



# Droughts and water security in south-eastern Australia: science and management

Francis Chiew

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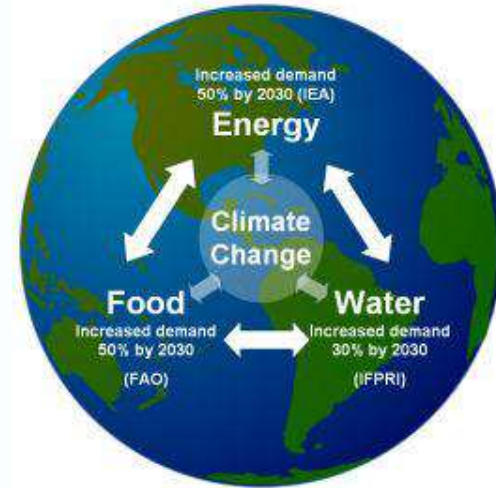
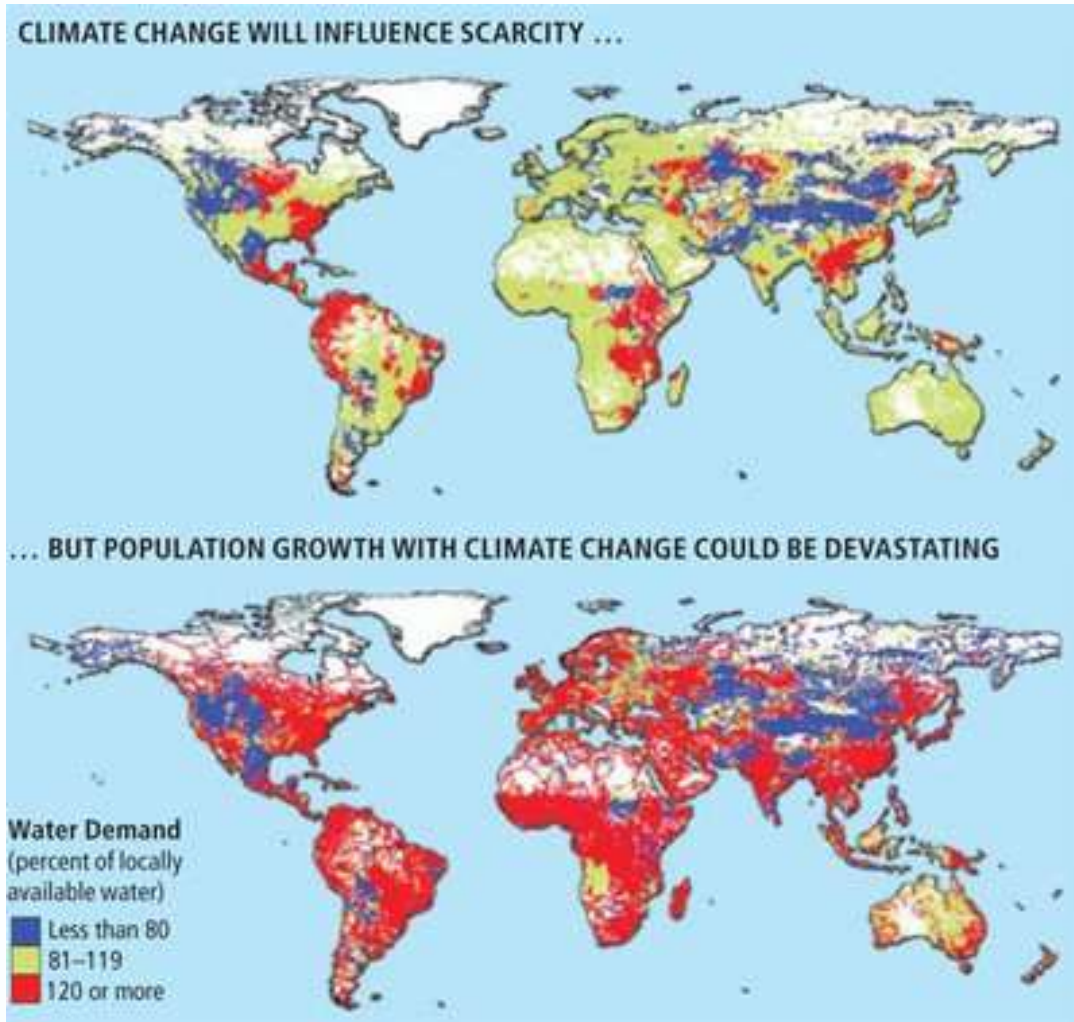


APEC Climate Symposium  
Nanjing, China, 27–29 October 2014

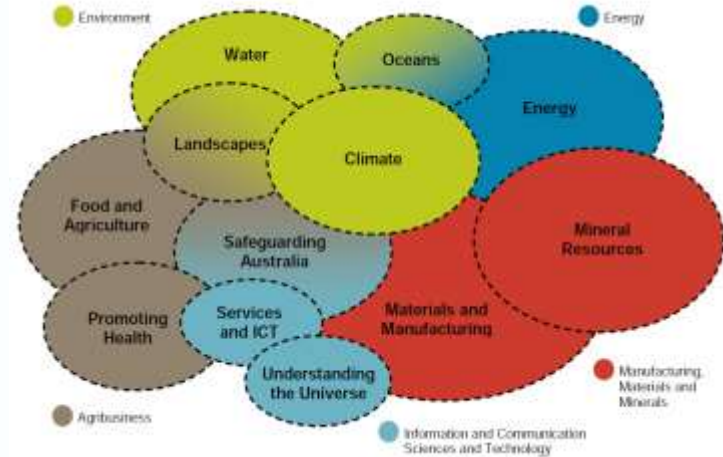
# Talk Outline

- **Hydroclimate variability and water resources management in Australia**
- **Droughts, declining rainfall trend and future water security in south-eastern Australia**
- **Water resources adaptation through policy and management**

# Water-food-energy nexus under changing climate and growing population

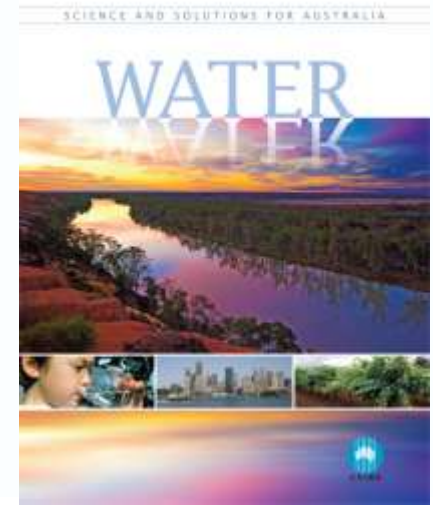


## CSIRO Research

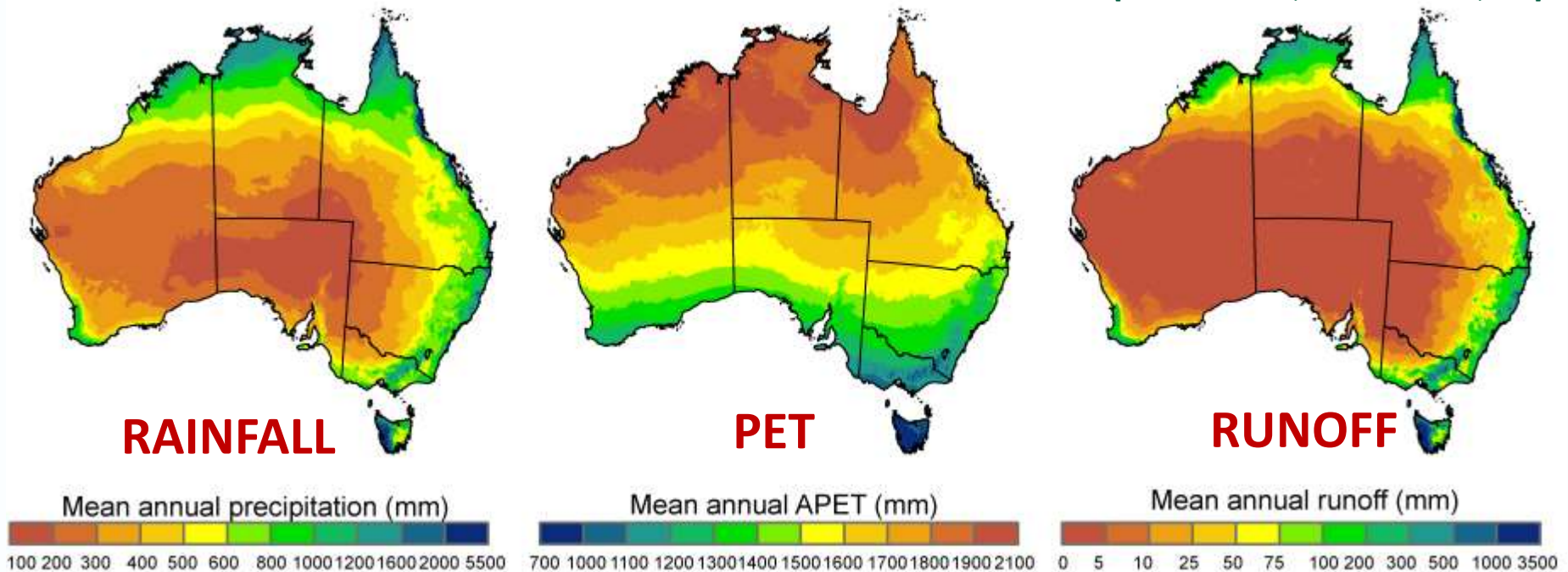


# Australian hydrology is different

- Very high spatial variability
- High evaporation from dry landscape
- Low runoff coefficient
- High inter-annual runoff variability
- Changes in rainfall amplified significantly in runoff



[Chiew and Prosser, CSIRO Water Book, 2011]



# Australian hydrology is different

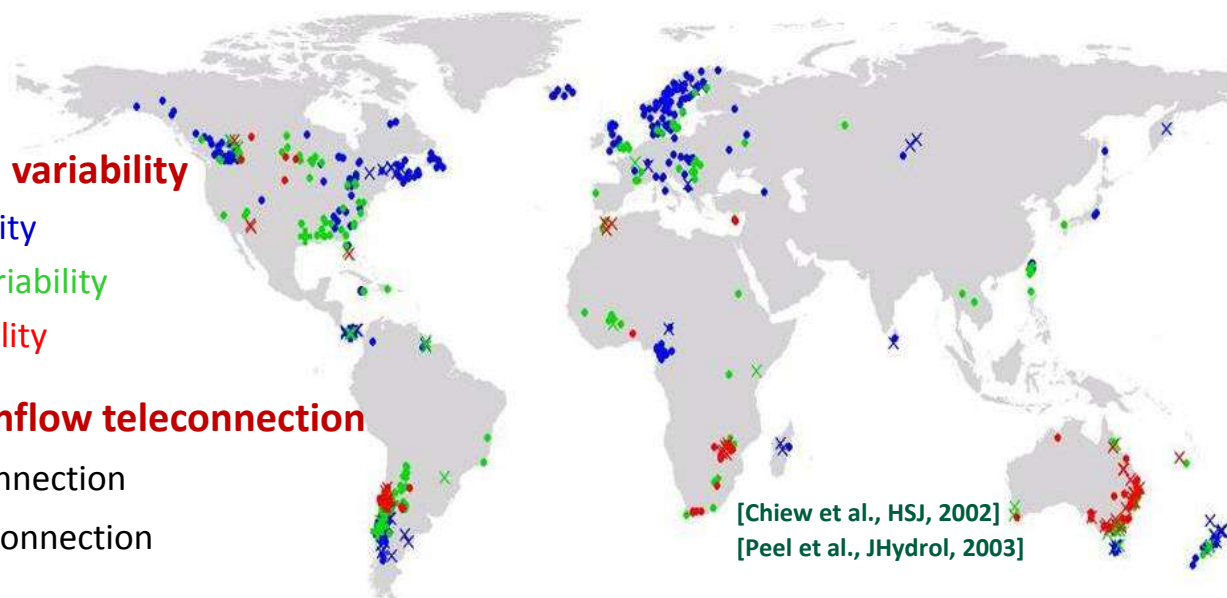
- Low runoff coefficient
- High inter-annual variability
- Reasonable predictability

## Inter-annual variability

- low variability
- medium variability
- high variability

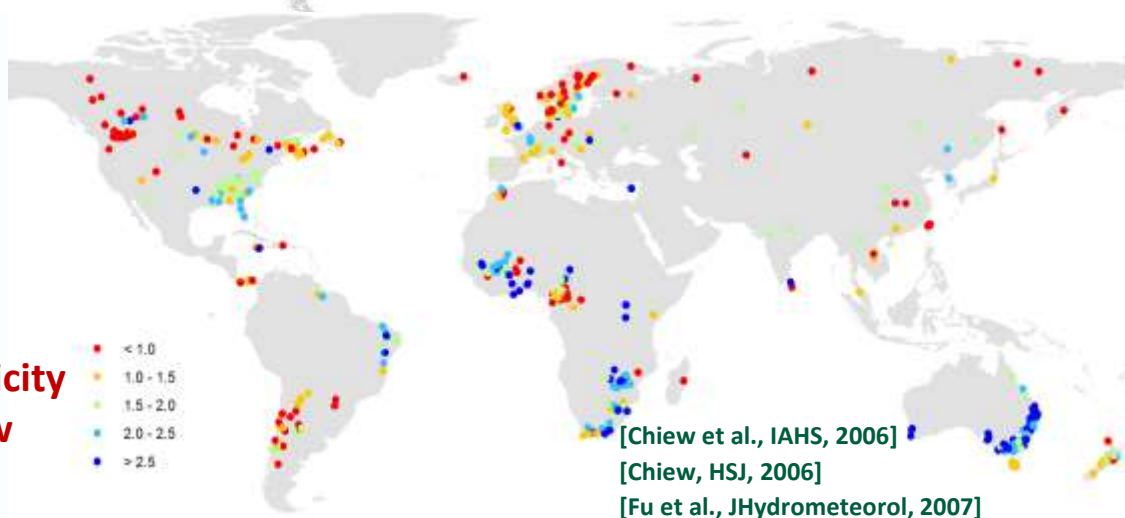
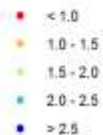
## ENSO-streamflow teleconnection

- little teleconnection
- x strong teleconnection



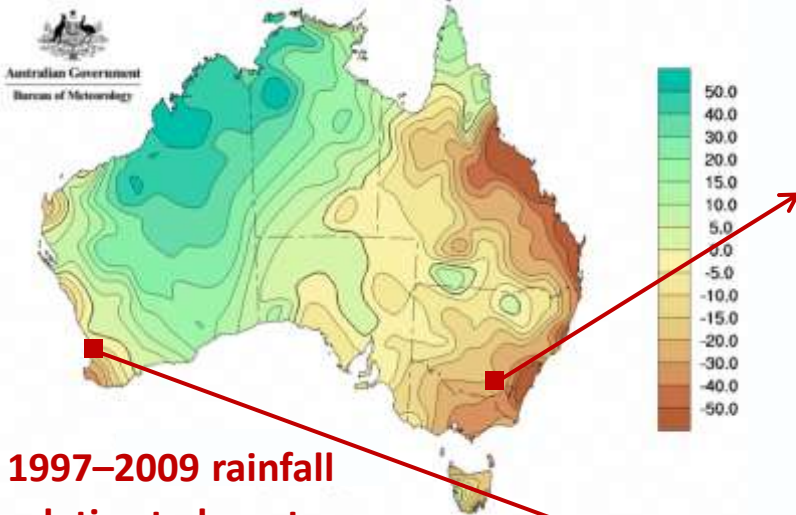
- Large amplification of rainfall change in the runoff

## Rainfall elasticity of streamflow

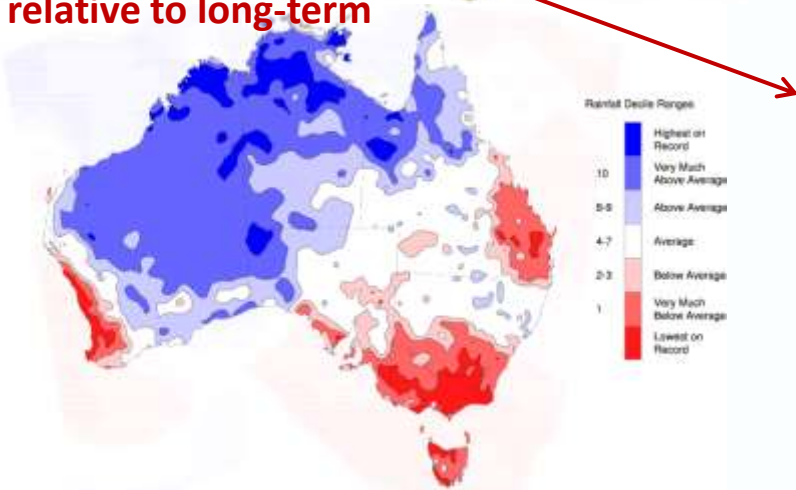


# Drying trend ..... amplified in the streamflow

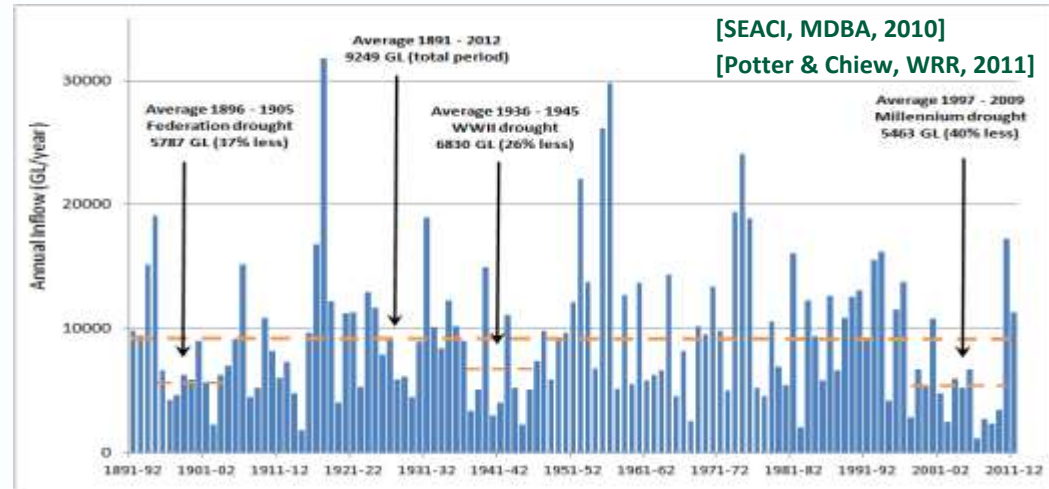
## Rainfall trend (1950 to present)



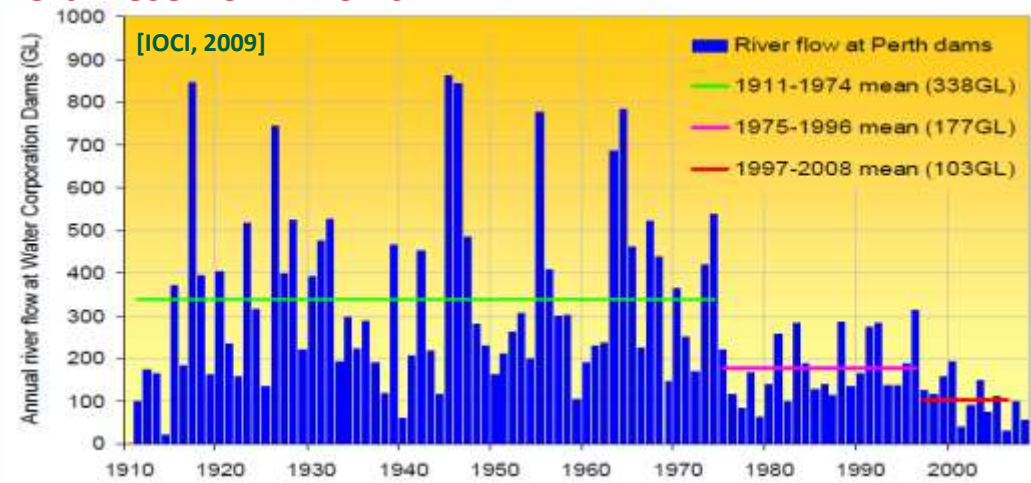
## 1997–2009 rainfall relative to long-term



## Murray River Basin inflows

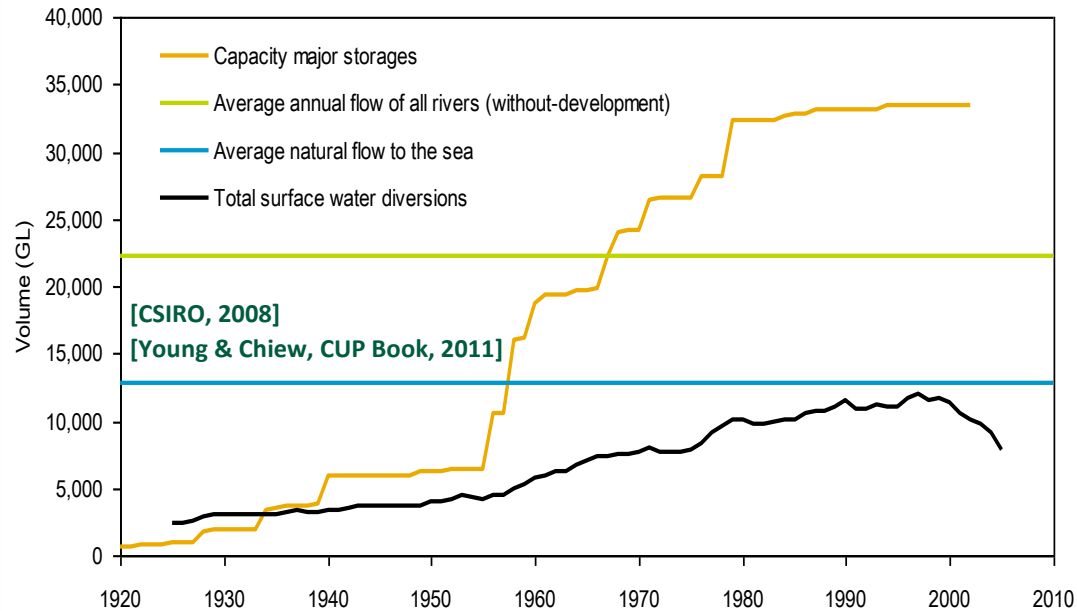


## Perth reservoir inflows



# Overallocation, increasing demand, declining supply

## Overallocation (in the Murray-Darling Basin)



## Increasing demand



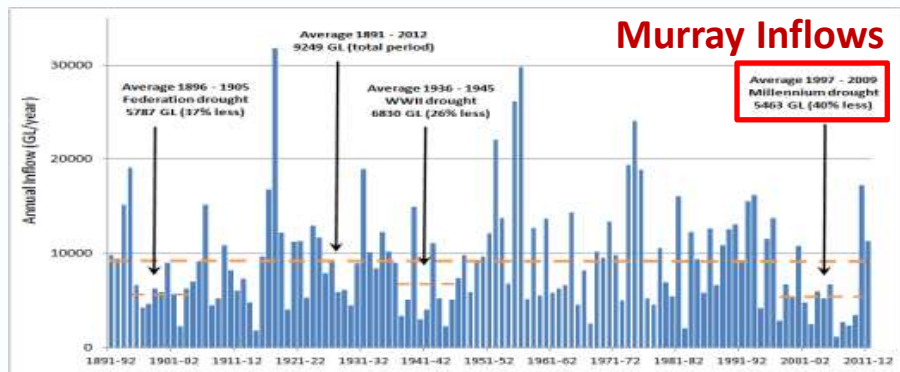
**Declining  
water  
availability**



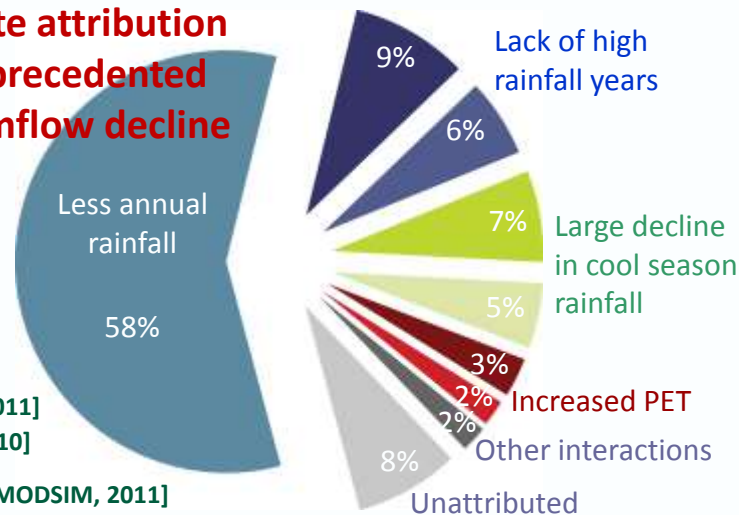
# Water security and environmental crisis



# Explaining the Millennium Drought in south-east Australia



## Climate attribution of unprecedented streamflow decline



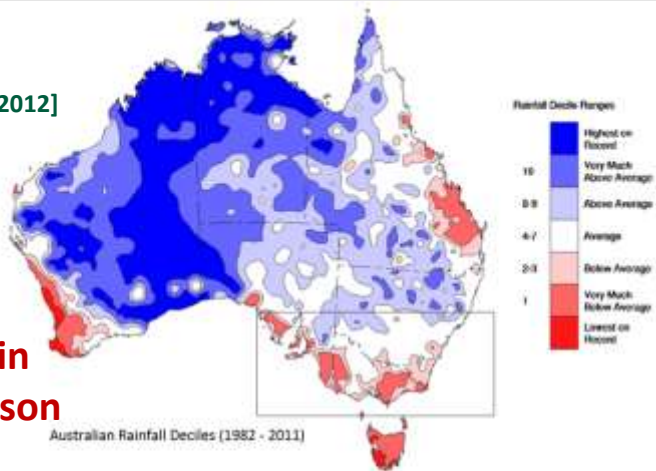
[Potter & Chiew, WRR, 2011]

[Potter et al., JHydrol, 2010]

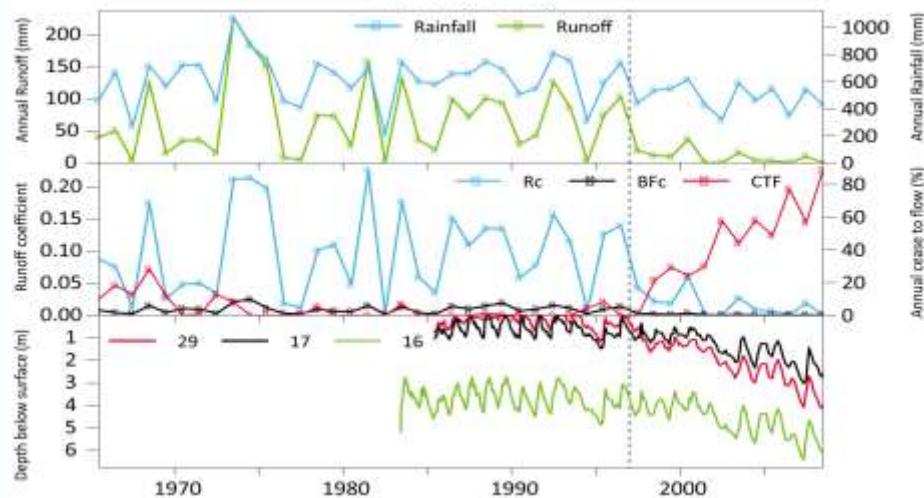
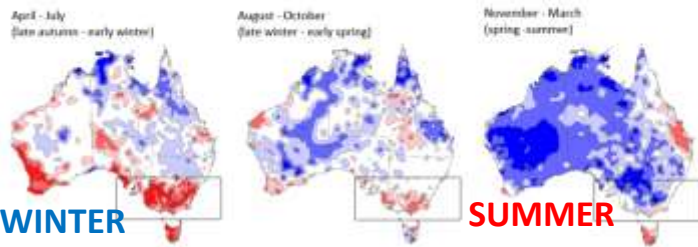
[Petheram et al., MODSIM, 2011]

[Chiew et al., SERRA, 2014]

[SEACI, 2012]



## Decline in cool season rainfall

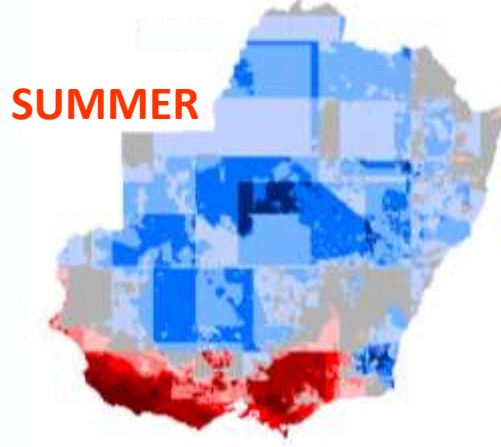
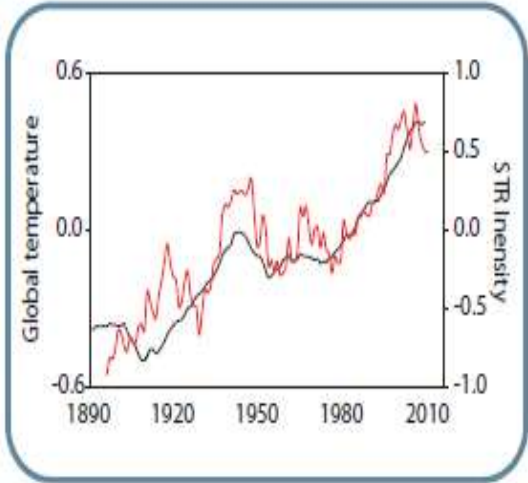
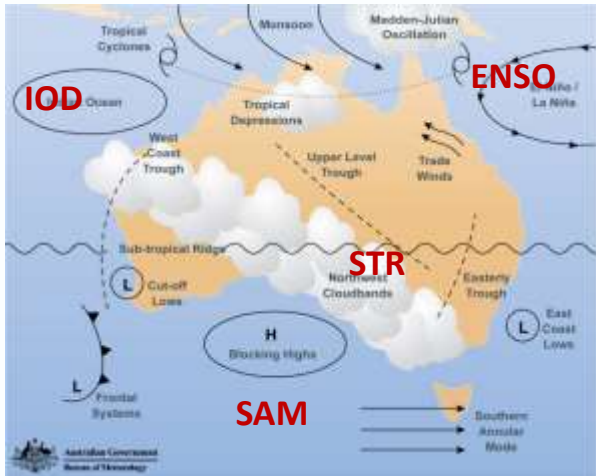


## Change in dominant processes (hydrologic non-stationarity)

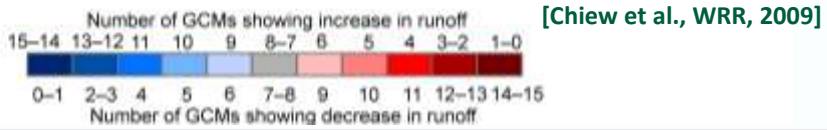
# Attribution to climate variability and climate change

**Expansion of Hadley cell and poleward shift of cool season storm tracks**

[SEACI, 2012]  
 [Timbal & Hendon, WRR, 2011]  
 [Post et al., Earth's Future, 2014]



**Climate models also project a drier winter**

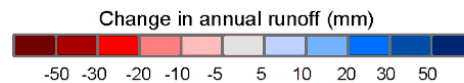
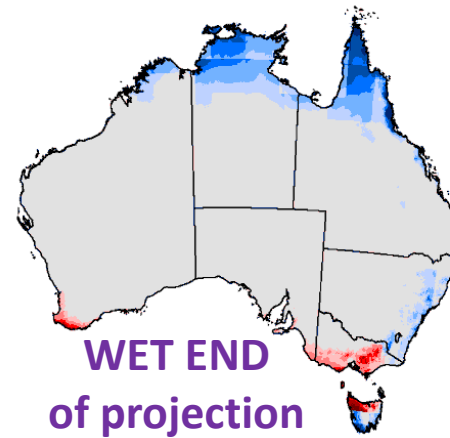
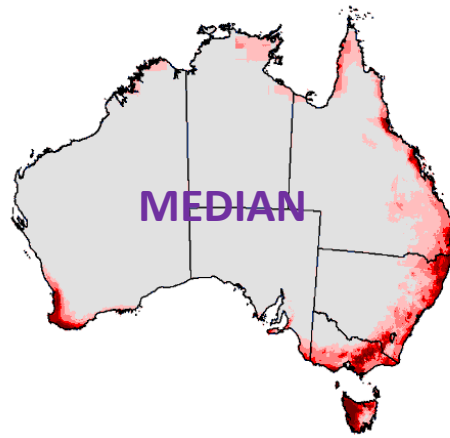
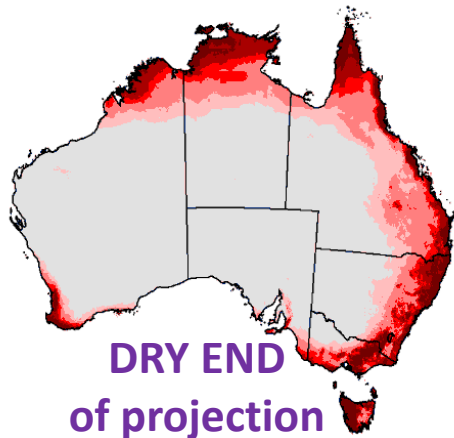
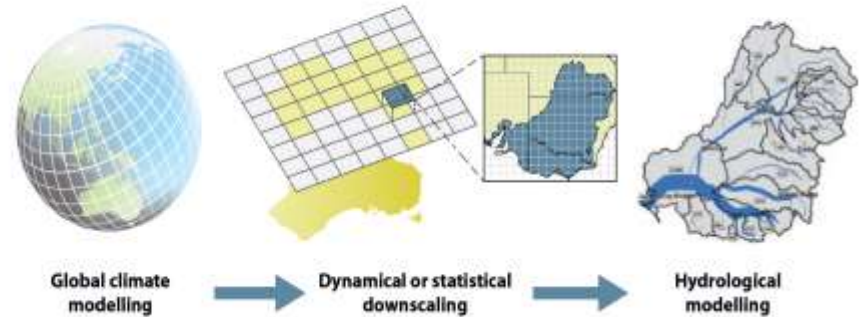


# Climate change impact on future water availability and river flow characteristics



## Integrated climate-water modelling

- [Chiew et al., WRR, 2009]
- [Petheram et al., JHydrometeorol, 2012]
- [Post et al., JHydrol, 2012]
- [Teng et al., JHydrometeorol, 2012]
- [Chiew and Prosser, CSIRO Water Book, 2011]

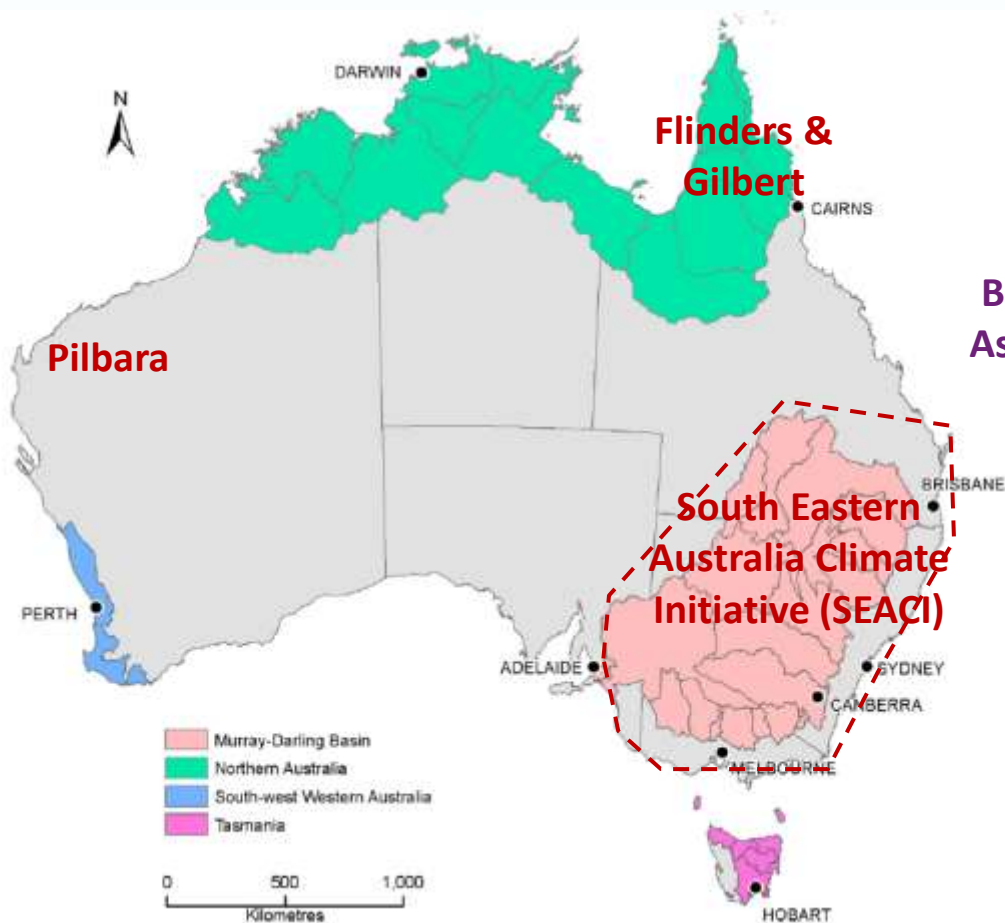


**mm change in average annual runoff for 1°C global warming**

# CSIRO Water Resources Assessments

Mapping water availability and use (and spatial and temporal characteristics) in the past, recent/current and future, under natural conditions and different development scenarios.

CSIRO  
Sustainable  
Yields  
Projects



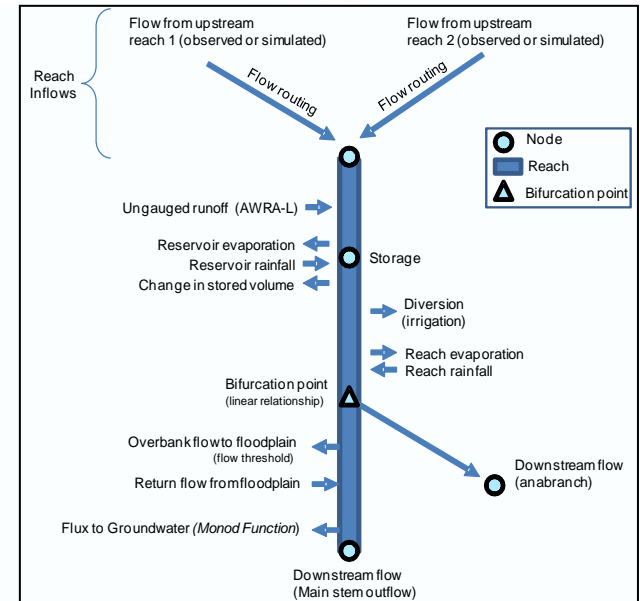
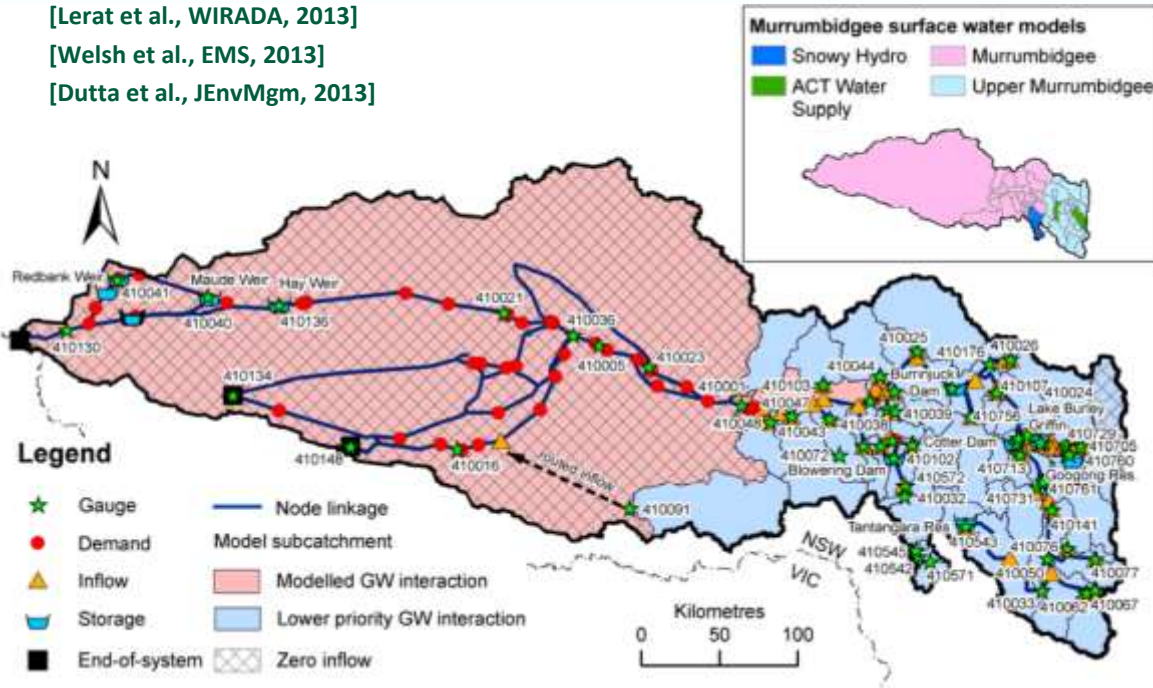
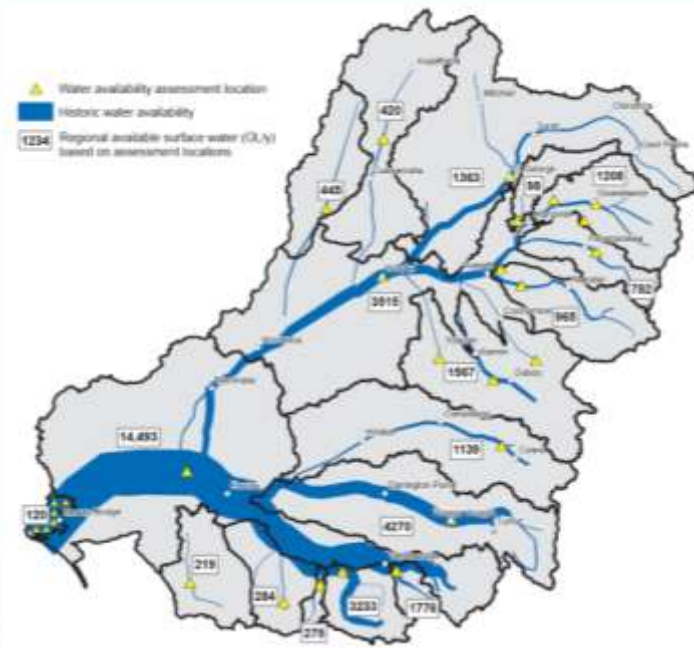
Bioregional  
Assessments

[Chiew et al., WRR, 2009]  
[Petheram et al., JHydro, 2012]  
[Post et al., JHydro, 2012]  
[Silberstein et al., CSIRO, 2011]  
[SEACI, 2012]

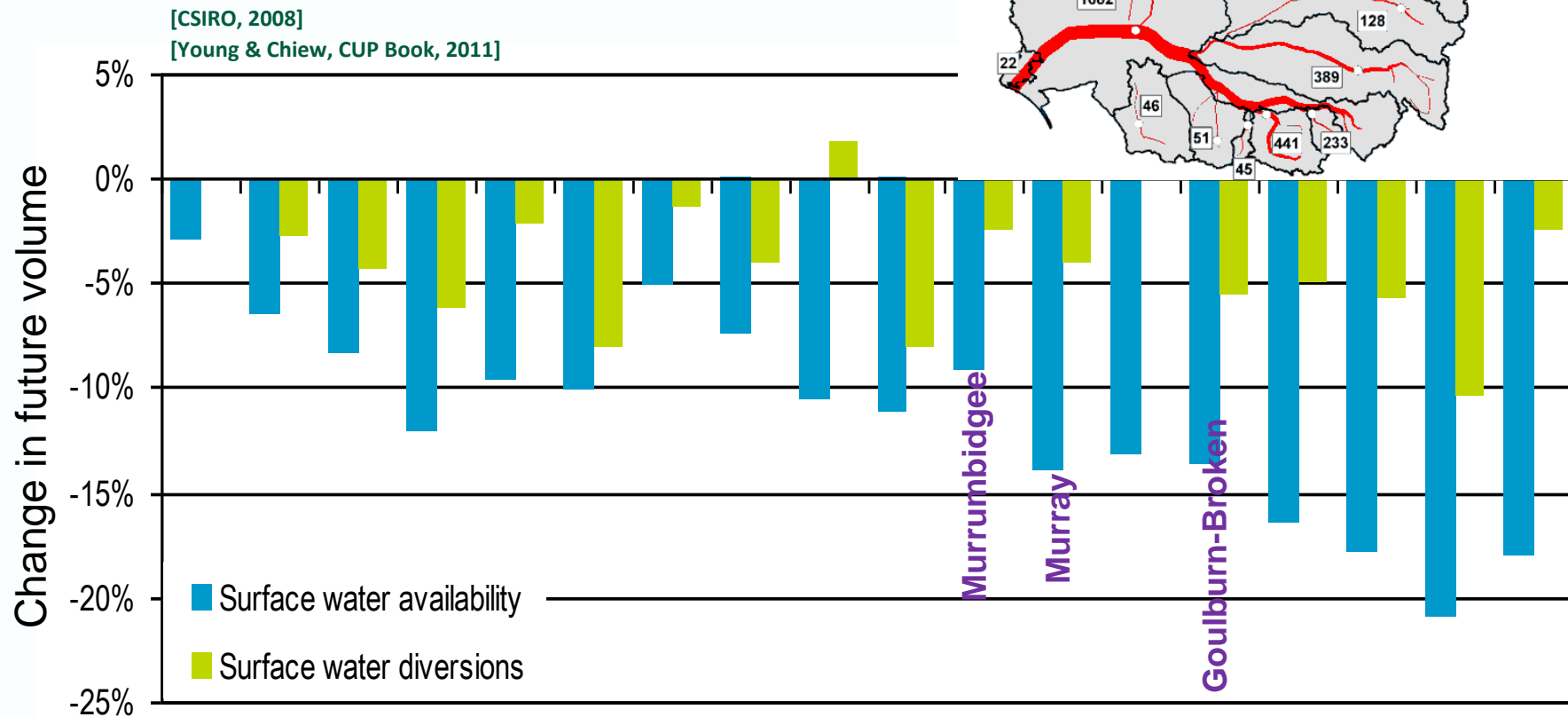
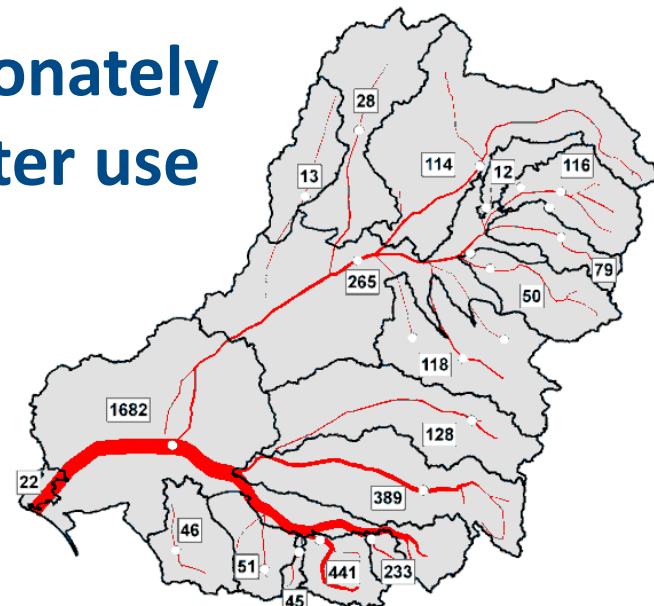
# Informing water management – drivers, impacts, levers, scenarios



- [Dutta et al., JHydro, 2013]
- [Lerat et al., WIRADA, 2013]
- [Welsh et al., EMS, 2013]
- [Dutta et al., JEnvMgm, 2013]

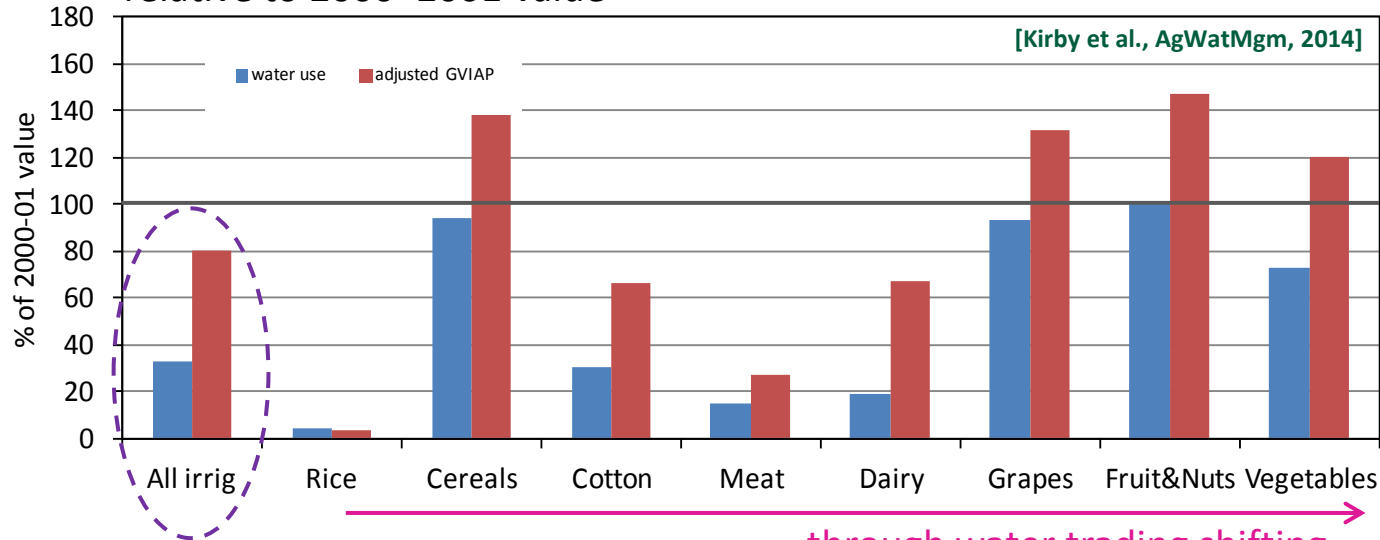


# Climate change impacts disproportionately on irrigation and environmental water use (under current water sharing rules)



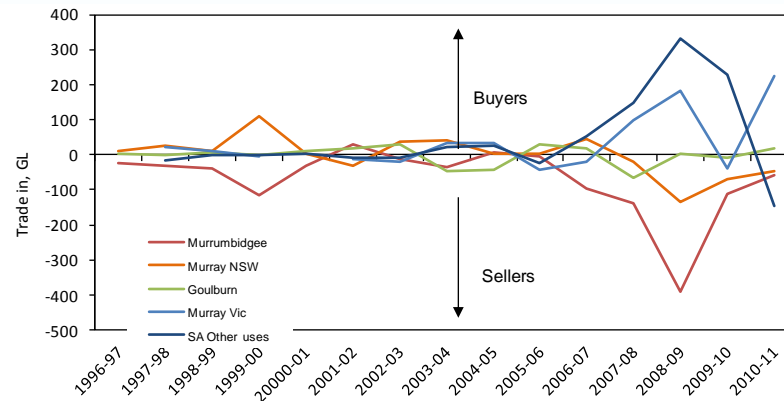
# Adaptation of irrigated agriculture through water trading

Irrigation water use and agricultural return (\$) during Millennium drought relative to 2000–2001 value



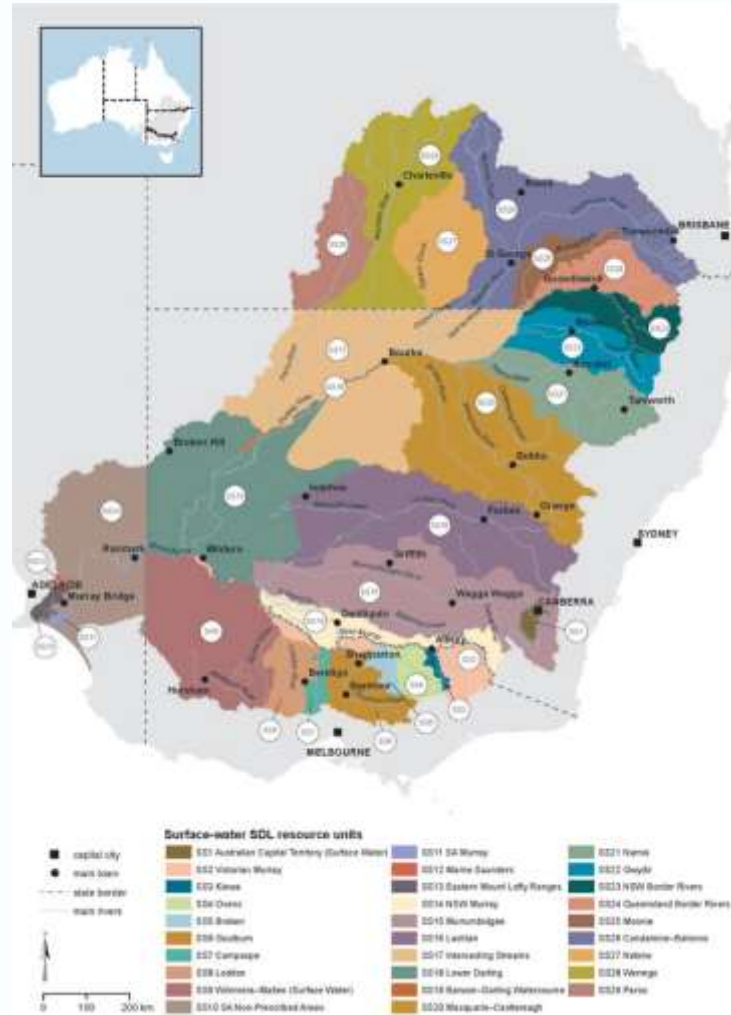
- 70% reduction in irrigation water use .....
- ..... but only 20% reduction in agricultural return

..... through water trading shifting water to higher value use



# Water reform in the Murray-Darling Basin

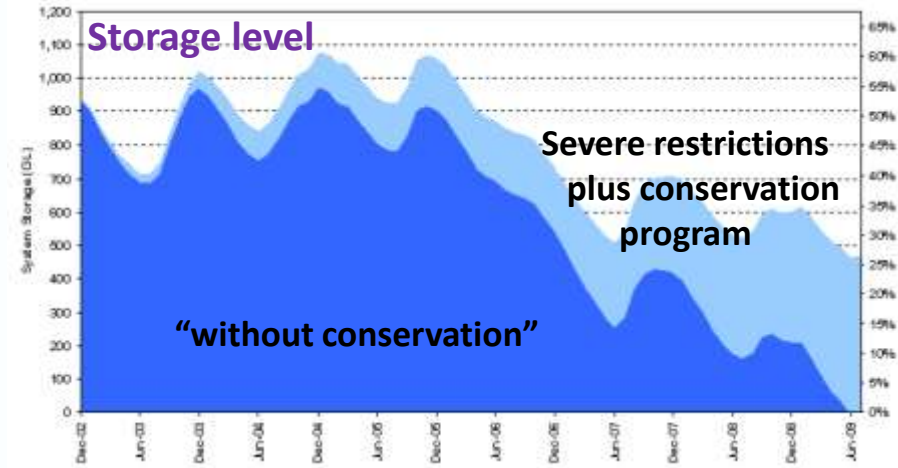
- AUD\$12 billion to upgrade irrigation infrastructure, improve irrigation water use efficiency and purchase water for the environment.
- 2,750 GL/yr of irrigation water entitlement (one fifth of current entitlement) purchased for the environment.
- Sustainable diversion limits set for all catchments in the Basin.
- Adaptive water sharing plan developed to cope with current and future climates.



# Water for Melbourne

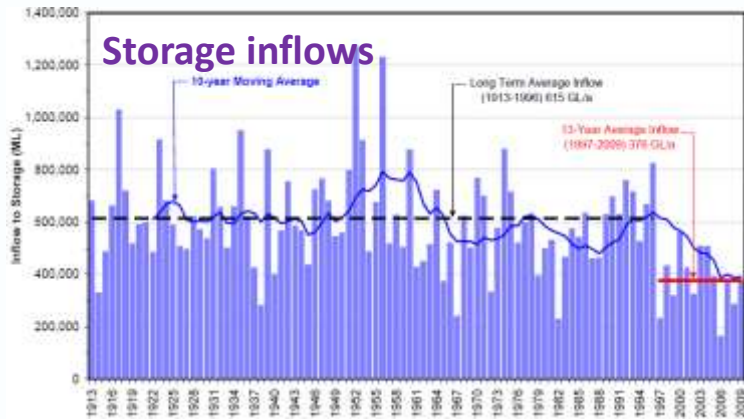


- Adaptation triggered by Millennium drought



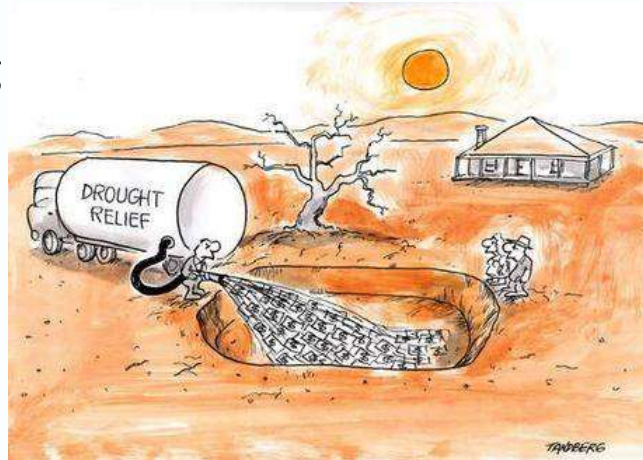
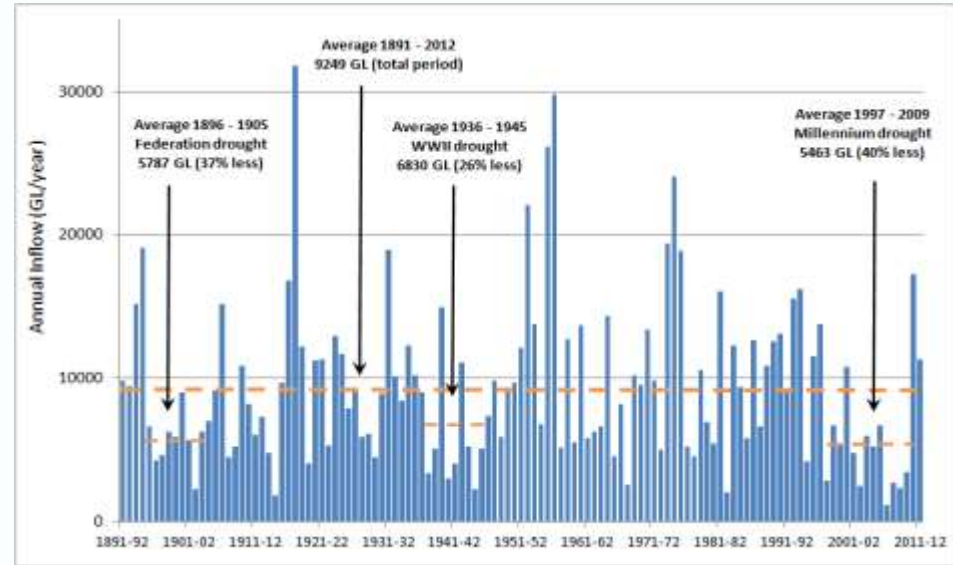
- Declining water supply and increasing demand (from expanding population)

- Augmenting supply (desalination plant, sewage recycling and stormwater)



# Water resources planning must take a long-term view

- Major water reforms triggered by Millennium drought.
- Initiatives stalled by breaking of drought.
- Hydroclimate variability will remain high, with long wet and dry periods.
- Declining cool season trend continues, water availability is likely to decline, and droughts will be more frequent.
- Water resources planning must take a longer-term view, and account for hydroclimate variability and potential climate change.



# Summary

- The 1997–2009 Millennium drought in south-eastern Australia had a substantial economic, environmental and social impact.
- The drought and projected declines in future water resources stimulated major water reforms and adaptation.
- Water resources planning must take a longer-term view, and account for hydroclimate variability and potential climate change.

# Thank you

## CSIRO LAND AND WATER FLAGSHIP

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