

## Executive summary

**The impacts of climate change on freshwater systems and their management are mainly due to the observed and projected increases in temperature, sea level and precipitation variability (very high confidence).**

More than one-sixth of the world's population live in glacier- or snowmelt-fed river basins and will be affected by the seasonal shift in streamflow, an increase in the ratio of winter to annual flows, and possibly the reduction in low flows caused by decreased glacier extent or snow water storage (high confidence) [3.4.1, 3.4.3]. Sea-level rise will extend areas of salinisation of groundwater and estuaries, resulting in a decrease in freshwater availability for humans and ecosystems in coastal areas (very high confidence) [3.2, 3.4.2]. Increased precipitation intensity and variability is projected to increase the risks of flooding and drought in many areas (high confidence) [3.3.1].

**Semi-arid and arid areas are particularly exposed to the impacts of climate change on freshwater (high confidence).**

Many of these areas (e.g., Mediterranean basin, western USA, southern Africa, and north-eastern Brazil) will suffer a decrease in water resources due to climate change (very high confidence) [3.4, 3.7]. Efforts to offset declining surface water availability due to increasing precipitation variability will be hampered by the fact that groundwater recharge will decrease considerably in some already water-stressed regions (high confidence) [3.2, 3.4.2], where vulnerability is often exacerbated by the rapid increase in population and water demand (very high confidence) [3.5.1].

**Higher water temperatures, increased precipitation intensity, and longer periods of low flows exacerbate many forms of water pollution, with impacts on ecosystems, human health, water system reliability and operating costs (high confidence).**

These pollutants include sediments, nutrients, dissolved organic carbon, pathogens, pesticides, salt, and thermal pollution [3.2, 3.4.4, 3.4.5].

**Climate change affects the function and operation of existing water infrastructure as well as water management practices (very high confidence).**

Adverse effects of climate on freshwater systems aggravate the impacts of other stresses, such as population growth, changing economic activity, land-use change, and urbanisation (very high confidence) [3.3.2, 3.5]. Globally, water demand will grow in the coming decades, primarily due to population growth and increased affluence; regionally, large changes in irrigation water demand as a result of climate change are likely (high confidence) [3.5.1]. Current water management practices are very likely to be inadequate to reduce the negative impacts of climate change on water supply reliability, flood risk, health, energy, and aquatic ecosystems (very high confidence) [3.4, 3.5]. Improved incorporation of current climate variability into water-related management would make adaptation to future climate change easier (very high confidence) [3.6].

Adaptation procedures and risk management practices for the water sector are being developed in some countries and regions (e.g., Caribbean, Canada, Australia, Netherlands, UK, USA, Germany) that have recognised projected hydrological changes with related uncertainties (very high confidence).

Since the IPCC Third Assessment, uncertainties have been evaluated, their interpretation has improved, and new methods (e.g., ensemble-based approaches) are being developed for their characterisation (very high confidence) [3.4, 3.5]. Nevertheless, quantitative projections of changes in precipitation, river flows, and water levels at the river-basin scale remain uncertain (very high confidence) [3.3.1, 3.4].

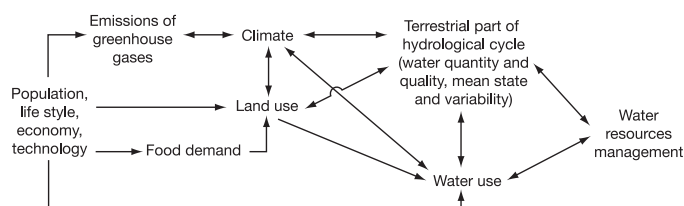
**The negative impacts of climate change on freshwater systems outweigh its benefits (high confidence).**

All IPCC regions (see Chapters 3–16) show an overall net negative impact of climate change on water resources and freshwater ecosystems (high confidence). Areas in which runoff is projected to decline are likely to face a reduction in the value of the services provided by water resources (very high confidence) [3.4, 3.5]. The beneficial impacts of increased annual runoff in other areas will be tempered by the negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality, and flood risks (high confidence) [3.4, 3.5].

## 3.1 Introduction

Water is indispensable for all forms of life. It is needed in almost all human activities. Access to safe freshwater is now regarded as a universal human right (United Nations Committee on Economic, Social and Cultural Rights, 2003), and the Millennium Development Goals include the extended access to safe drinking water and sanitation (UNDP, 2006). Sustainable management of freshwater resources has gained importance at regional (e.g., European Union, 2000) and global scales (United Nations, 2002, 2006; World Water Council, 2006), and 'Integrated Water Resources Management' has become the corresponding scientific paradigm.

Figure 3.1 shows schematically how human activities affect freshwater resources (both quantity and quality) and their management. Anthropogenic climate change is only one of many pressures on freshwater systems. Climate and freshwater systems are interconnected in complex ways. Any change in one



**Figure 3.1.** Impact of human activities on freshwater resources and their management, with climate change being only one of multiple pressures (modified after Oki, 2005).