areas globally and threaten nearly half of all irrigated areas in the long term (Le Kama and Tomini, 2013). One and half million hectares of agriculture land is taken out of production annually as a result of land salinity with total costs for producers potentially exceeding USD 11 billion per year (Schoengold and Zilberman, 2007). Plants can absorb toxic chemicals from contaminated water and pass them on to humans and animals who consume them (OECD, 2013b). Toxic contamination of water bodies may poison livestock and generate losses in the meat processing and milk industries. For example, 80% of the milk supply in Hawaii was disrupted in 1982 following water contamination by the insecticide heptachlor, generating a loss of USD 8.5 million for the milk industry (Pimentel, 2005).

These water risks, in isolation or in combination, could have much wider food security implications (Hanjra and Qureshi, 2010; Ringler et al., 2010), "threatening the sustainability of livelihoods dependent on water and agriculture" in key production regions (FAO and WWC, 2015). Stresses on groundwater resources in highly populated irrigated areas could result in a significant impact on food security for millions (Famiglietti, 2014). Food-insecure regions, especially in parts of Sub-Saharan Africa, which depend on rainfed agriculture, could further suffer from repeated droughts (Ringler et al., 2010).[6] Fisheries in the Mekong River basin will suffer from any shortage of water associated with upstream dam-induced water stresses, with millions of people at risk of losing critical protein and income sources (Orr et al., 2012). Irrigation will likely have to play a more important role in agriculture in some of these regions, but in a context of increased competition for water both within and outside the sector (Ibid.).

Acute water risks in agriculture regions will also impact the environment. Ecosystems in rural areas could be directly affected by droughts (OECD, 2016). Associated with heat, droughts facilitate wild fires that ravage entire forest systems. Water quality will decrease in regions with water shortages due to the increased concentration of pollutants further impacting water dependent species (OECD, 2012a). Extreme weather events may also damage the environment and limit its resilience to future shocks.

1.3. How can policy respond to emerging water risks?

While agriculture is expected to be impacted by future water stresses, it can also play a significant role in mitigating these risks. The agriculture sector is a significant emitter of greenhouse gas and therefore has a role to play in addressing human-induced climate change (MacLeod et al., 2015). Agriculture is also the largest freshwater consuming sector intrinsically linked to improved water resource management, which can happen via a more efficient use of water in addition to reducing the sector's negative impact on water quality (OECD, 2014a). Irrigation, for example, has been supporting agriculture productivity, but pollution from large irrigation schemes has affected 34 million hectares globally to date (Mateo-Sagasta and Burke, 2011). In most cases the effect of irrigation on groundwater recharge will be positive; however, groundwater quality can be impacted by diffuse pollution from agriculture practices such as fertiliser and manure spreading (Böhlke, 2002). Better agriculture and water management policies can help mitigate these impacts as well as those stemming from droughts and floods (OECD, 2016).

These interlinked challenges are often not adequately addressed by national policies due to their complexity and the importance of local differences. A targeted or "hotspot" approach could be an effective and cost efficient way to address future agriculture water risks. It would require the identification of specific areas where future agricultural water risks are expected to be the greatest within a particular geographic or administrative area and the use of targeted actions to limit potential negative impacts.

This report aims to assess and propose policy responses to mitigate the effects of acute future water risks in localised productive agriculture regions (hotspots) for agro-food systems and markets. The proposed hotspot approach is defined to be used at any geographical or administrative level. At the same time, the report specifically considers hotspots that can have cross-border implications, analysing direct future risks to agriculture production in water stressed countries, but also indirect risks via market effects driven by deteriorating water conditions in other countries.

This report builds on OECD work on climate change, water, and agriculture (OECD, 2013a and 2014a), water quality (OECD, 2012b), the management of agriculture risks (OECD, 2009 and 2011), effective targeting of agriculture policies (OECD, 2007), and water security (OECD, 2013b).[7] It adds to the existing body of work in four ways.

The report addresses three questions:

1. *Where are the future water risk hotspots for agriculture?* This report defines the hotspot approach and then applies this method to identify some of the most pressing geographic and commodity-specific water risk hotspots for agriculture production, agro-food systems and markets, globally, using available data, and acknowledging uncertainties in models and projections, trade-offs in scale of analyses, and types of risks.

2. *What are the implications of water risk hotspots for agriculture production and markets, and more widely for food security?* This report offers an analysis of the expected impacts on agriculture markets related to water risk hotspots in hotspot and non-hotspot areas, and the broader consequences they may have on food security.

3. *How can public policy mitigate these risks?* The role, effectiveness and efficiency of current and future public policies to manage risks is analysed in hotspot and non-hotspot areas, taking into account endogenous farm-level and market-driven adaptation actions, as well as forward-looking actions by private agro-food sector companies.

Chapter 2 discusses the relevance and methods to use the hotspot approach and applies the approach by conducting an assessment of global future water risk hotspots for agriculture production based on existing literature and agriculture baseline projections. Chapter 3 analyses the implications of water risk hotspots for the agro-food sector and broader food security. Chapter 4 proposes a policy action plan to mitigate critical future water risks and their propagation at the local, market and broader level.

Notes

1. Recent research has used refined methods to evaluate water risks at the global, regional or local level. In particular, better data and more sophisticated analyses have measured groundwater depletion rates (e.g. Famiglietti, 2014; Gleeson et al., 2012), identified regions most subject to floods or droughts damages (Sadoff et al., 2015), and evaluated the irrigation area, cities and population facing water scarcity (e.g. Hanasaki et al., 2008; Brauman et al., 2015; Mekonnen and Hoekstra, 2016).

2. The IPCC projects that climate change will "reduce renewable surface water and groundwater resources in most dry subtropical regions (robust evidence, high agreement), intensifying competition for water among sectors (limited evidence, medium agreement)" (Pachauri et al., 2014; Jimenez Cisneros et al., 2014).

3. Climate change is projected to increase water temperatures and precipitation intensity, and induce longer periods of low flows which will "exacerbate many forms of water pollution, including sediments, nutrients, dissolved organic carbon, pathogens, pesticides, salt and thermal pollution" (Bates et al., 2008).

4. Surface water or groundwater may be subject to risks of depleting quality due in particular to inadequate wastewater treatment or pollution activities making it unusable.

5. Defined here as the absence of water security constraints (quality, quantity) for agriculture.

6. For instance, Pauw et al. (2010) show that droughts and floods result in losses of 1.7% GDP due to their effects on agriculture. Small-scale farmers in lowlands are the most affected by floods. Agriculture losses can create food shortages and price increases with direct effect on urban populations.

7. In a broader policy setting, OECD (2010) provided strategic management approaches to future shocks, including extreme events and natural catastrophes. The report served as a foundation for the OECD recommendation on critical risks (OECD, 2014b), outlining five necessary axes of governance: supporting a comprehensive approach to critical risks, ensuring preparedness, raising awareness, and building adaptive capacity in crisis management, all to be done in a transparent and accountable manner.

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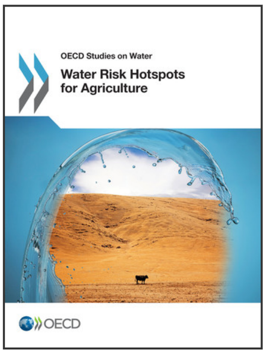

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