4.3.3 Increasing water demands and resilience

Water demand, withdrawal and consumptive use are growing rapidly in many parts of the world, compounded by water quality degradation, in response to population increases and economic development, changes in lifestyles and diets, and technological development. The resulting overexploitation is demonstrated e.g. in lower groundwater tables, reduced river discharge, compromised environmental flows and basin closures (Falkenmark and Molden, 2008). Box 4.6 highlights areas of groundwater overexploitation, in particular in India, China, western Asia, North Africa, the United States and Mexico.

Groundwater serves as storage which buffers dry seasons or droughts and at the same time avoids evaporative losses and reduces vulnerability to pollution, compared to surface water storage. The loss of these functions through overexploitation – which can also result in irreversible saltwater intrusion and the compaction of aquifers – is likely to reduce the resilience of groundwater-dependent social–ecological systems.

Like groundwater, surface water and its respective aquatic ecosystems can be overexploited and degraded in terms of structure, diversity, functions and services (Arthington et al., 2009), and with it the resilience of the social–ecological systems that depend on it. Box 4.7 summarises current knowledge on environmental flows and the methods for assessing and implementing them.

| Box 4.5 Coping with a chaotic climate in Australia |

**Will Steffen**, The Australian National University and Climate Commissioner

**Large hydrological variability**

Australia is the ‘land of drought and flooding rains’, a continent with a historically high variability in its hydrological cycle that has created water challenges for its inhabitants for 60,000 years. Indigenous Australians used their high level of mobility to follow the resources that moved across the landscape in response to a variable climate. European and Asian Australians, with a vastly shorter period of experience on the continent and a more sedentary lifestyle, are still learning to cope with this variability.

The challenge now is to understand not only how modes of natural variability – ENSO, Indian Ocean Dipole (IOD), Southern Annual Mode (SAM) and Pacific Decadal Oscillation (PDO) – work and how they interact with each other, but also how the underlying trends of global climate change are interacting with these existing modes of natural variability to produce novel patterns of rainfall and water availability. Although some progress is being made with understanding how some of the physical processes that influence Australia’s rainfall are changing (e.g. Frederiksen et al., 2011; Nicholls, 2010; Timbal et al., 2010), much remains uncertain and the level of confidence in future predictions is low for much of the continent.

**Rainfall reliability**

In the face of such uncertainty, the agricultural sector, for example, is developing new ways of gaining insights into changing rainfall patterns to help it cope with the future. The concept of rainfall reliability, rather than variability, has been developed to help the cropping sector cope with change in water availability (Steffen et al., 2011). Reliability refers to the distribution of rainfall through a particular period relevant to a user group, for example, a growing season (e.g. whether a location receives a certain amount – say 25 mm – per month for the period). Figure 4b5.1 shows the change in the reliability of autumn rainfall over the past 100 years. The pattern is complex, but one location – the southwest corner of Western Australia – shows a clear decrease in reliability.

**Rainfall amounts have changed**

This decrease in rainfall reliability has been accompanied by a decrease in the absolute magnitude of rainfall, which together mean that overall water availability is decreasing and the availability of water throughout the year is becoming less predictable.
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**Box 4.5** Coping with a chaotic climate in Australia

WILL STEFFENS, THE AUSTRALIAN NATURAL HISTORY AND LAND USE COMMISSION

**Large hydrological variability**

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**Rainfall reliability**

In the face of such uncertainty, the agricultural sector, for example, is developing new and higher levels of resilience into changing rainfall patterns to help it cope with the future. The concept of rainfall reliability, rather than variability, has been developed to help the cropping sector cope with change in water availability (Steffen et al., 2011). Reliability refers to the distribution of rainfall through a particular period relevant to a user group, for example, a growing season (e.g. whether a location receives a certain amount – say 25 mm – per month for the period). Figure 4.5.1 shows the change in the reliability of autumn rainfall over the past 100 years. The pattern is complex, but one location – the southwest corner of Western Australia – shows a clear decrease in reliability.

**Rainfall amounts have changed**

This decrease in rainfall reliability has been accompanied by a decrease in the absolute magnitude of rainfall, which together mean that overall water availability is decreasing and the availability of water throughout the year is becoming less predictable.

Interestingly, because these trends are now known with some certainty, the ability of people in the region to cope with these changes is surprisingly high. Figure 4.6.5.2 shows the change in inflow to the water supply dams of the city of Perth over the past century, with a sharp, stepped decrease beginning in the mid-1970s. The city has coped well so far, with a combination of increases in efficiency in the water system, demand management and the construction of two desalination plants.

The agricultural sector in the region, which is dominated by wheat production, has also coped well. Despite the drop in rainfall from the mid-1970s, wheat yields actually increased over the same period because of a range of changes in technology and management that were adopted, some for reasons unrelated to the rainfall change but some directly in response to it. An example of the latter is the use of previously waterlogged areas for crop production, while an example of the former is the widespread adoption of no-till agriculture, which conserves soil moisture (Steffen et al., 2006). However, following the very dry conditions in 2010, production of wheat and other winter crops in 2010–11 was 43% lower than for the previous season (ABARES, 2011).

**The Millennium Drought, 1997–2009**

Where reliability, variability or longer-term trends are not changing in such clear patterns, however, it is much more difficult to cope with changes in water availability. Unfortunately, this is the case for much of Australia, including the more heavily populated southeastern region. A crippling drought from 1997 to 2009, which threatened urban water supplies in Melbourne, Sydney, Brisbane and Canberra and led to severe water use restrictions in those cities, was suddenly and dramatically broken in mid-2010 by a period of heavy rainfall and flooding along much of the east coast. December 2010 was the wettest December ever recorded in eastern Australia (BoM, 2011). These rapid and dramatic swings in water availability have undermined efforts to secure water resources for the future in some areas, as actions planned to respond to a drying climate have now been called into question.

**Towards resilience to chaotic shocks**

Only in a few places in Australia – the southwest corner of Western Australia and some areas of the continent – can coping responses be made to directional changes in rainfall or water availability with a high degree of confidence. In most places, the country faces a highly uncertain future with changes in water availability of both uncertain magnitude and uncertain direction (wetter or drier). This implies that building the general resilience of water systems to chaotic shocks and uncertain trends is more appropriate than trying to adapt to directional changes that have high levels of uncertainty. Australia is still the land of drought and flooding rains, but they are perhaps becoming less predictable and more extreme.

Box 4.8 describes that hydro-climatic conditions in combination with socio-economic trends (through changes in water demand) can affect the resilience of water-scarce regions. The North China Plaist have much higher population pressure than...