Water availability across the Murray-Darling Basin

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Presentation outline

- Water resources – issues and challenges
- Murray-Darling Basin Sustainable Yields (MDBSY) Project
- Modelling historical, recent and future runoff across the Murray-Darling Basin
- River system modelling and impact on water users in managed river systems
- Runoff, streamflow and water availability
- Summary
Water resources – issues and challenges

- Global and Australian climate is becoming warmer.
- Prolonged drought across south-east Australia.
- Water resources are fully committed.
- Demand for water from competing users is increasing.
- Water resources availability is likely to decline (due to climate and other drivers).
- Water sharing and governance between Commonwealth and States.
Australian hydroclimates are different

- Australia is drier and less of its rainfall becomes runoff. Australian river flows are more variable than elsewhere in the world. As a result, Australia requires bigger storages, and droughts in Australia are more severe than elsewhere in the world.

- The ENSO-streamflow teleconnection in Australia is amongst the strongest in the world. This offers potential for forecasting hydroclimate several months to several years ahead.
MDBSY Project – terms of reference

• Water Summit, November 2006 – PM and First Ministers CSIRO to report progressively through to 2008 on sustainable yields of surface and groundwater systems within the MDB.

• Estimate current and likely future (~2030) water availability in each catchment/aquifer and for the entire MDB considering (i) climate change and other risks and (ii) surface-groundwater interactions.

• Compare the estimated current and future water availability to that required to meet the current levels of extractive water use.

• Numerous results, presented in various forms, now being used to help develop the next round of MDB water sharing plans.
For the first time, a consistent modelling across the entire MDB to estimate current and future water availability (including surface and groundwater interactions), and impacts given current level of use and water sharing rules.
Rainfall-runoff modelling across Murray-Darling Basin

- Modelling at 0.05° x 0.05° grid cells using lumped conceptual daily rainfall-runoff models.

- Model calibrated against daily streamflow data from 1975 to 2006 from 183 ‘unimpaired’ catchments.

- Optimised parameter values from closest ‘calibration catchment’ used to model runoff in ‘ungauged grid cells’.

- Future runoff modelled using future climate series with same parameter values.
Mean annual runoff estimated by SIMHYD, Sacramento and remote sensing

- **SIMHYD**: RMSE = 70 mm/yr, NSE = 0.76
- **Sacramento**: RMSE = 66 mm/yr, NSE = 0.79
- **Remote sensing**
Improving runoff estimation from rainfall-runoff models for ungauged catchments

• Uncertainty in runoff estimates can be reduced by output averaging of results from multiple donor catchments (model ensemble).

• Research areas for improving runoff estimation in ungauged catchments include:
  - better methods for choosing donor catchments and models (spatial proximity, physical similarity, integrated similarity, flow characteristics);
  - using new data types to adapt model structure and to calibrate models (e.g., MODIS-LAI and remotely-sensed ET and soil moisture);
  - optimising over the entire region or system using all available data and using appropriate weights to choose donor catchments and models; and
  - improved consideration of uncertainty in input data, calibration data and model structure.

• The research studies can and should provide explicit quantifications of uncertainty in the modelling results.
There is a clear east–west rainfall and runoff gradient, with most of the runoff in the MDB coming from upland catchments in the south-east.
Recent (1997–2006) rainfall and runoff relative to long-term means

<table>
<thead>
<tr>
<th>Percent difference (1997-2006 relative to 1895-2006)</th>
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<tbody>
<tr>
<td>&lt; -50</td>
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**Rainfall**

**Runoff**
Average recurrence interval of 1997-2006 rainfall and runoff

<table>
<thead>
<tr>
<th>Average recurrence interval (years)</th>
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<tr>
<td>&lt; 20</td>
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Rainfall

Runoff
Recent runoff is a lot lower than similar dry periods in the past.

Likely reasons include:

- 1997–2006 autumn and early winter rainfall is disproportionately lower, translating to significantly lower winter runoff when most of the runoff occurs.
- Temperatures are higher in current drought, accentuating the impact on runoff.
- Connectivity with subsurface system may have been lost and significant diffused rainfall recharge is needed to re-establish connection for subsurface runoff to occur.
Future (~2030) climate

- Two types of uncertainties in future climate projections considered
  (i) greenhouse gas emission and associated global warming; and
  (ii) GCM modelling of local rainfall response to global warming.

- 45 112-year daily rainfall (and climate) variants, informed by 15 GCMs for three global warming projections.

- Percentage change in rainfall (and climate) used to scale 1895 to 2006 historical daily rainfall (and climate) series.

- Different scaling factors used for the four seasons.

- Changes in daily rainfall distribution also considered.
Percentage change in future mean annual rainfall and runoff (~2030 relative to ~1990)
Number of modelling results showing decrease/increase in runoff

- There is large uncertainty in the results.
- The majority of results show a decrease in runoff.
- Most results indicate that future winter runoff will be lower across the MDB.
- Most of the runoff in southern MDB occur in winter, and almost all the results indicate less winter runoff there.
Future (~2030) runoff relative to historical (1895–2006) runoff

- Averaged across the MDB, the median estimate is a 10 percent decrease in mean annual runoff.

- Averaged across the MDB, the extreme dry and extreme wet estimates range from a 33 percent decrease to a 16 percent increase in mean annual runoff.
Water balance and water use in managed river systems

Management and water sharing rules

Environment

Floodplain losses

End-of-system flow

Legend
- Town
- Dam
- State border
- Main Road
- River
- Lakes
- Irrigation
- Native vegetation
- Other (see table)

Runoff

Irrigation gains/losses

S-GW gains/losses

Storages
Surface and groundwater models used in MDBSY

- Paroo IQQM
- Warrego IQQM
- Barwon-Darling IQQM
- Menindee IQQM
- Bidgee IQQM
- Lower Bidgee
- MODFLOW
- Murray BigMod
- Murray MSM
- Eastern Mt Lofty Ranges
- 6*WATERCRESS
- Southern Riverine
- Plains MODFLOW
- Wimmera REALM
- Daily
- Weekly
- Monthly
- Avoca REALM
- GSM REALM
- Ovens REALM
- Mid Bidgee MODFLOW
- Nebine IQQM
- Lower Balonne IQQM
- St George SGCS13NT
- Middle Condamine IQQM
- Condamine MODFLOW
- Upper Condamine IQQM
- Border Rivers MODFLOW
- Bord Riv and Mac B IQQM
- Moonie IQQM
- Lower Gwydir MODFLOW
- Gwydir IQQM
- Upper Namoi MODFLOW
- Peel IQQM
- Namoi IQQM
- Lower Namoi MODFLOW
- Macq-Castlereagh 6*IQQM
- Macquarie MODFLOW
- Lachlan IQQM
- Mid-Lachlan MODFLOW
- Lower Lachlan MODFLOW
- Snowy SIM_V9
- ACTEW REALM
- Upper Bidgee IQQM
Surface water availability across the MDB

Current surface water availability

Impact of median 2030 climate on surface water availability

Median climate change impact on future water availability
Impact of climate change on water availability

Median impact is an 11 percent reduction in water availability (~2500 GL/year)
Impact sharing for median 2030 climate

Surface water availability
Surface water diversions

Change under median 2030 climate (%)

-25%
-20%
-15%
-10%
-5%
0%
5%
10%
15%
20%
25%

Paroo
Warrego
Condamine-Balonne
Moonie
Border Rivers
Gwydir
Namoi
Banw-on-Darling
Lachlan
Murrumbidgee
Murray
Ovens
Goulburn-Broken
Campaspe
Loddon-Avoca
Wimmera
Eastern Mount Lofty Ranges
Estimating future water availability: methods and research questions

How will the future climate look like?
- Climate science and climate change science
- Informed by GCMs (which GCMs?, which emission/global warming?, uncertainty, etc…)

Future catchment-scale climate

Historical catchment-scale climate

Rainfall-runoff modelling to estimate runoff

River system and groundwater modelling to estimate water availability for users across managed systems

Future catchment-scale climate

Rainfall-runoff modelling to estimate climate change impact on future runoff

River system and groundwater modelling to estimate climate change impact on future water availability for users across managed systems

- Runoff prediction in ungauged catchments
- Hydrologic sensitivity to rainfall and temperature
- Calibration/parameterisation and feedback modelling for extrapolation to the future
- Climate change impact in the context of other drivers

- Simple scaling or perturbation methods
- Statistical and dynamic downscaling
Runoff, streamflow and water availability

Runoff

- Runoff can be defined as surface runoff or total runoff at a point, averaged across a grid or averaged across a catchment.

‘Natural’ Streamflow

- Streamflow is the flow in a river. Streamflow is the variable that is measured/gauged in a river. Streamflow can be ‘thought of’ as the runoff from a catchment that reaches the river.

Development impact on streamflow

- In managed river systems, ‘natural’ streamflow is altered by development and water management rules, allocations and operations.
Runoff, streamflow and ‘water availability’

• In the Murray-Darling Basin Sustainable Yields Project, ‘water availability’ for a region is assessed as the mean annual streamflow (under pre-development conditions) at a point where the river changes from net gaining to net losing.

• Total mean annual runoff across MDB (aggregated over all 0.05° grid cells) is 28,900 GL.

• Total mean annual water availability (aggregated for the 18 MDBSY reporting regions) is 23,400 GL.

• Total mean annual streamflow is 14,500 GL at Wentworth and 12,200 GL at the mouth.
Summary

• Water resources – issues and challenges.

• Murray-Darling Basin Sustainable Yields (MDBSY) Project.

• Modelling historical, recent and future runoff across the Murray-Darling Basin (water and energy budgets).

• Modelling managed river and groundwater systems (water accounts of availability, storage, transfer and use).