Water in Australia – assessing Australia's available water resources and use

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Key Points

- Knowledge on water resource conditions built on national consistent data can support better management and strategic developments
- The '*Water in Australia'* reports are a compendium of annual information on the status of Australia's water resources: where, why and how much water is available and how much is used
- Australia's rainfall has changed since 1950 with increasing trends in the North and declining trend in the West, East and South – a trend likely to continue in the future – which has implication for water resource management and security also in relation to a growing population
- The 2013–14 assessment period followed much the overall pattern of the existing long-term rainfall changes
- On average in 2013–14 more water was made available (31 500 GL) than used (23 500GL), but water shortages were experienced in some parts of the country

Abstract

To improve water management of Australia's water resources the Bureau of Meteorology, at the peak of the Millennium drought in 2008 was tasked by the Australia government to 'provide water data necessary for good decision-making by governments and industry'. Since then the Bureau has been building capacity to integrate and convey information about weather, climate and water helping to better respond to the inherent risks of the Australian water resources. To support decision making, the *Water in Australia* report provides information on the current water resource condition and issues in the face of a changing climate and growing population. The report will be of value to government agencies, policy makers, industry, researchers and educators looking for an insight into the key water issues in Australia.

Keywords

Australian water resources, assessment, water availability, water use, long-term changes, trends, water security

Introduction

Water is one of the world's most important resources and usable, accessible water resources are becoming a matter of increasing concern across many countries in the world. Australia is no different to this. By nature Australia's rainfall and streamflow is one of the most variable in the world. On average, less than 10 per cent of rainfall becomes streamflow in rivers in Australia, with large geographic variations. Higher runoff is only generated in the summer-rainfall-dominant area in the north and in winter-rainfall-dominant areas in the south, like Tasmania and the southern and eastern headwater areas of the Murray–Darling Basin. Frequent droughts and floods as well as the general high variability in streamflow make water resource management quite challenging in this country. It involves designing infrastructure that is able to cope with such variability. For example, the high streamflow variability, combined with high evaporation rates and the need for flood protection, has led to relatively large storage volumes in some areas. Also, environmental releases have to be considered in dam operations because Australian fauna and flora have evolved around high streamflow variability.

Knowledge of water resource conditions based on data that is relevant, nationally consistent and readily available can help for example to use water resources more wisely or to protect the natural environment. This article introduces one of the Bureau's products: the '*Water in Australia*' report summarising the water situation across Australia for a financial year. It identifies existing water resource issues in the face of a changing climate and growing population. Future reports will be similar in content to this report, covering the water situation across the continent for the previous year and putting that in the context of longer term changes and patterns. Thus, the *Water in Australia* series is designed to become a useful set of reference documents on the characteristics of the country's water resources and their use over time, and to provide annual updates to enable us to identify emerging issues.

Material and Methods

Water in Australia draws on a range of Bureau's information products and sources of information to describe the characteristics and conditions of Australia's water resources, availability and use for the financial year starting from 1 July to 30 June in the following year.

Information on physical resource includes rainfall, groundwater, streamflow and specific climate drivers in the reporting year. The streamflow and groundwater data used in this report was supplied by almost 200 organisations across Australia. In addition the Bureau's operational Australian Water Resources Assessment Landscape model was used to produce gridded and spatial distributed water balance estimates for potential and actual evapotranspiration, soil moisture and runoff (http://www.bom.gov.au/water/landscape/).

Water availability and use information includes entitlements, storages, water supply as well as commercial and environmental water use. The estimates are based on a variety of sources, including the Bureau's National Water Account (www.bom.gov.au/water/nwa) and other Bureau products (www.bom.gov.au/water), water license registers of various States and Territories, water sharing plans and local reports.

Water in Australia is complemented by two online products showing water resource information at various local scales: (i) the 'Regional Water Information' product showing spatial information down to a river region level on the status of water resources during the assessment year (http://www.bom.gov.au/water/rwi) and (ii) the 'Monthly Water Update', which provides regular snapshots of rainfall and streamflow for the previous month relative to average conditions (http://www.bom.gov.au/water/monthly-water-update).

Results and Conclusions

To demonstrate the nature of the report, results of the *Water in Australia* 2013–14 report are shown as follows. The *Water in Australia* reports are available at http://www.bom.gov.au/water/waterinaustralia.

Long-term changes to rainfall and runoff

In Australia many climate influences exist driving the amount and distribution of rainfall, runoff and streamflow. These drivers have varying levels of impact in different regions and at different times of the year, e.g. the El Niño–Southern Oscillation (ENSO). El Niño can results in drier conditions over much of eastern Australia, while La Niña is associated with higher than average winter, spring and early summer rainfall over much of Australia.

Since 1950, rainfall patterns across Australia have changed significantly (Frederiksen and Grainger 2015). Increasing rainfall has been observed in Australia's north and northwest, mostly associated with increases in daily rainfall intensity and frequency during the wet seasons (Gallant et al. 2014). These combined increases in rainfall have been large enough to increase the average rainfall total of Australia by 50 mm in 1970–2013 compared to the 1900–1969 period. However, the mechanisms for this increase remain uncertain (Bureau of Meteorology and CSIRO 2014).

Along the west coast, particularly southwest Western Australia, much of eastern Australia as well as southern Victoria, rainfall has declined by 20–50 mm on average per decade since 1950 (Figure 1). In south-eastern Australia, 1997–2009 was the driest 13-year period since the start of instrumental records in 1900. The rainfall changes are generally most pronounced for the high rainfall seasons, autumn–winter in the south and east and summer to the north-east, which generate the majority of runoff. Even during the record-breaking 2010–2012 La Niña years, in which exceptional wet conditions broke the Millennium Drought, the lack of autumn and winter rainfall continued. Across southwestern Australia the rainfall decline is also largely due to failures of late autumn and early winter rainfall (Bureau of Meteorology and CSIRO 2014). It is also associated with the reduction in high-rainfall years since the mid-1990s, caused by a decline in the number of days with rainfall. At the same time, summer rainfalls have increased, but not enough to counterbalance the winter rainfall decline, given the high summer evapotranspiration rates.

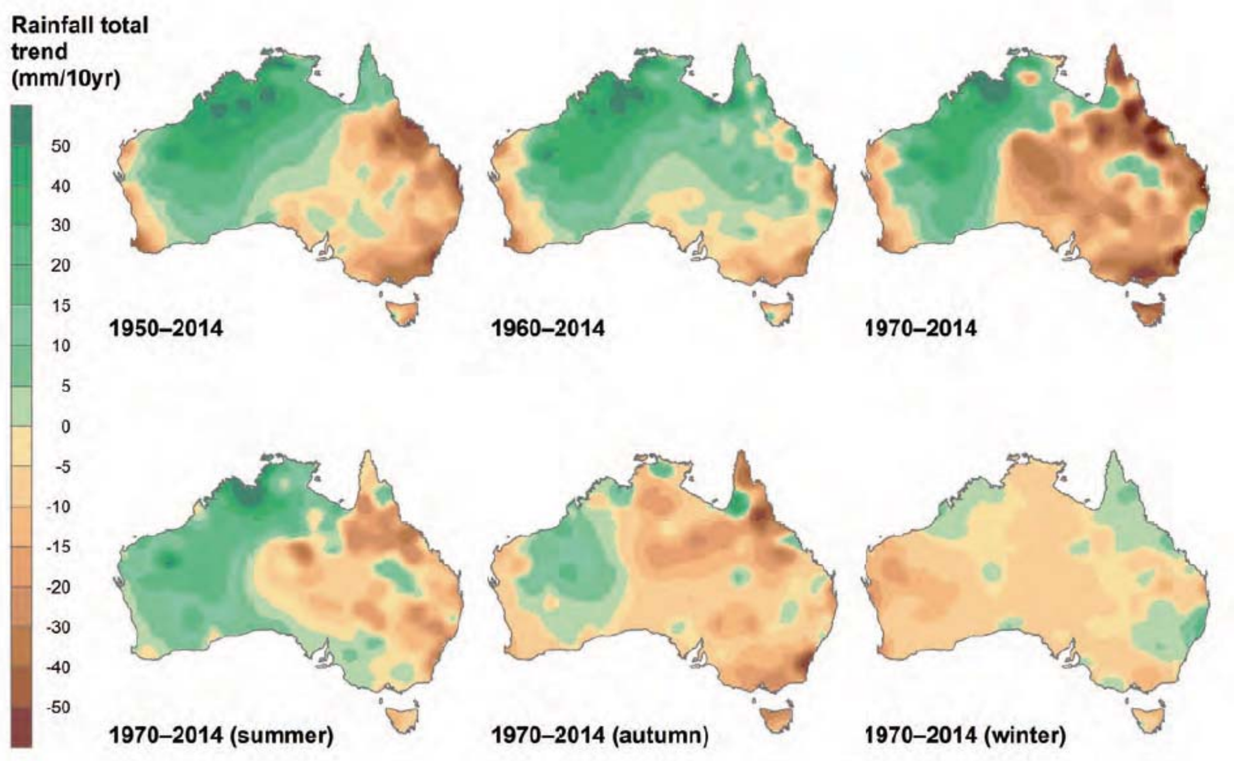

Figure 1. Rainfall total trends for Australia and changes in seasonal summer, autumn and winter rainfall from 1950–, 1960– and 1970–2014

The rainfall decline in southern Australia has, to some degree, been associated with global warming (Timbal et al. 2010). The changes in surface climate are associated with changes in the mean meridional circulation, which is the mechanism for the global transfer of heat from the warmer equatorial region to the cooler polar regions. This change can also be described as an expansion of the tropics (Lucas et al. 2014). In response, high pressure systems that usually sit over the arid centre of Australia have also moved southward and intensified, pushing rain-bearing fronts and low pressure systems south, not allowing them to pass over the continent (Timbal et al. 2006, CSIRO 2012, Timbal and Drosdowsky 2013). These changes can be reproduced in climate models when anthropogenic forces are used, thus linking these global climate changes to global warming

(Nguyen et al. 2015). However, uncertainties remain about the mechanisms of this change, and it is an area of active research (Hope et al. 2015).

Runoff generation and streamflow volumes have amplified responses to the decadal changes in rainfall. The rainfall and streamflow decline is of great concern because the major population centres and most agricultural activity occur in these areas and, consequently, use of water resources is highest. A reduction in rainfall typically results in a proportionately larger decline in streamflow. As a general principle, a 10 per cent decrease in rainfall can result in a 20–30 per cent decrease in streamflow (Chiew 2006). This relationship is likely to vary for individual catchments, as well as over time (Potter et al. 2008). As a response to changes in rainfall, increasing streamflow is observed in the north, whereas declining streamflow is observed in the southwest, southeast and east (Zhang et al. 2014). Reduced rainfall leads to loss of soil moisture, surface runoff and groundwater recharge. In addition, runoff generation and, subsequently, streamflow can be indirectly affected by mostly gradual changes in catchment characteristics such as vegetation cover or soil properties.

In the southeast and on the east coast, trends of declining runoff are strongest in the headwater areas of major river systems (Figure 2). This is a cause of much concern for water resource management because these are areas where the majority of flow is typically generated. For example, the declining streamflow in the southwest since the mid-1970s has caused a 70 per cent decline in annual inflows into reservoirs in this region (Bates et al. 2008), forcing major augmentation of water supplies.

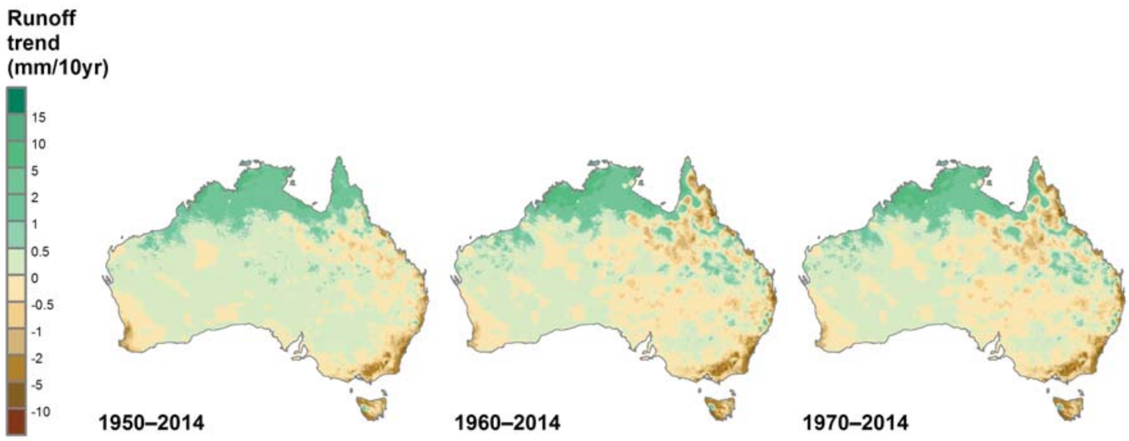

Figure 2. Runoff total trends for Australia from 1950–, 1960– and 1970–2014

With the observed changes in rainfall and runoff over the last few decades—in particular, the decline in surface water availability in some parts of Australia—water resource conditions such as rainfall, streamflow and groundwater need to be closely monitored and assessed. Water resource conditions showed many regional features of the recent decadal changes in rainfall patterns across Australia.

The water resource situation in 2013–14

The neutral ENSO conditions in 2013–14 suggested a return to average rainfall, but rainfall patterns in many places followed the decadal changes, with reduced rainfall in the west and east, and higher rainfall in the north as well as in much of northern Western Australia. Streamflow in these areas responded accordingly. In southern Queensland and northern New South Wales, a severe drought, which started in 2012, continued in 2013–14, with streamflow being very much below average in drought-impacted areas, particular the Northern Rivers, Gwydir and Namoi catchments impacting on irrigation and urban supplies.

Groundwater levels often respond slower to rainfall conditions. In 2013–14 most of the bores had average levels, except in South Australia and Queensland, where more than one-third of all bores had an above-average level. Below-average groundwater levels were present in 5–20 per cent of bores in each State and Territory (Figure 3).

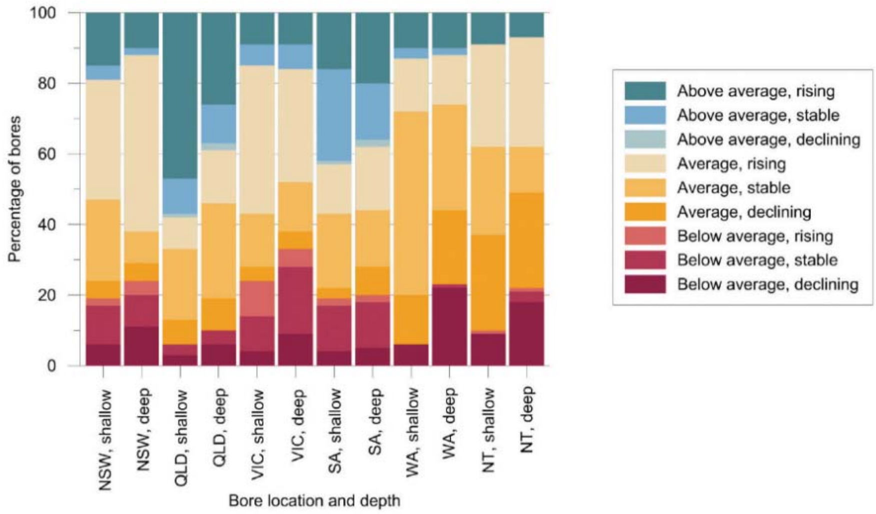

Figure 3. Summary of combined groundwater-level trends (2009–2010 to 2013–14) and status (average level for 2013–14 compared to 20-year average) by State and Territory

Water available for use

Australia has extensive water supplies, and their use is managed by various institutional arrangements. The majority of water that is made available for use is through storages (Figure 4), which at the end of the reporting period were on average at 63 per cent capacity.

Urban centres have also increased their climate resilience towards water supply capacity, mainly in response to the declining rainfall and the Millennium drought. Increasingly recycled and desalinated water is now used (Figure 4).

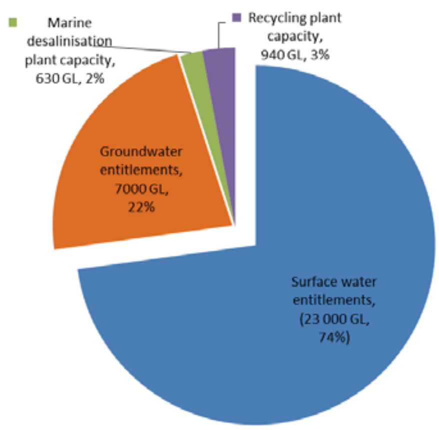

Figure 4. Water available for use across Australia at 30 June 2014

Greater protection is also being afforded to the environment through the purchase of entitlements from water users and by investments in water-saving infrastructure. Environmental water holders in the Murray–Darling Basin held 3192 giga litres (GL) of surface water entitlements at the end of 2013–14 (increasing from

3160 GL at the end of 2012–13). Of the total allocated environmental water available in 2013–14, 68 per cent was delivered for environmental purposes and 27 per cent was carried over to 2014–15. Some of this was made available through entitlement and allocation trading, which was close to 2400GL, respectively 5500 GL. Water trading mostly occurred within the Murray–Darling Basin (Figure 5). Entitlement trade increased in 2013–14 which can be attributed partly to entitlements being transferred to the Commonwealth for the environment (linked to water-saving infrastructure upgrades) and partly to declining water storage levels that prompted buyers into the market to secure more water.

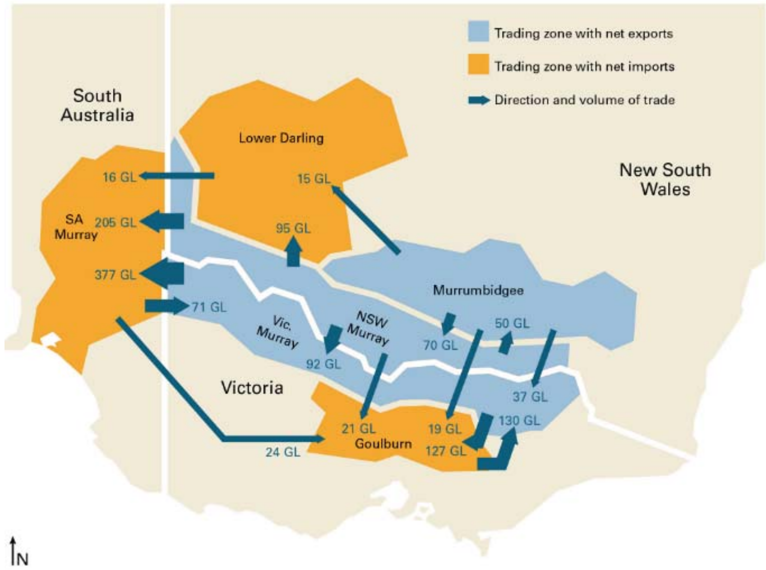

Figure 5. Volume and direction of significant interregional allocation trades in the southern Murray–Darling Basin, 2013–14

Water use

Australia's water resources support its population, agriculture and industry by making water available for various types of uses. The estimated total water use across Australia was 23 500 GL in 2013–14 or 74 per cent of the water being available for use (Figure 6). The top two water uses were irrigation (57 per cent of total use) and urban consumption (17 per cent of total use). The main irrigation use is in the Murray–Darling Basin and was just over 9500 GL in 2013–14. The estimated total surface water use for irrigation in the Murray–Darling Basin decreased from about 11 000 GL in 2012–13 to about 8400 GL in 2013–14—a drop of 24 per cent. Groundwater use for irrigation increased by 18 per cent to just over 1100 GL because of drier conditions and limited surface water allocation announcements, particularly in the northern Murray–Darling Basin. Outside the Basin, around 3900 GL was used for irrigation.

Figure 6. Estimated total water use in Australia, 2013–14.

Total water use in 2013–14 in the major cities shows no significant changes in recent years, with Sydney, Melbourne and South East Queensland all recording slight increases in water use since 2011–12. Sydney, Melbourne and South East Queensland use mainly surface water; Perth and Adelaide are using increasing amounts of desalinated water. Urban residential use in 2013–14 was 185 kL per property, up 3 per cent from 2012–13. However, use per property has not increased significantly from the levels at the end of the Millennium Drought.

Other water uses include mining, electricity production (excluding hydro-electricity), stock and domestic groundwater, plantations and farm dams. Combined, these constitute about 6200 GL, or 26 per cent of total water use across Australia. Some progress is being made in considering and making provision for Indigenous needs relating to water.

Conclusions

Water in Australia 2013–14 is the first publication of a series of reports assessing the annual water resource conditions, water availability and use across Australia based on consistent datasets. Each report will elaborate on key water resource aspects for Australia. For example the *Water in Australia 2014–15* will show how the build-up of an El Niño event influenced water resource conditions. El Niños are associated with above average temperatures and substantially below average winter and spring rainfall, although not always.

The first *Water in Australia 2013-14* report looked into how decadal rainfall changes influenced runoff and streamflow across the country. Many features of the decadal trends in rainfall, runoff and streamflow were recognisable for the July 2013–June 2014 assessment period with wetter conditions in the North and below average conditions in southern and some eastern areas. Overall water use in 2013–14 showed that on average there was more water available than used (an estimated 31 500 GL available compared to 23 500 GL used) but showed regional differences. For example in the northern Murray–Darling Basin the available water for use in storages was about 29 % full where it was 69% full in the southern Basin reflecting the hydro-climatic conditions during the assessment period.

Irrigation was the major user of water, one of the major users being centred in southern Murray–Darling Basin. Since the Millennium drought, there has been a maturing of the water market in this area. This means that, with continually increasing volumes of seasonal water allocations being traded as an adaptation to variable water security, impacts on agricultural production may not be as marked.

Also river ecosystems of the Murray–Darling Basin have been better catered for since the Millennium Drought as a result of nearly 70 per cent of the Basin-wide water recovery requirements being met by 30 June 2014. Some of this has come from purchase of entitlements from irrigation, so less surface water is now used for irrigation.

However, the persistence of dry cool-seasons in southern Australia, and their attribution to changes in climate that are projected to continue, means that it is likely that cool-season runoff will continue to be frequently below the historical average. This has significant implications for future water supplies and water security. Many major cities have augmented their supply systems. Desalination plants, though more expensive, can now supply 10–60 per cent of urban water to all capital cities in mainland southern Australia except Canberra, which has augmented its supplies by increasing storage capacities.

Acknowledgments

The *Water in Australia* reports and the broader Bureau program for improving water information rely on water data collected by almost 200 water management organisations across Australia. In addition, the report has been reviewed by a panel of experts in hydrology, climatology and water resources modelling. We appreciate the valuable contributions of these organisations and individuals.

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