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Glossary

acid sulfate soils: a mix of low-lying coastal clays and sands that contain sulphur-bearing compounds at concentrations above 0.5% in clays and 0.01% in sands

albedo: The fraction of the total light striking a surface that gets reflected from that surface

alluvial: arising from sediments deposited from flowing water

anthropogenic: Produced or caused by human activity

biodiversity: The variety of all life forms: the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form

biomass: The total mass of living material occupying a specific part, or the whole of, an ecosystem at a given time

biophysical environment: The biological and physical elements of an environment

climate: the synthesis of the day-to-day weather conditions in a given area; the actual climate is characterised by long-term statistics of the state of the atmosphere in an area

colonial birds: bird species which congregate in large numbers to feed or nest

domain of acceptable fire intervals: specifies the upper and lower limits of fire intervals, beyond which significant decline of species populations and local extinction is likely; a decline in biodiversity can occur as a result of either too infrequent (above maximum limit or threshold) or too frequent burning (below minimum threshold) (Kenny *et al*. 2004)

East Coast Low: an intense low-pressure system which occurs on average several times each year off the eastern coast of Australia; can cause gale or storm force winds, heavy widespread rainfall, and very rough seas and prolonged heavy swells

ecological community: an aggregation of organisms characterised by a distinctive combination of two or more ecologically related species

ecosystem: a functional system which includes communities of living organisms and their associated physical, non-living environment, which interact to form an ecological unit, such as a tidal rock pool, wetland or forest

El Niño–Southern Oscillation: a natural oscillation in the state of the ocean–atmosphere system that leads to substantial changes in atmospheric circulation throughout the Asia-Pacific region and generally drier conditions in eastern Australia; *see also* La Niña

erosion: the loosening and transportation of soil and other material, chiefly by wind and running water; see also gully erosion, rill erosion, sheet erosion

generalist species: species that are able to thrive in a wide variety of environmental conditions and can make use of many different resources

general security users: those who have 'regulated river (general security) access licences' under the *Water Management Act 2000*; general security users have lower priority of access to water compared with environmental water, 'regulated river (high security) access licences', stock and domestic and town water supply water

geomorphological: relating to the Earth's form, especially the surface and physical features, and the relationship of these to the geological structures beneath

global climate model: mathematical tool for simulating the climate system; based on the physical, chemical and biological properties of the climate system and their interactions

greenhouse gases: atmospheric gases, including carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, ozone and water vapour, which trap heat reflected from the Earth's surface

groundwater: water that occurs beneath the ground held in or moving through saturated layers of soil, sediment or rock

gully erosion: form of erosion involving the formation of deep sided channels or gullies

Indian Ocean Dipole: ocean–atmosphere phenomenon in the Indian Ocean; defined by an index that is the difference between sea surface temperature in the western (50°–70°E, 10°S–10°N) and eastern (90°–110°E, 10°–0°S) tropical Indian Oceans

intertidal: between the levels of low and high tide

La Niña: the extensive cooling of the central and eastern Pacific Ocean; in Australia (particularly eastern Australia) associated with an increased probability of wetter conditions

ozone: a gas made of three oxygen atoms, occurring naturally in the stratosphere where it protects life on Earth from harmful levels of solar ultraviolet radiation; ozone at ground-level is formed from anthropogenic emissions and is a major component of photochemical smog

Ramsar Convention: common name for the *Convention on Wetlands of International Importance Especially as Waterfowl Habitat*, signed in Ramsar, Iran in 1971

Ramsar wetland: a wetland classified as internationally important under the Ramsar Convention

rill erosion: soil erosion resulting in the formation of shallow drainage lines less than 30 cm deep; occurs when surface water concentrates in depressions or low points

run-off: water that flows across the land surface and does not soak into the ground; can be a major agent of soil erosion and can carry pollutants

salinisation: the accumulation of salts in the soil; leads to degradation of soils and vegetation

salinity hazard: the extent to which natural physical characteristics, excluding land cover, predispose a landscape to salinisation; relevant characteristics include topography, soils, geology, climate

sheet erosion: the removal of the upper layers of soil by raindrop splash and/or run-off

sodic soils: soils containing a high proportion of sodium; sodic soils cause poor physical conditions for plant growth and are susceptible to erosion

soil acidification: a reduction in soil pH (increase in acidity)

specialist species: species that can only thrive in a narrow range of environmental conditions

storm bite: the volume of beach sand that can be eroded from the visible part of the beach and dunes during a storm

southern Annular Mode: north–south movement of the strong westerly winds in the middle to higher latitudes of the Southern Hemisphere

weather: the day-to-day state of the atmosphere and its short-term variation

Appendix A: Assessment of hydrological impacts

Run-off projections

The GCMs used as part of the IPCC's work are the best available tools for modelling future climate scenarios. However, temperature and rainfall results produced by GCMs are at too coarse a spatial resolution (typically ≈ 200 km × 200 km) to allow for an appropriate analysis of hydrologic impacts.

In order to manage water resources for the future, the NSW Department of Water and Energy (DWE) undertook a study to investigate how future projections for temperature and rainfall were likely to impact on run-off and water availability for all of New South Wales.

The method used was to firstly generate a reference (no climate change) time series of run-off estimates for 5 km × 5 km areas of land at daily time steps for the period 1895–2006. The run-off estimates were generated using the historical daily rainfall record and estimated evaporation applied to rainfall run-off models calibrated to over a hundred gauged catchments in NSW.

Comparable time series of climate change run-off estimates at a reference date of 2030 were then generated for the 15 GCMs that had daily data available for the A1B emissions scenario for the current and future time periods. A daily scaling method was used to adjust the historical daily rainfall record. The daily scaling method applies different scaling factors based on ratios of seasonal distributions of daily rainfall totals. (For full details of this method refer to the original report: Future climate and run-off projections (~2030) for New South Wales and Australian Capital Territory (2008).) The method adjusts daily rainfall totals on a seasonal basis to be higher or lower than the historical, and maintains the inter-annual and inter-decadal patterns.

The method applied to results from the 15 GCMs produced a range of changes to rainfall and resulting run-offs, from significantly wetter to significantly drier futures, reflecting the current level of uncertainty of rainfall projections (but there is greater consensus for temperature projections). However, the model assessment and selection of the four best GCMs by UNSW has narrowed the range of results and associated uncertainty study quite significantly.

There are a couple of important differences between the results from this work and work for the other components of the regional impacts study:

- This study used a different emissions scenario (A1B instead of A2) and assessment date (2030 instead of 2050). This was because the modelling was completed before the design of the regional impact study. Given the overall strengths of this work, these differences are considered to be minor compared to the uncertainty of GCM outputs.
- The daily scaling method and the longer modelling period used to estimate rainfall and run-off changes (112 years compared to 20 years) may result in some statistical differences in the results of mean seasonal changes.

Analysis of run-off estimates

Modelled run-off estimates across the State Plan regions were extracted for the 112-year modelling period, for the historical reference period and the four selected GCMs from the database created for the project discussed in the previous section. These results were analysed for the following:

- percentage change in average seasonal run-off depths, and
- percentage change in total run-off depths for the driest period of record during the 112-year record for period durations of 0.5, 1, 2, 3, 4, 5, 6 and 7 years.

In addition, modelled historical reference and GCM run-off estimates were extracted for gauged catchments for which the rainfall run-off models had been calibrated. The catchments with the best reproduction of historical flow distributions were analysed for changes in:

- the magnitude of high flows (the flow rate currently exceeded 1% of the time), and
- the frequency of occurrence of low flows (the flow rate currently exceeded 90% of the time).

Analysis of drought severity

Hydrological drought is associated with the effect of extended periods of low rainfall on the amount of water entering rivers, lakes and other water bodies. The important issue in analysing hydrologic drought is the amount of run-off generated by rainfall, and not the amount of rainfall itself.

The minimum amount of run-off over a continuous period is important in understanding, for example, how much water needs to be stored to ensure there is water available to supply to water users during droughts. The amount of water stored is generally a socio-economic decision, and may be based on lowest run-off for a short duration (e.g. six months) or for a longer duration (e.g. seven years).

This study analysed the modelled daily run-off results from Vaze *et al.* (2008) to understand whether hydrologic droughts of different lengths of time are likely to be more or less severe than they have been historically. The total run-off for a given continuous length of time was calculated from the 112-year period of results, and the lowest total over that period recorded. For example, the lowest run-off for any period of one year may have been 50 mm, and occurred between 18 July 1902 and 17 July 1903, whereas the lowest run-off for any seven-year period may have been 200 mm, occurring between 21 February 1941 to 20 February 1948.

These calculations were done for each region, for eight different lengths of time including short durations (0.5 and 1 year), medium durations (2, 3, and 4 years) and longer durations (5, 6, and 7 years), and for the historical period, as well as for each GCM. The changes in drought severity for any particular duration were the percentage change for the GCM results compared to the historical period.

Presentation of analysis

Each GCM resulted in a different estimate of run-off changes. The reporting of these results is based on the following characteristics:

- the magnitude of the average of the changes from the four GCMs
- the full range of changes (from lowest to highest percentage change)
- the degree of agreement between the four GCMs regarding the direction of change.

For the magnitude of changes, the following descriptions were used for the average increase or decrease:

Description	Range for % change in:		
	Run-off depths	High flow magnitude	Low flow frequency
Slight	0–3	0–5	0–10
Minor	3–6	N/A	N/A
Moderate	6–9	5–10	10–20
Substantial	>9	>10	>20

Terminology for the degree of agreement is as follows:

Description	Number of GCMs agreeing on direction of average change
Very likely	4
Likely	3
About as likely as not	2
Possibly	1

Reasons for differences in reported rainfall changes and run-off results

Changes in rainfall have been estimated using two different methods for different impact assessment in this report, and in some cases produce different results. This will be apparent where 'expected regional climate change' results reported at the beginning of each regional section do not fully correspond to reported changes in seasonal run-off.

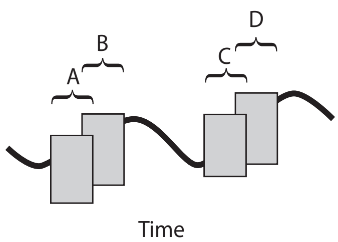
There are several reasons for this, including that the hydrology was estimated for the A1B emissions scenario at a 2030 assessment date, whereas the regional climate change was estimated for the A2 emissions scenario at a 2050 assessment date. The effect of this would be that the changes estimated for the hydrology would be smaller. A further reason for the different results is because different methods were used to estimate rainfall. A brief explanation of these methods follows.

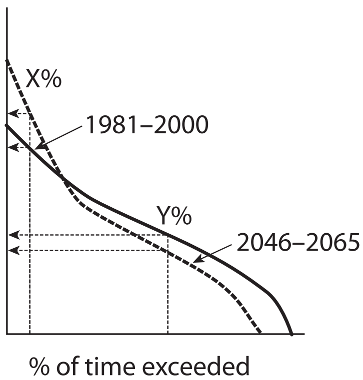
The expected regional rainfall changes are calculated directly from GCM modelled results. The first step was to calculate the ratio of seasonal rainfall for the respective current and future sample dates. Daily data is stored for twenty-year periods centred around 1990 and 2055, so the percent change in rainfall (P) is calculated as

$$\%\,\text{Change}_{\,(\text{season})} = 100 * \frac{\overline{P}_{(\text{season},\,2046 \rightarrow 2065)}}{\overline{P}_{(\text{season},\,1981 \rightarrow 2000)}}$$

These ratios were then averaged for the four models, and interpolated from the native GCM resolution of around 200 km to a finer resolution of 50 km, and averaged within each region.

The first step is a source of uncertainty because of the natural decadal scale variability of rainfall. The diagram to the right illustrates this. The decadal natural variability is represented by a smoothed line. The calculated change for future climate will in part depend on the selection of the current period (A or B) and the future period (C or D). A change represented by C/B would be much smaller than that calculated by D/A.





The method used to estimate rainfall for changes in hydrology, described in Chiew *et al.* (2008), is quite different. Rainfall for future climatic conditions was estimated using the same data set (GCM modelled daily rainfall for 1981–2000 and 2046–2055).

The first step in the method calculates the ratio of daily modelled rainfalls with the same exceedence probability for each season. In the example shown, the higher daily rainfalls with low exceedence probabilities (X%) increase, and the lower daily rainfalls with higher exceedence probabilities (Y%) decrease.

The next step is to rescale these factors to account for the assessment date of 2030 compared to the data date of 2055. These factors are scaled by the ratios of the average temperature increase of 1990 → 2030 compared to 1990 → 2055. These re-scaled factors for each percentile rainfall for each season are then used to scale daily rainfall from the Bureau of Meteorology's SILO database for all data sets within the GCM grid cell for the period 1895–2006, and these re-scaled daily rainfall data sets used in calibrated rainfall run-off models.

The hydrology uses a much longer data set of rainfall examples of wet and dry periods. Different subsets of this may show either an increase or decrease in rainfall totals, depending on whether it is a wet period or dry period.