WATER RESOURCES MANAGEMENT IN AUSTRALIA

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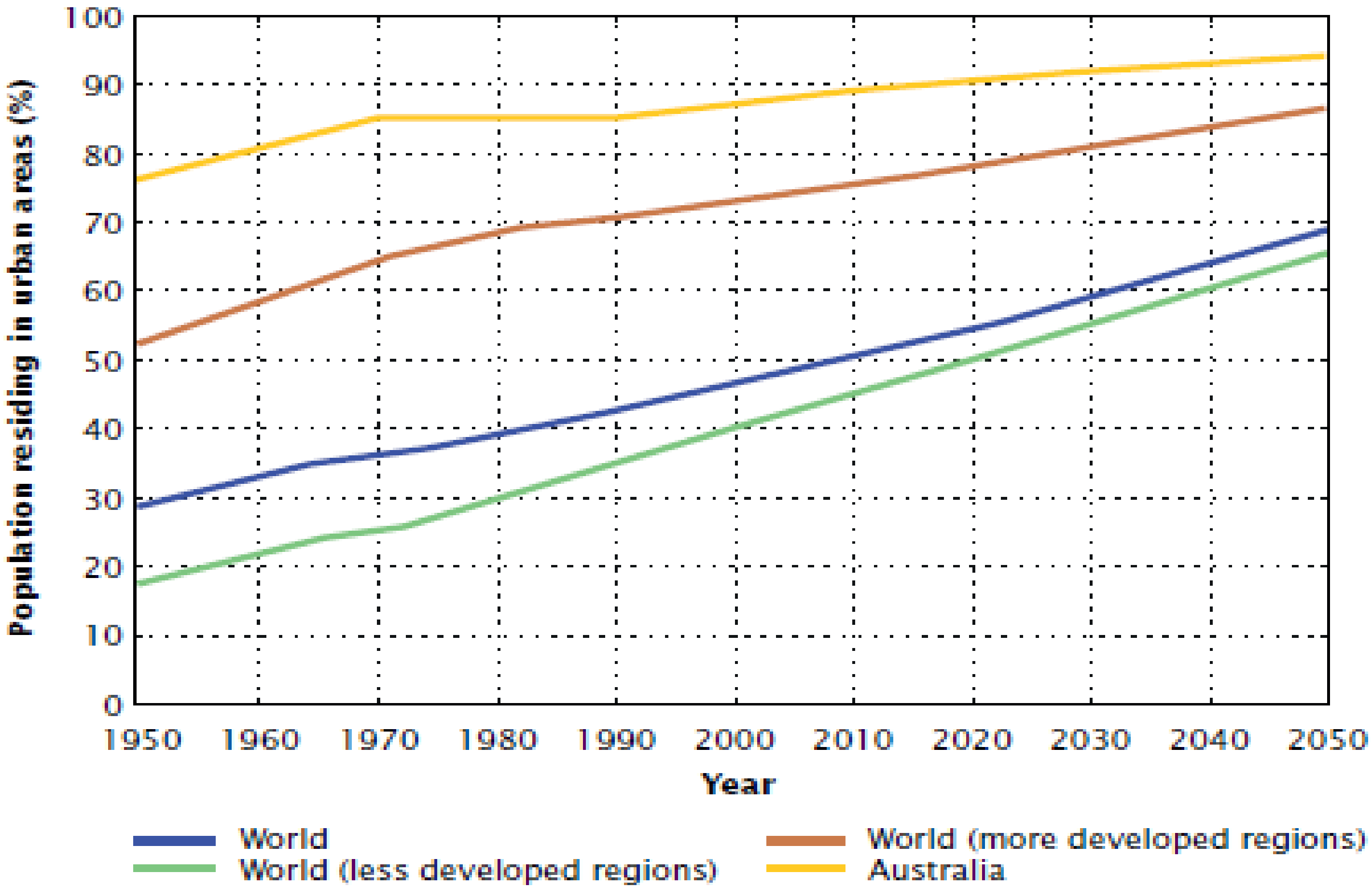
THE UNIVERSITY OF MELBOURNE

Background

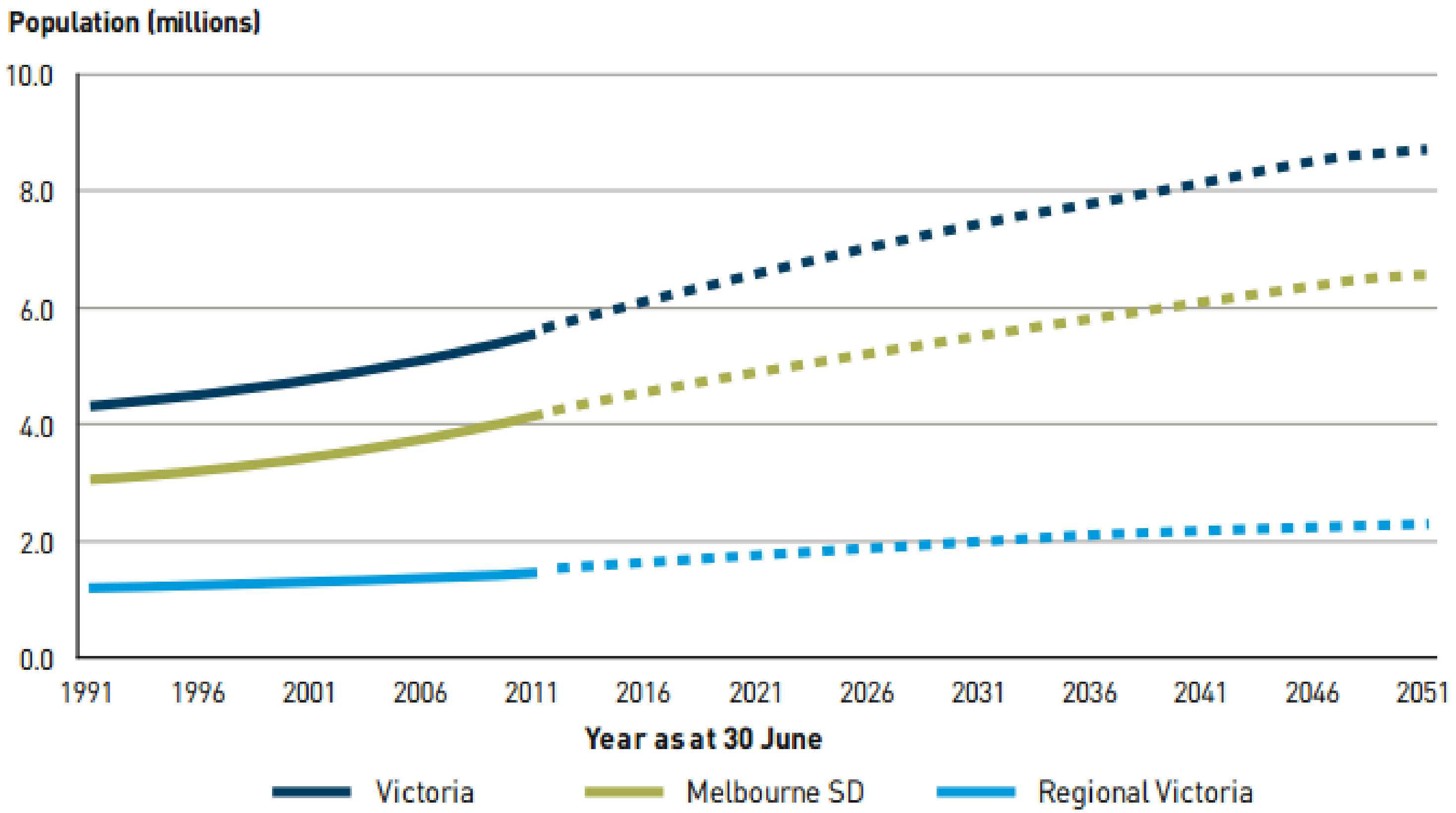
The percentage of global population living in urban areas



Ref: GREGORY, A. & HALL, M. 2011. Urban water sustainability. *In:* PROSSER, I. P. (ed.) *Water : science and solutions for Australia.* CSIRO

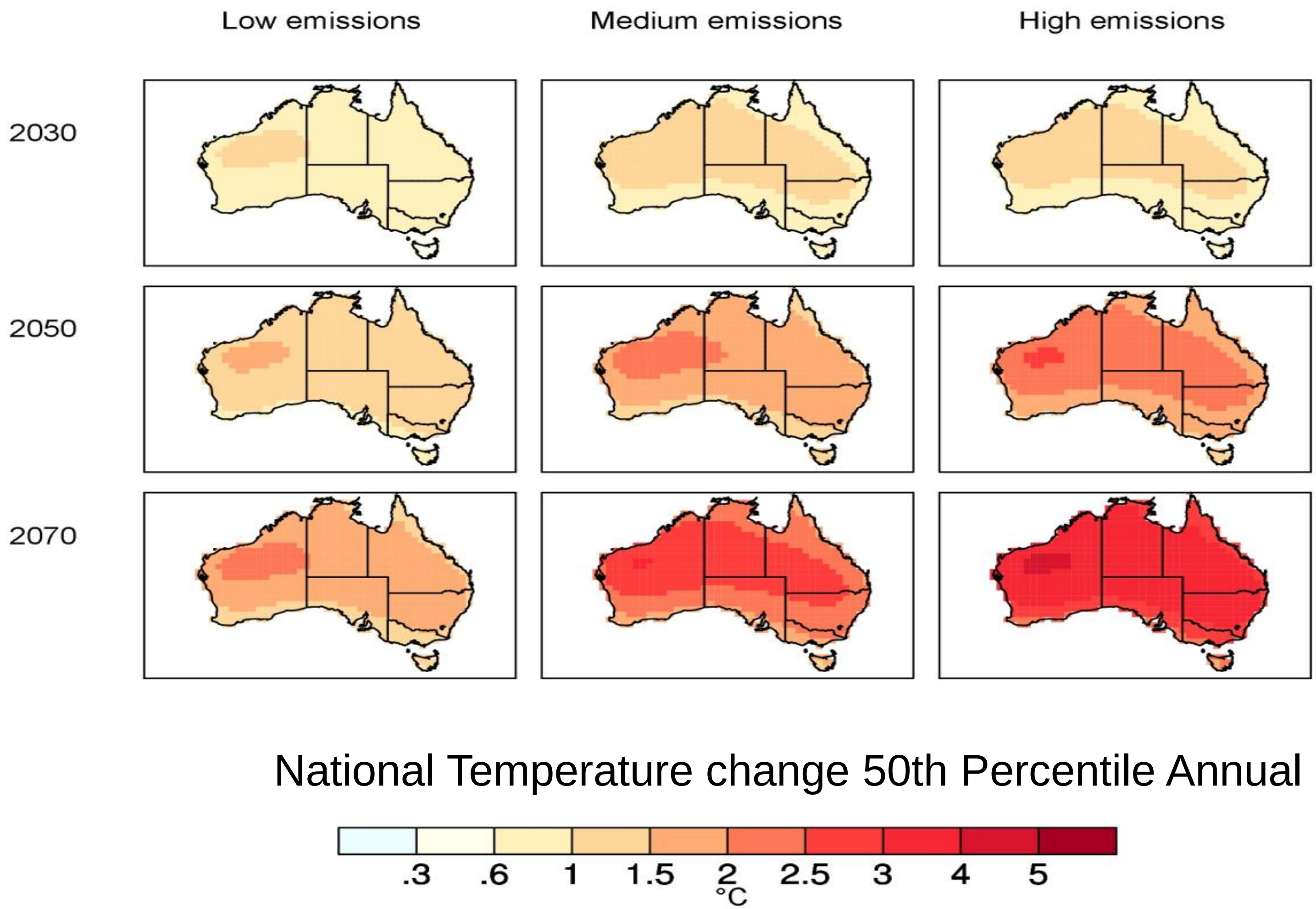
Background

Historical and projected population, Victoria, Melbourne and regional Victoria, 1991–2051



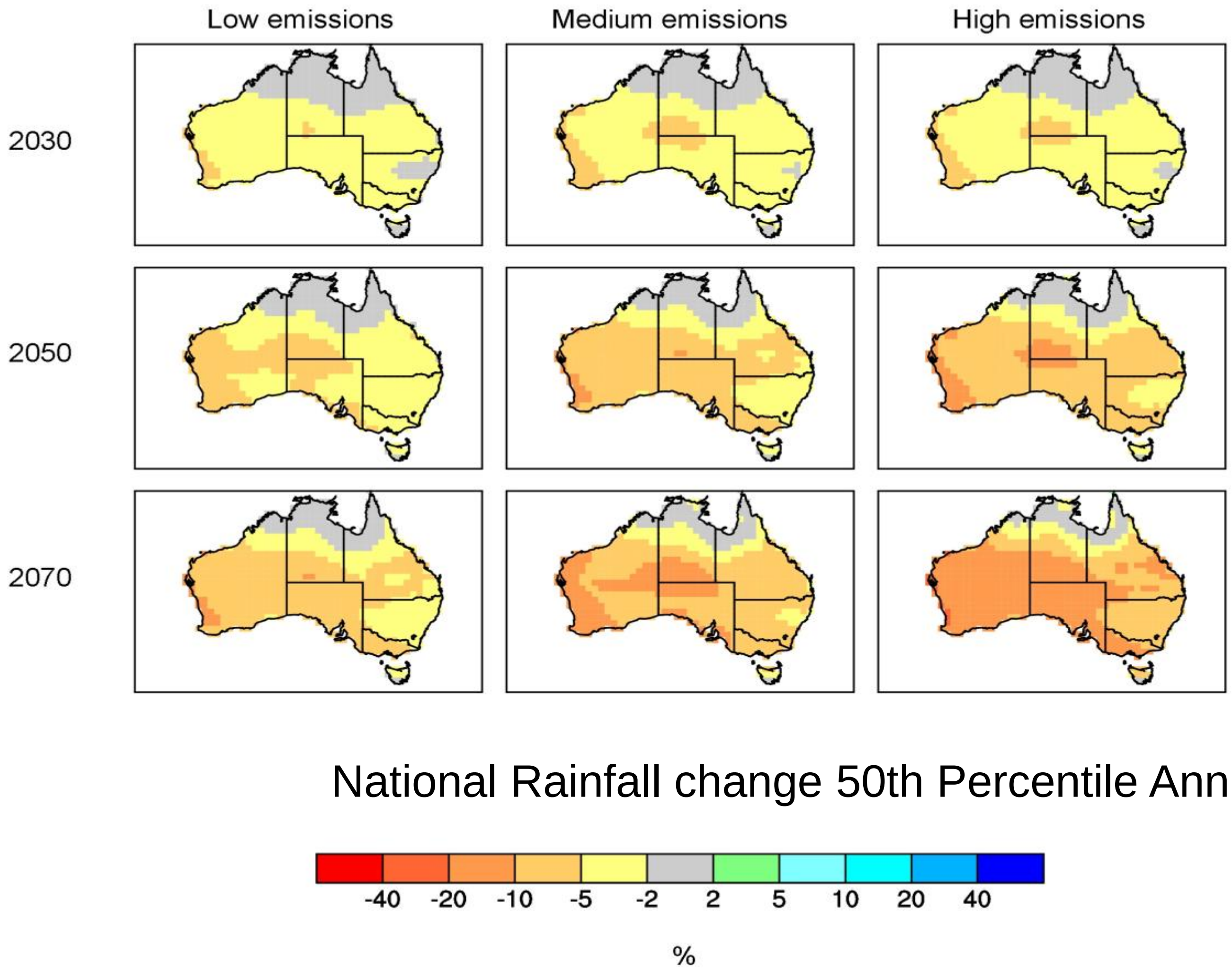
Source: Department of Planning and Community Development (2012)

Key challenges – Climate change



Projections are given relative to the period 1980-1999 (referred to as the 1990 baseline for convenience). The projections give an estimate of the average climate around 2030, 2050 and 2070, taking into account consistency among climate models. Individual years will show variation from this average. The 50th percentile (the mid-point of the spread of model results) provides a best estimate result. Source: http://www.climatechangeinaustralia.gov.au

Key challenges – Climate change



National Rainfall change 50th Percentile Annual

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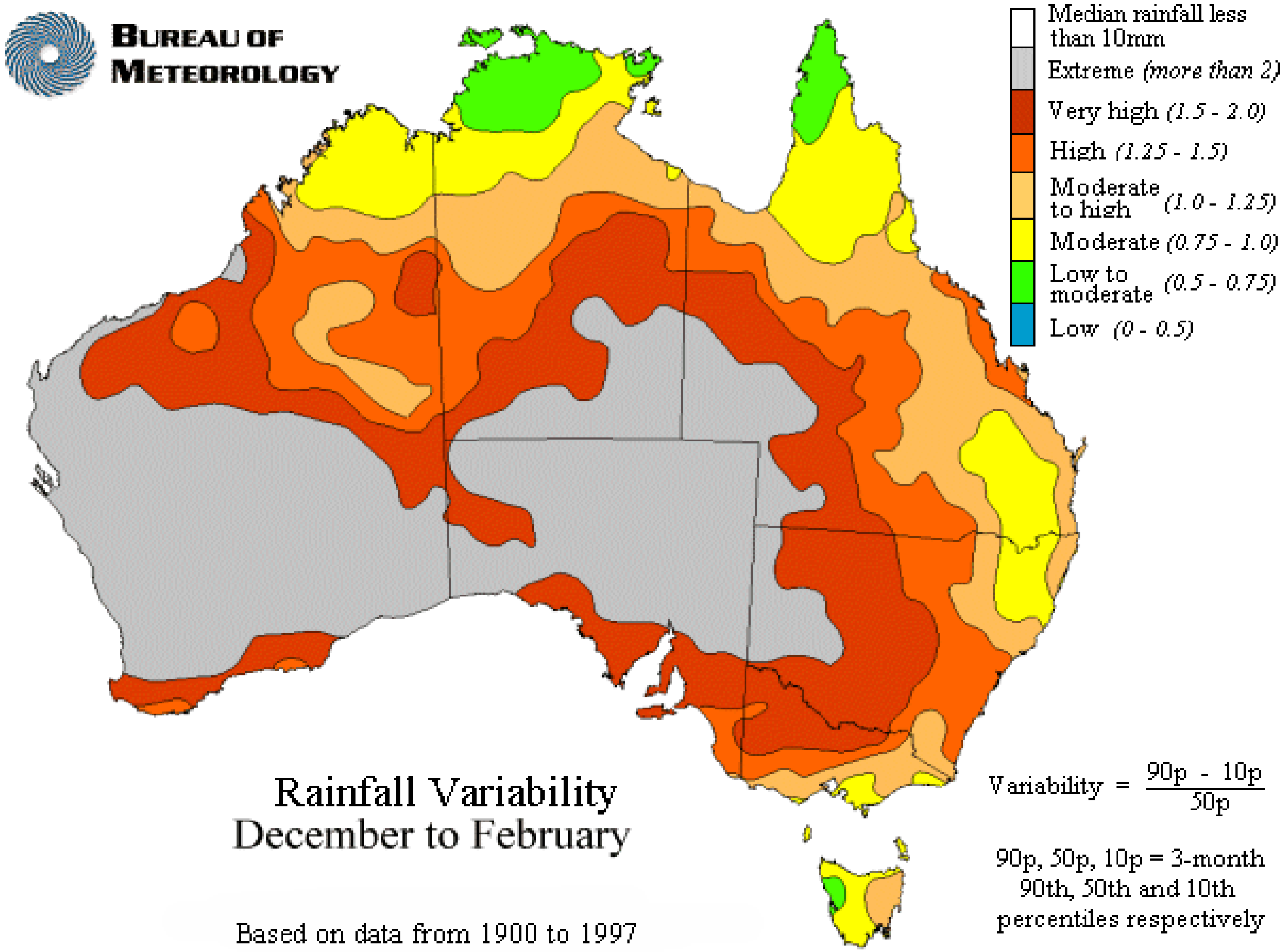
Rainfall variability



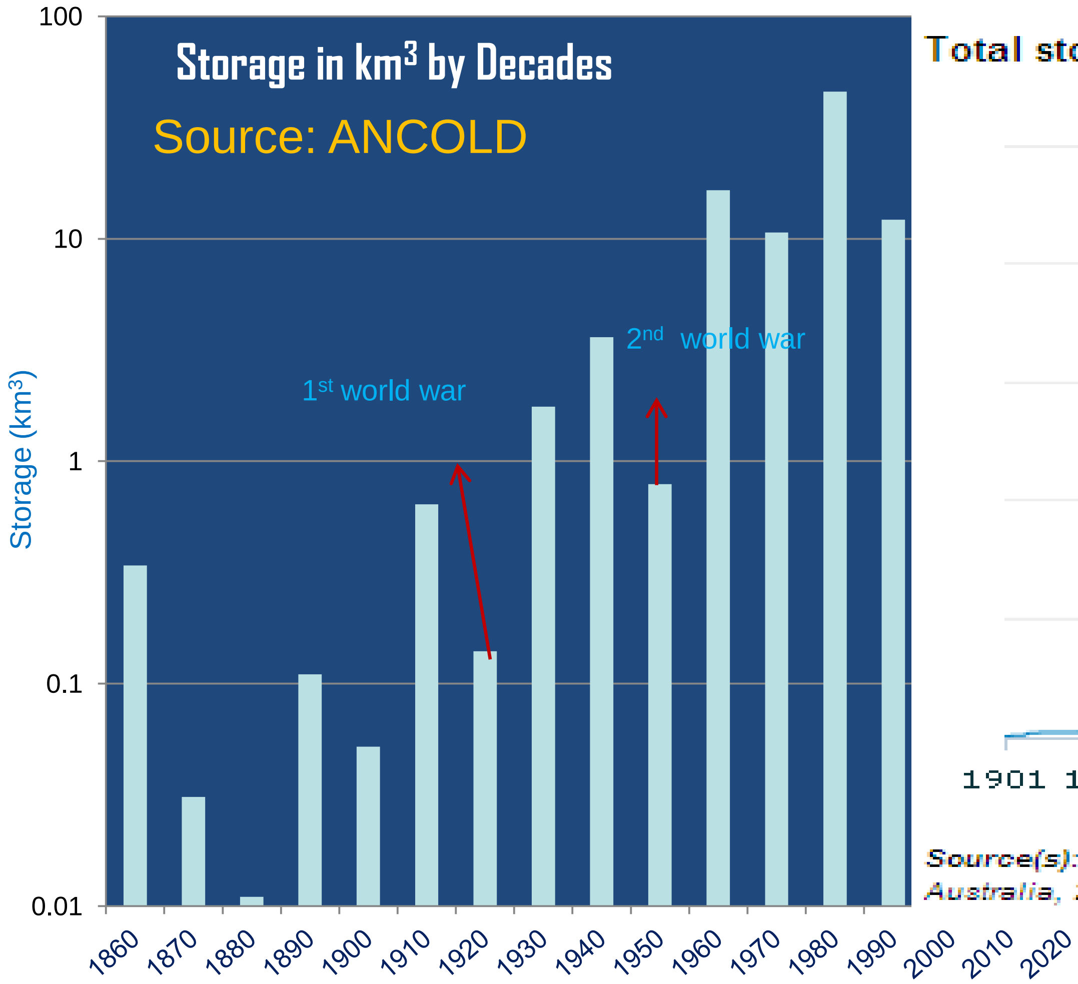
Where does Melbourne get its water from?

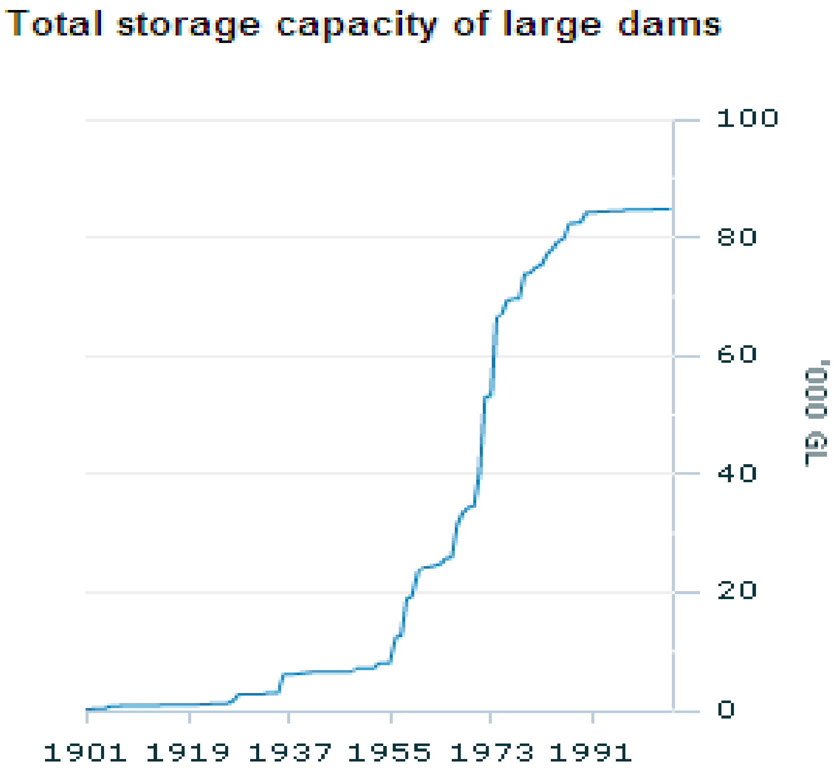
- **Protected catchments**: forested areas in north and east (156,700 hectares)
- Most catchments are located in national parks and state forests where public access is limited: **used exclusively for harvesting** water more than 100 years.
- **Deep soils** act like sponges to hold and filter the rain water.
- **Long storage times in reservoirs** provide further treatment.
- A smaller proportion of water comes from **open catchments**: farmland, rural properties and state forests and **camping, driving and small amounts of timber harvesting**.
- A **treatment process** to meet the same drinking water quality requirements as water from protected catchments.

Water Storage and Treatment

- 10 interconnected storage reservoirs
- Total storage capacity: 1,810 billion litres.
- Capacity varies from 3 billion litres 1,068 billion litres (Thomson).
- Water rests in the storage reservoirs for up to five years, which helps improve its quality.
- Level of treatment varies depending on source
  - Safe Drinking Water Act 2003
  - Safe Drinking Water Regulations 2005
  - Australian Drinking Water Guidelines 2011
- 38 service reservoirs at elevation
- Water is distributed via gravity.

Trends in storage development

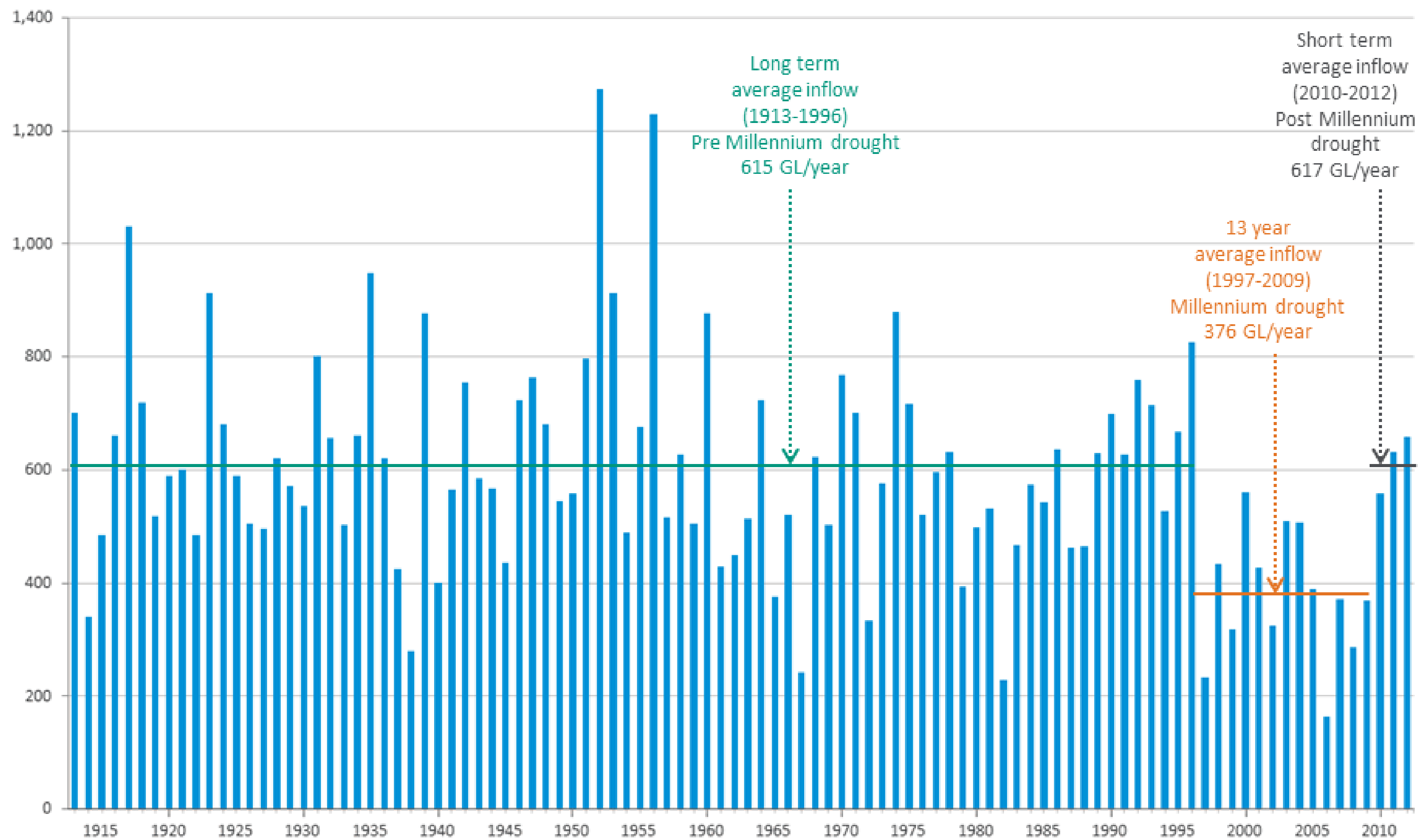




Source(s): ABS data available on request, Water Account Australia, 2004-05

Water inflow in Melbourne's Reservoirs

Annual Streamflow at Melbourne's Major Harvesting Reservoirs (Thomson, Upper Yarra, O'Shannassy and Maroondah Reservoirs)



Melbourne’s response to Drought

Two large infrastructure projects

1. Desalination plant

- 150 billion litres water/year
- In standby mode since Dec 2012.
- 84 kilometre transfer pipeline from Wonthaggi to Berwick. Where it joins water supply network and flows on to Cardinia Reservoir

2. North- South (Sugarloaf) pipeline: Feb 2010

- A 70 Km to carry water from the Goulburn River to Melbourne’s storages at Sugarloaf Reservoir
- Goulbourn river will receive this water from Lake Eildon, which is known as Melbourne’s ‘critical water reserve.
- $750 million budget
- An insurance for future droughts

Melbourne’s response to Drought

Demand Management

- Water restrictions
- Voluntary conservations campaigns
- Rebates for efficient appliances and rain water tanks
- 40% reduction in per capita daily demand

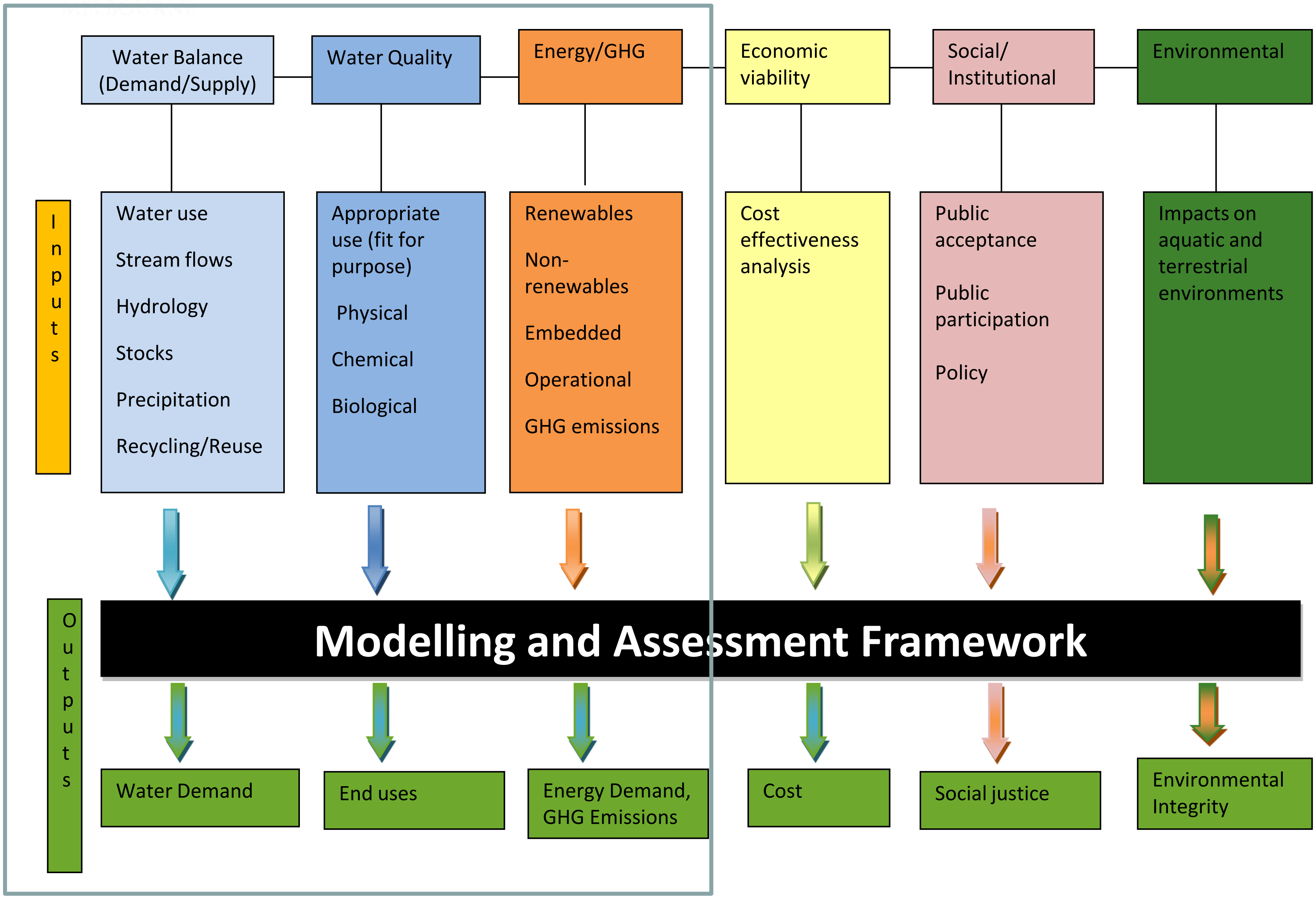
Water substitution:

- Recycled water: a target of 20% reuse by 2010.
  - 23% reuse by 2009, after drought, the trends have reversed.
- Stormwater capture
  - Average annual rainfall>average annual demand
  - Office of Living Victoria: $ 50 million fund
  - Rainwater harvesting < 2% total demand

Adaptive response to climate change and demand uncertainties

- Historical rainfall and stream flow data: no dependable guide to future.
- Need rainfall independent water supply sources.
- Diversification of water supply sources
- Non linear system of water supply (reuse and recycle)
- Water conservation (Demand management)
- Integration of water planning with urban planning

INTEGRATED MODELLING AND ASSESSMENT FRAMEWORK



Key Questions

1. What's the most appropriate mix of various water supply options?
2. What will be the impact on overall energy use and GHG emissions?
3. How will such systems interact with the existing infrastructure?

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Water Demand and Supply Modelling

Hydrological flow model

Water demand model

- Household surveys, meter readings: extrapolated
- Deterministic models: Monthly or annual water demand forecasts for the whole of urban water system.
- Good for centralized systems.

- IUWM: Local sources and highly diverse over small spatial and temporal scale

- End use water demand

The end-use model

$$EU_d = Fre \times FR \times Dur$$

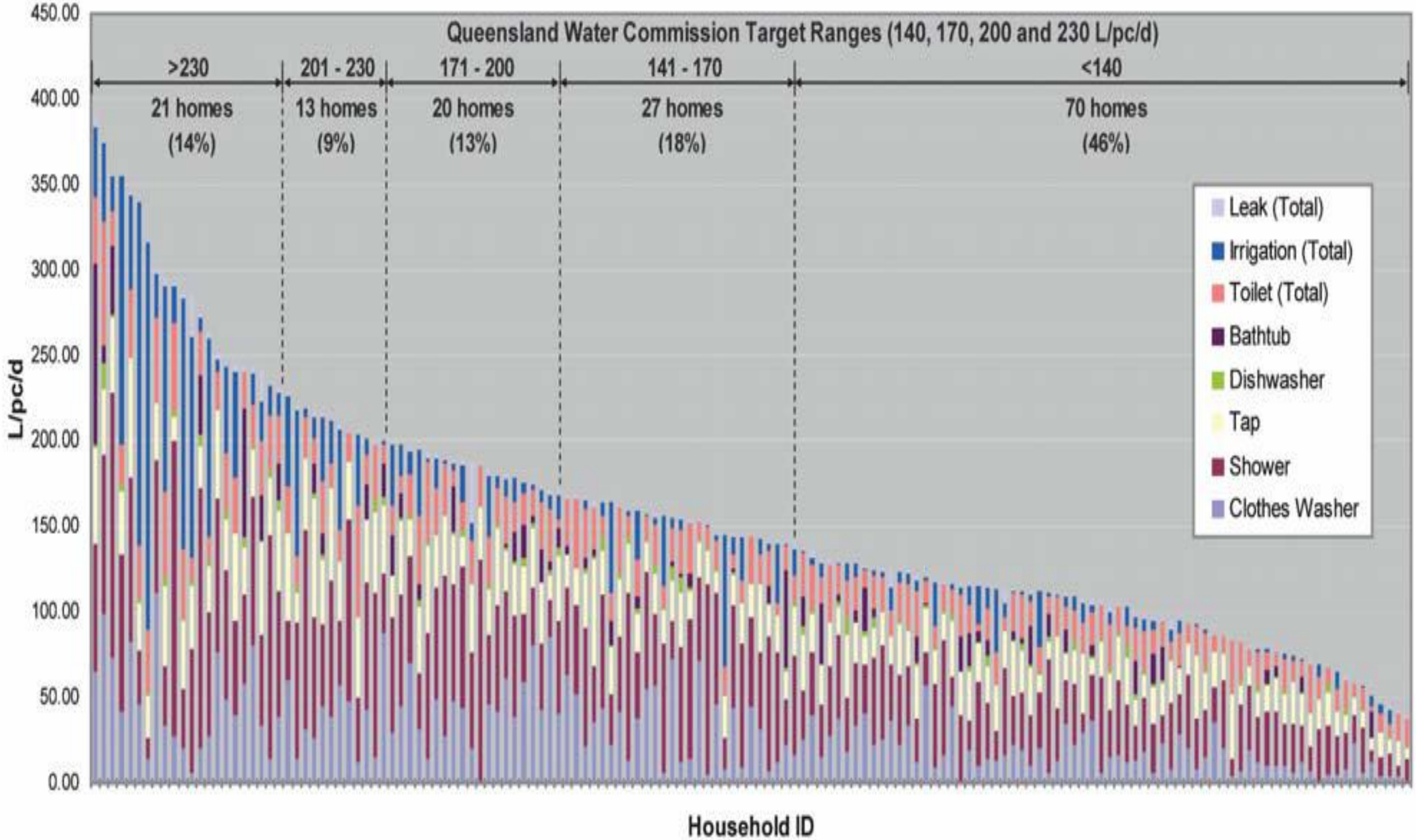
- EU_d = End-use water demand per person (Ld^{-1})
- Fre = Frequency of use (Events/day)
- FR = Flow rate (L s-1)
- Dur = Duration of an event (seconds)

$$WD = \sum EU_d$$

- WD = Water demand per person (Ld-1)
- EUd = End-use water demands per person (Ld-1)

$$WD_{Annual} = n * WD * 365$$

Household Daily Per Capita water consumption



How to predict the water demand in an urban precinct with representation of spatial and temporal variability?

(Willis et al., 2009)

Spatial and Temporal variability:

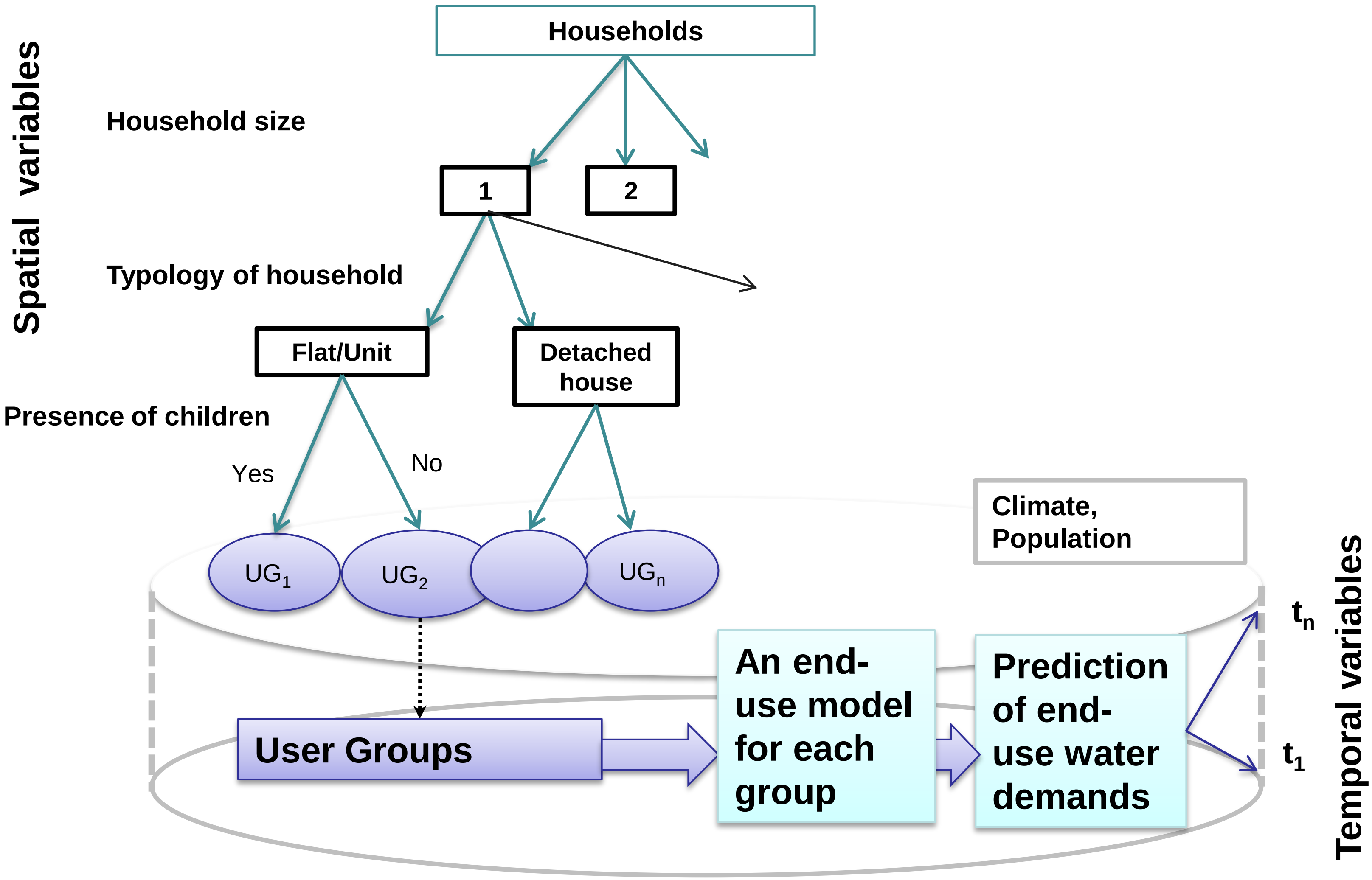
1. Identification of spatial variables: Multiple Regression –survey data and meter readings, YVW and CWW.
   - Household size (1-7)
   - Typology of dwelling (Flats/units, Detached houses, Apartments)
   - Presence of children under 12 years (Yes/No)
   - Appliance efficiency
   - Pool, dishwashers, size of garden and irrigation method

3. Identification of temporal variables: 2 sample t-tests, End use measurement data and climate data
   - Climate (temperature, rainfall, season): Shower, irrigation and cooler
   - Day of the week (weekdays or weekend): Washing machine.

4. User Groups:

5. An end use model: for each group to predict end use water demand

Conceptual Model



No. of user groups: 7*3*2 = 42

The end-use model

$$EU_d = PR \times Fre \times FR \times Dur$$

- EU_d = End-use water demand per household(Ld^{-1})
- PR = Penetration rate
- Fre = Frequency of use (Events/day)
- FR = Flow rate (L s-1)
- Dur = Duration of an event (seconds)

$$WD = \sum EU_d$$

- WD = Water demand per household (Ld-1)
- EUd = End-use water demands per household (Ld-1)

$$EU_{h1} = PO \times EU_d$$

- EU_{h1}=End-use water demand per household in first hour (Lh^{-1})
- PO= Probability of occurrence
- EU_d = End-use water demand per day per household (Ld^{-1})

Key Questions

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Key Question

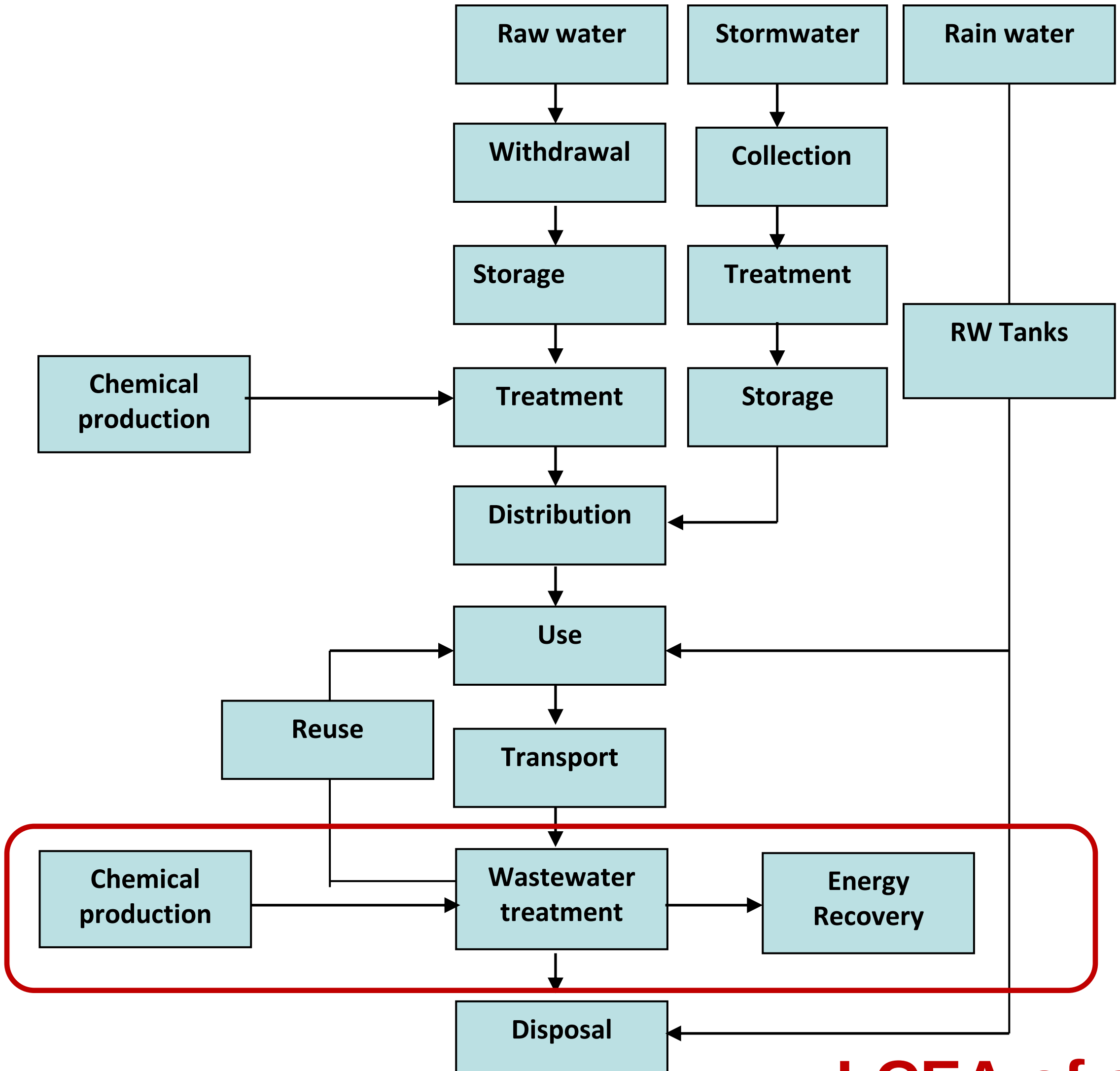
What is the most appropriate level of decentralisation, in which

- **Energy use and GHG emissions from urban water systems are minimum**
- **Various end use water demands are met according to the quality required.**

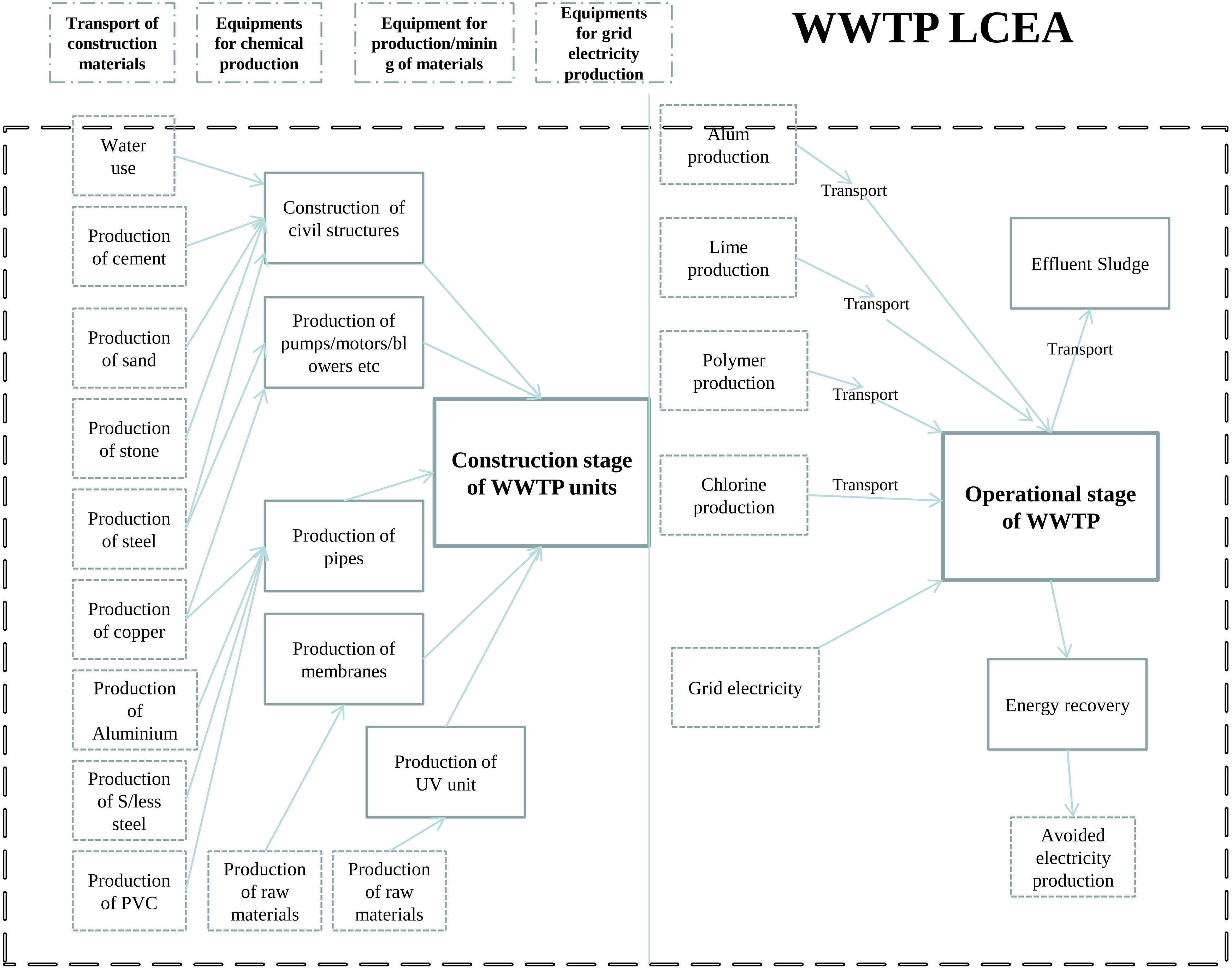
Two step approach:

1. Characterize the energy use (both operational & embodied) and environmental impacts (GHG emissions) in each step of the water system by LCEA analysis: Simapro software.
2. Modelling Various “what-if” scenarios in a System Dynamic Model (Simulink) to identify best possible outcome in terms of energy &GHG emissions

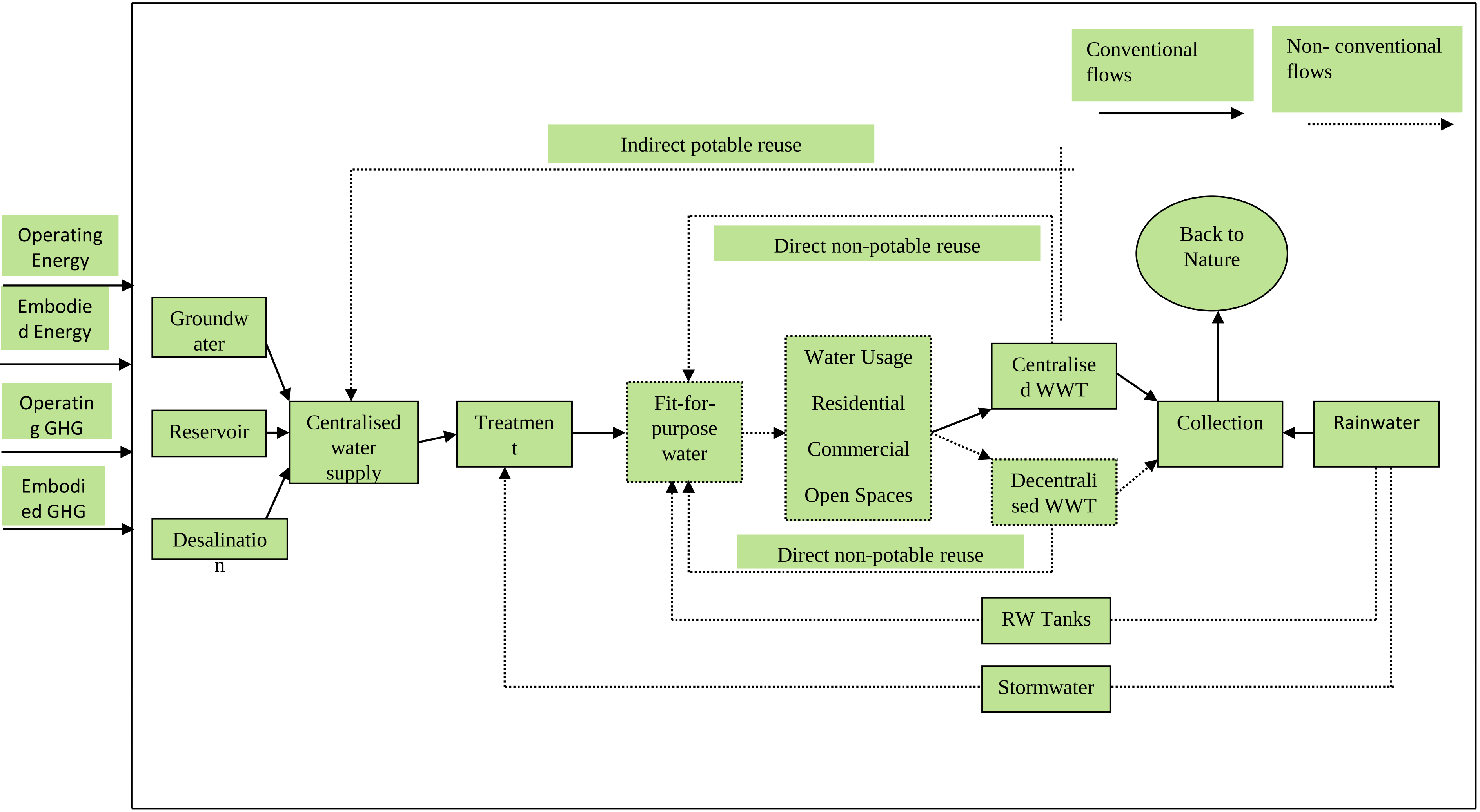
LCEA analysis



LCEA of a Waste Water Treatment Plant


Transport of construction materials
Equipments for chemical production
Equipment for production/mining of materials
Equipments for grid electricity production
WWTP LCEA
Water use
Production of cement
Production of sand
Production of stone
Production of steel
Production of copper
Production of Aluminium
Production of S/less steel
Production of PVC
Construction of civil structures
Production of pumps/motors/blowers etc
Production of pipes
Production of membranes
Production of UV unit
Production of raw materials
Production of raw materials
Construction stage of WWTP units
Alum production
Lime production
Polymer production
Chlorine production
Grid electricity
Transport
Transport
Transport
Transport
Transport
Effluent Sludge
Operational stage of WWTP
Energy recovery
Avoided electricity production

System Dynamic Model



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Impacts of hybrid systems on existing infrastructure

a) Grey water reuse: More concentrated sewage.

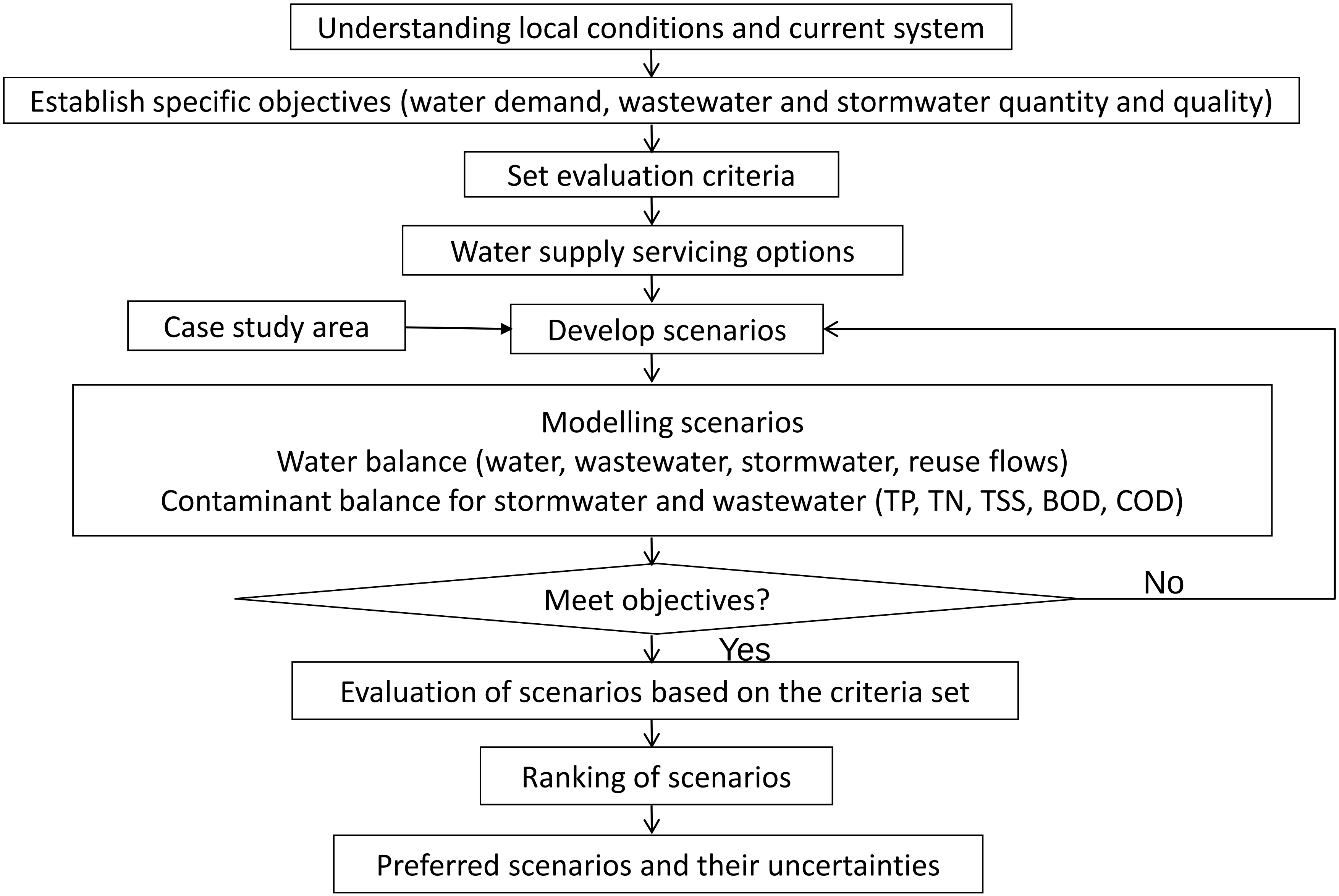
b) Storm water harvesting: Higher concentrations of heavy metals in the waste.

How to assess/model the impacts of hybrid water systems on central water infrastructure in terms of flow quantity and quality?

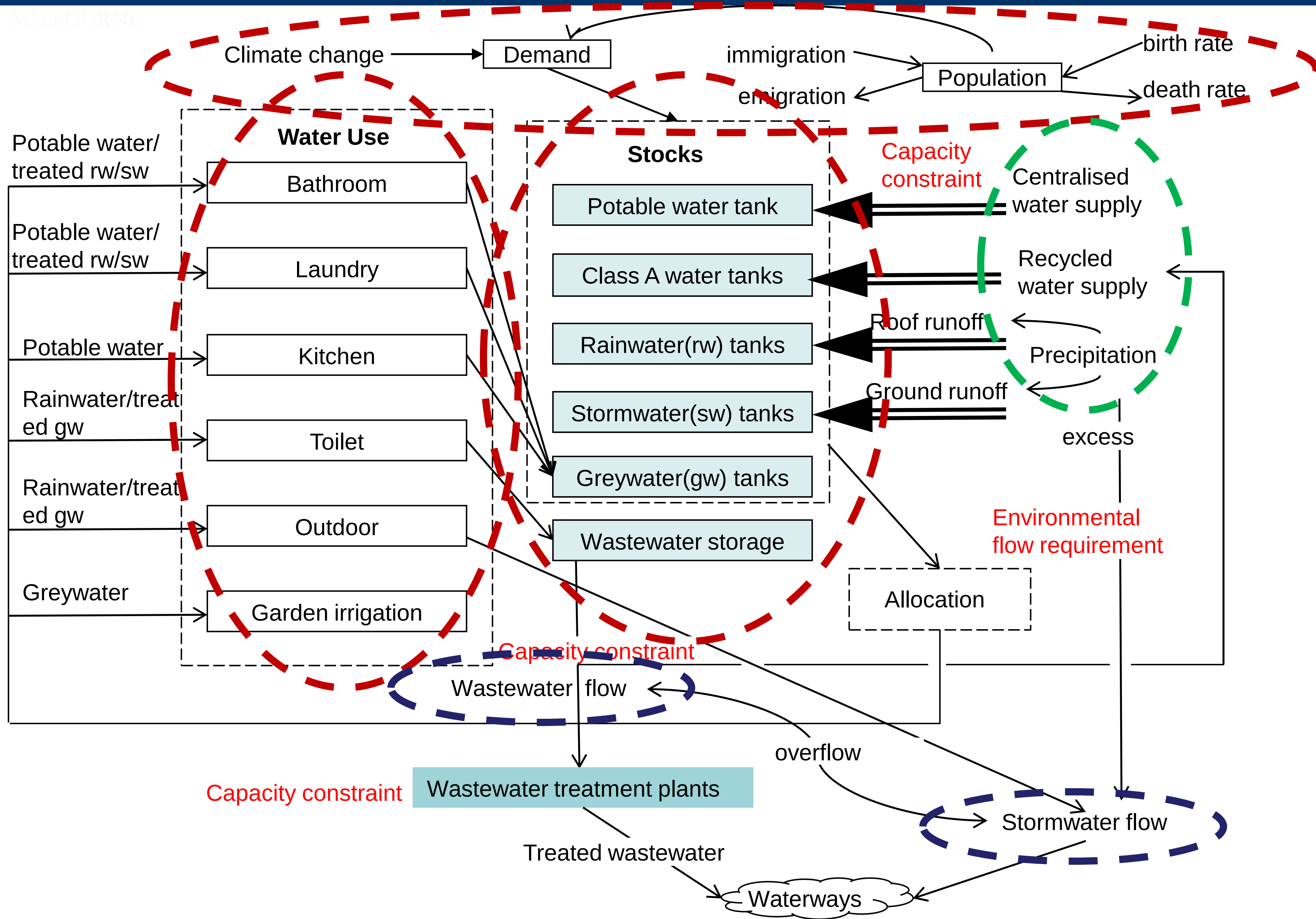
- Water balance (water, wastewater, stormwater, reuse flows)
- Contaminant balance for stormwater and wastewater (TP, TN, TSS, BOD, COD.

- MCDA: Evaluate the outputs against a criteria (based on meeting service objectives and infrastructure constraints).
- Uncertainty analysis for the most appropriate scenarios.

Framework to evaluate hybrid WSS



Stock-and-flow diagram of hybrid WSS



Water Quality

1. Water quality issues in urban catchments
   – Stormwater bio filtration
   – Stream water quality
2. Groundwater quality
   - Fluoride and Arsenic removal from underground water
   - Contaminated land remediation in Antarctica

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Thank You for your attention