A consideration of Water Sensitive Urban Design (WSUD) modelling strategies

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CRC For Water Sensitive Cities: Cities as Water Supply Catchments Project

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MONASH University

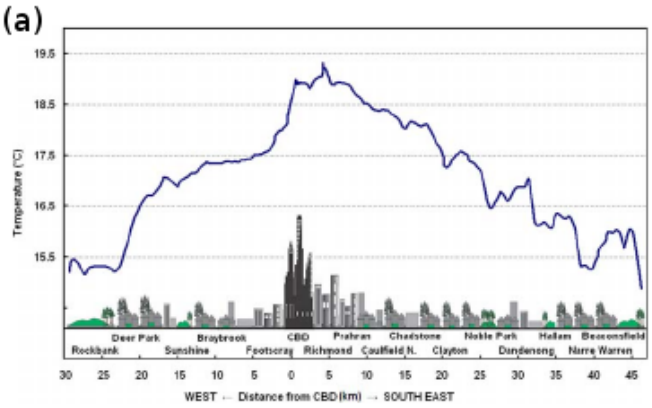
CRC for Water Sensitive Cities

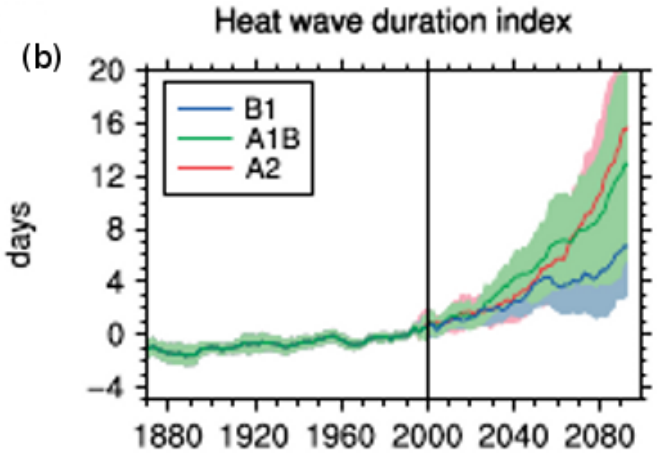
Increasingly vulnerable Australian demographics

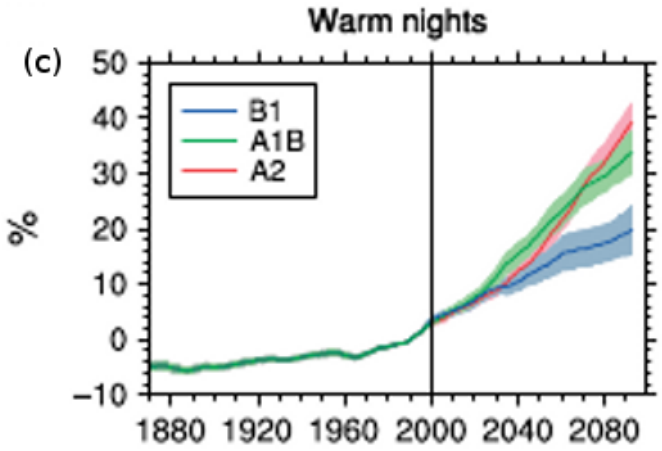
- **Population growth** - In 2007, 21.0 million people
  30.9 to 42.5 by 2056
  33.7 and 62.2 by 2101.
- **Ageing population** - Median age, 36.8 years in 2007
  38.7 to 40.7 years in 2026
  41.9 to 45.2 years in 2056.
  In 2007, 13% of population 65 years and over
  23% to 25% in 2056
- **Increased urbanisation** - In 2007, 64% lived in a capital city.
  By 2056, increase to 67%.

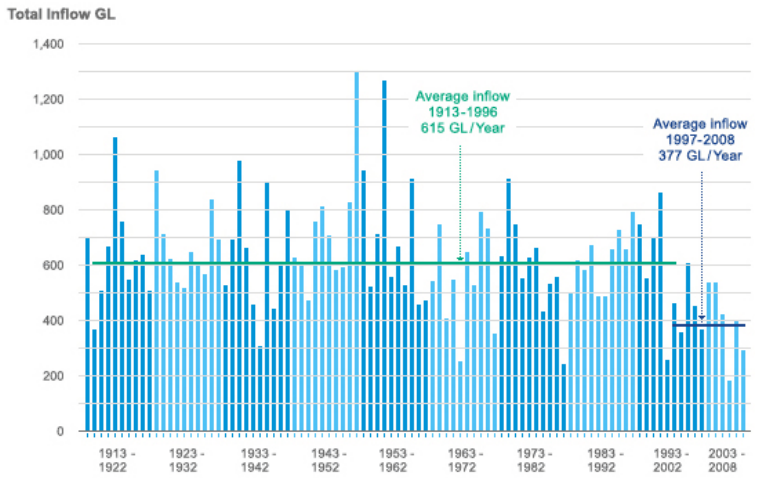
(http://www.abs.gov.au/Ausstats/abs@.nsf/mf/3222.0)

Urban heat, climate trends, water supply







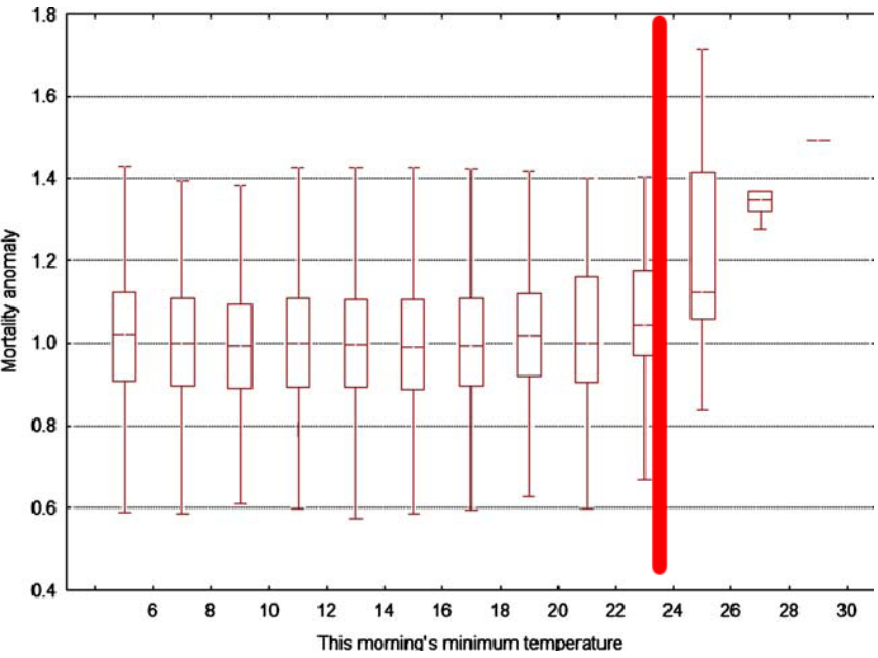


Urban heat island effects; predicted increasing extremes for Australia; Melbourne's water supply

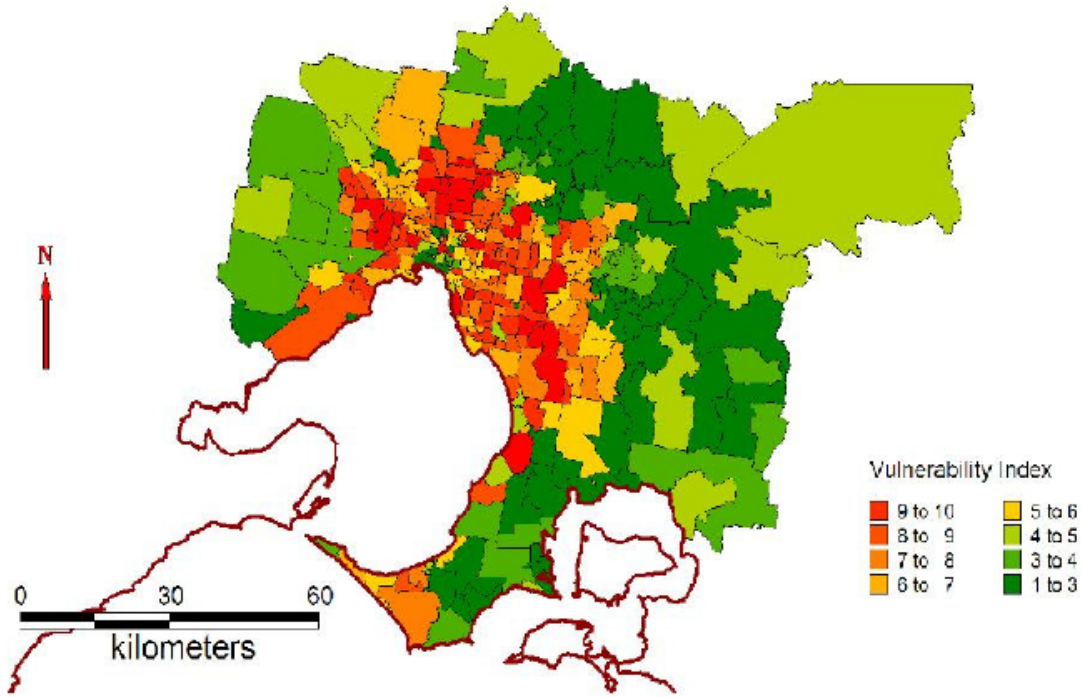
(Coutts et al. 2010; Alexander & Arblaster 2009; Melbourne Water 2008)

Melbourne heat index thresholds and spatial vulnerability of high risk populations during hot weather

Melbourne: Daily min. temp. 24 °C threshold



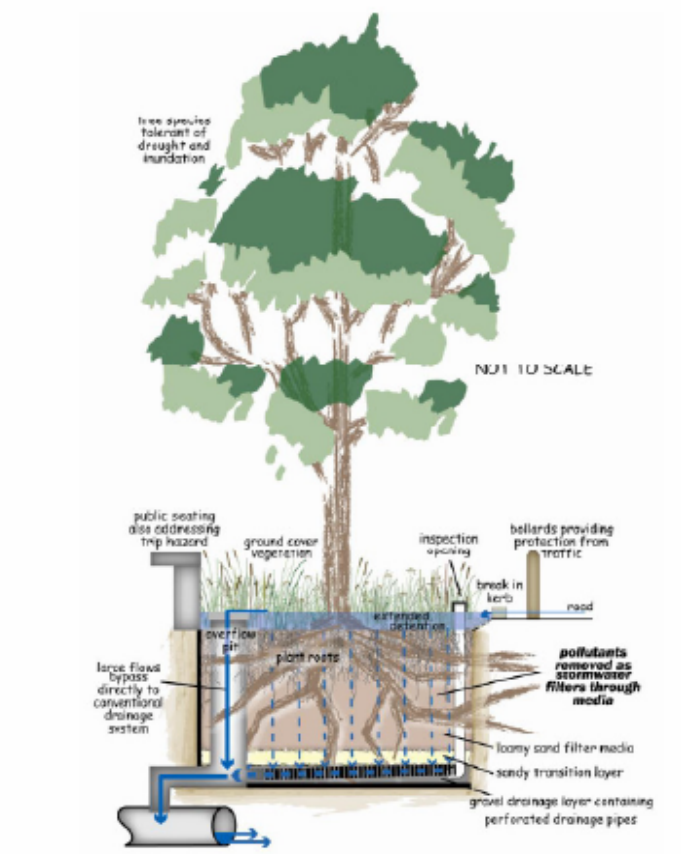
(Nicholls et al. 2008; Loughnan et al., 2009)



Melbourne vulnerability index based on UHI, land use, urban form, demographics (age, medical conditions, socio-economic, social isolation)

Water Sensitive Urban Design (WSUD) as mitigation/adaptation

Tree pits and other WSUD features in urban areas.

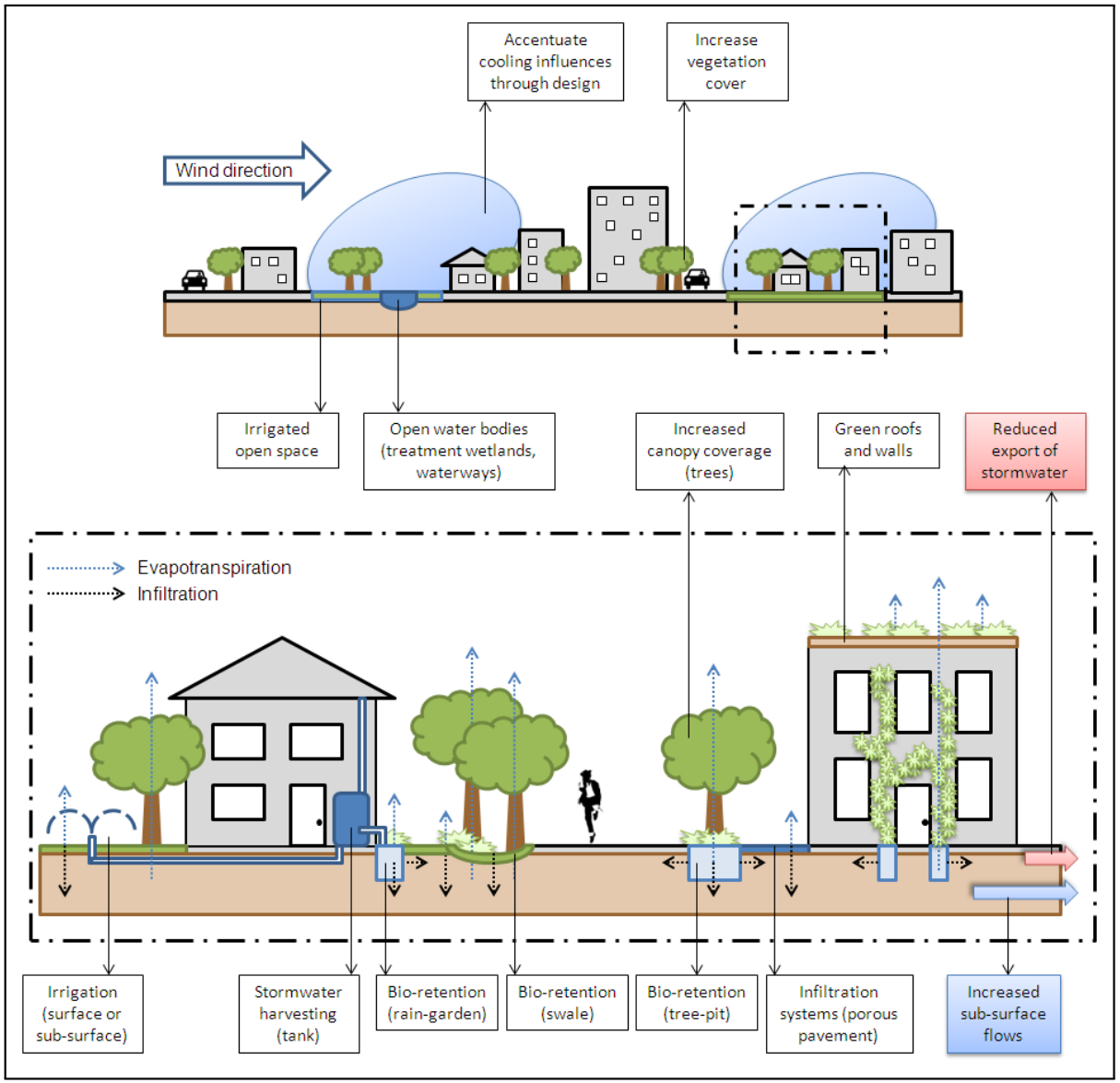


Design of a tree-pit (FAWB, 2009)

Are there positive climatic impacts on human thermal comfort?

(FAWB 2009; FAWB 2008)

CRC for Water Sensitive Cities research overview

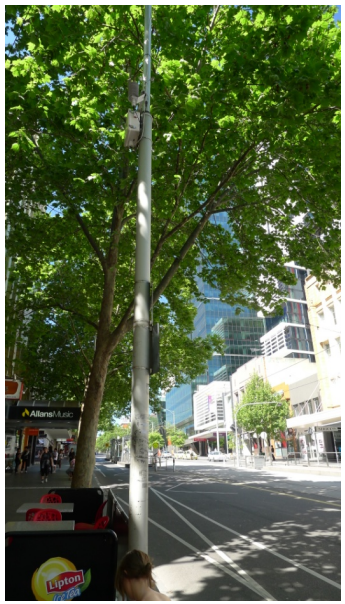


(Coutts 2012)

Cities as Water Supply Catchments, Project 3: Green Cities and micro-climate

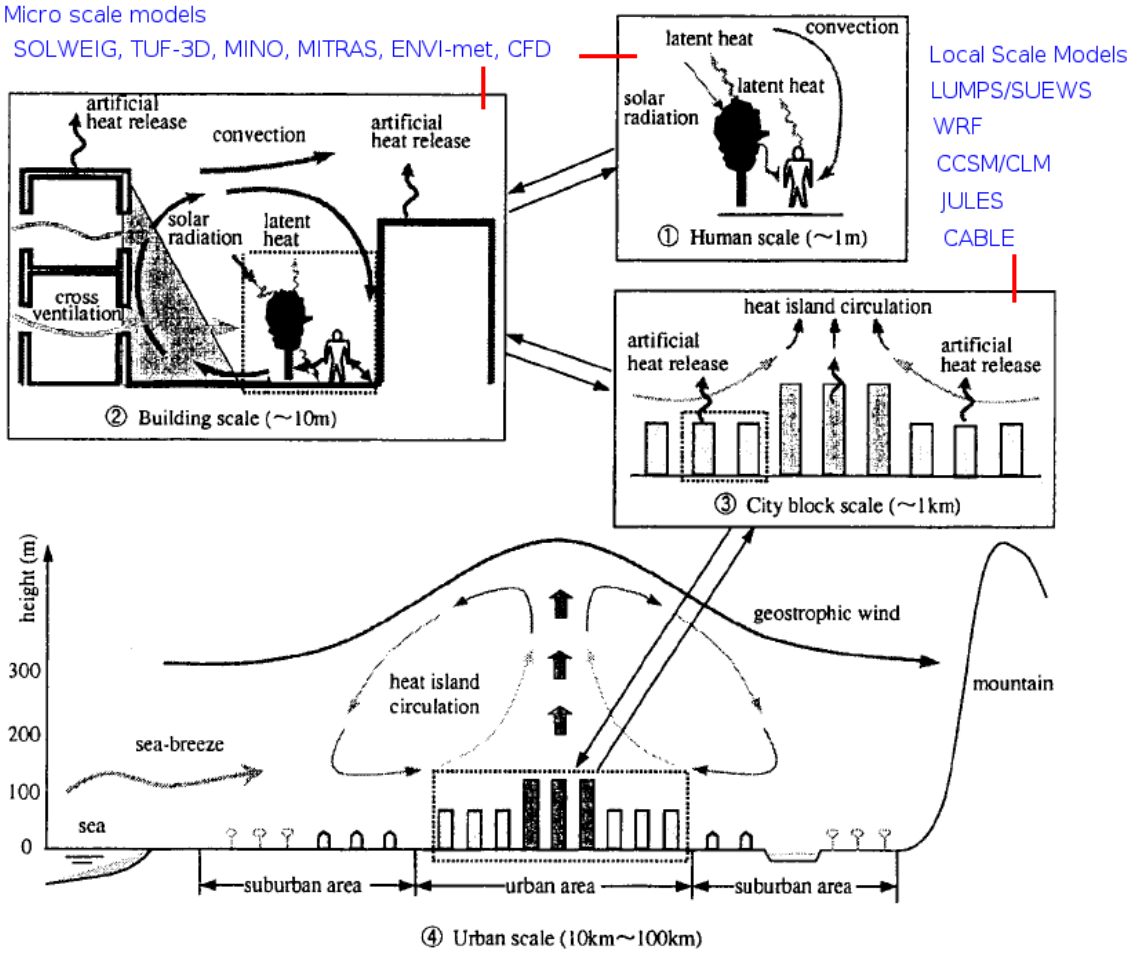
- Meet challenges of drought & water restrictions, poor vegetation health, strained water supplies, degraded stream health
- Integrating Water Sensitive Urban Design features throughout the urban landscape as a natural cooling mechanism and UHI mitigation strategy
- Increasing vegetation in the landscape AND providing water for vegetation health
- Enhanced infiltration and evapotranspiration

Monitoring of WSUD features - Observational research



- How effective are SW harvesting technologies, green infrastructure and WSUD in improving urban climates at a range of scales?
- How much water and vegetation is required to limit temperatures and enhance human thermal comfort and liveability?

Modelling WSUD



Observations can only examine what already exists. Modelling is needed to examine a wider range of scenarios, technologies, and climatic benefits at a variety of scales.

(Adapted from Murakami et al. 1999)

Local to regional scaled modelling for WSUD

- Modelling at this scale to examine broad impacts of WSUD to moderate air temperature extremes as well as examine daily temperature cycles and UHI effects.
- At this scale, LUMPS/SUEWS, which has the most complete water cycle features, appears to be a good avenue to model these features at this resolution for the Cities as Water Catchments program.
- Other modelling assessments are also being done by the program at this scale using WRF and CESM/CLM

Micro scaled modelling for WSUD

- For a complete picture of climatic benefits of WSUD techniques at this scale, models need to handle vegetation effects (shading/evaporation) as well as include a complete water cycle and take particular care to get latent energy fluxes correct
- Mean radiant temperature predictions are essential as this is the scale where WSUD's impact on HTC will be best seen.
- A simplified modelling approach, as opposed to full 3-D computational fluid dynamics (CFD) techniques, is desirable as industry partners will lack the expertise and time necessary to use a more complex model as part of a planning toolkit.
- TUF-3D is chosen as the basis for the modelling to be done at this scale for WSUD assessments due to these criteria.

Project title and objectives

An assessment of water sensitive urban design (WSUD) feature influences on urban micro-climates in support of human thermal comfort (HTC) in urban areas: Urban micro-climate modelling and improvements to the Temperatures of Urban Facets in 3-D (TUF-3D) urban micro-climate model

Project objectives:

- Assess current model state of art and TUF-3D selection
- TUF-3D modifications and assessment of improvement:

  Additions of green roof/walls, tree pits, biofiltration pits
- Assessement of WSUD scenarios and urban morphologies

TUF-3D model structure

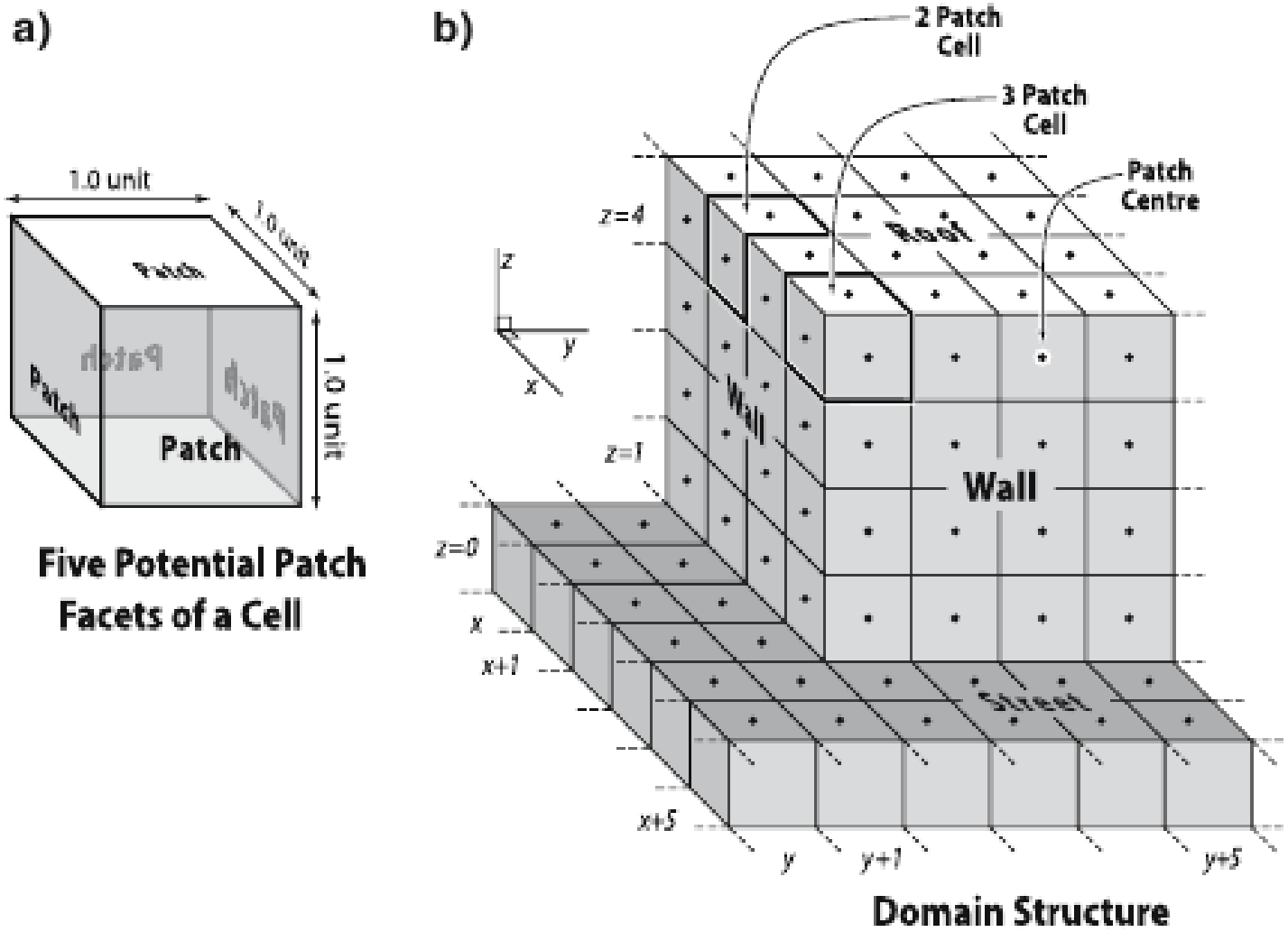


Fig. 1 Basic cubic cell and surface patch structure of TUF-3D

(Krayenhoff & Voogt 2007)

TUF-3D domains

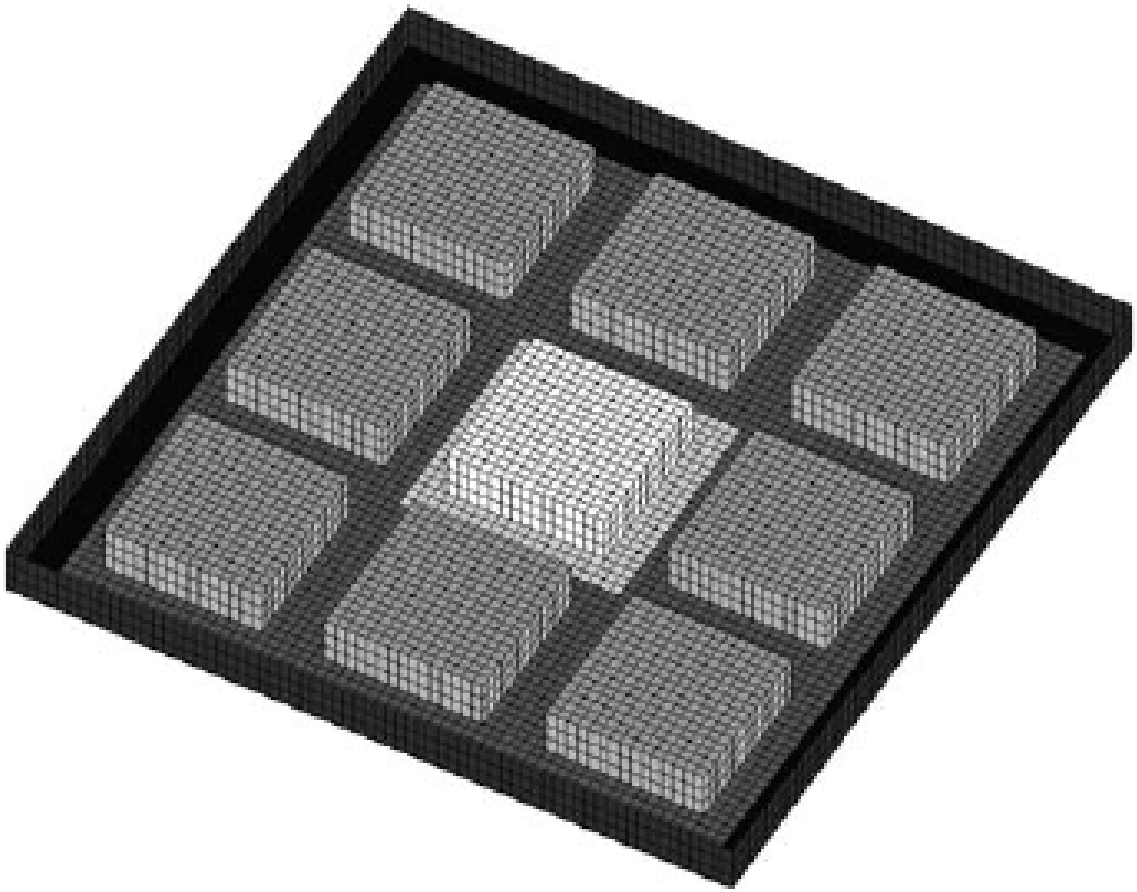
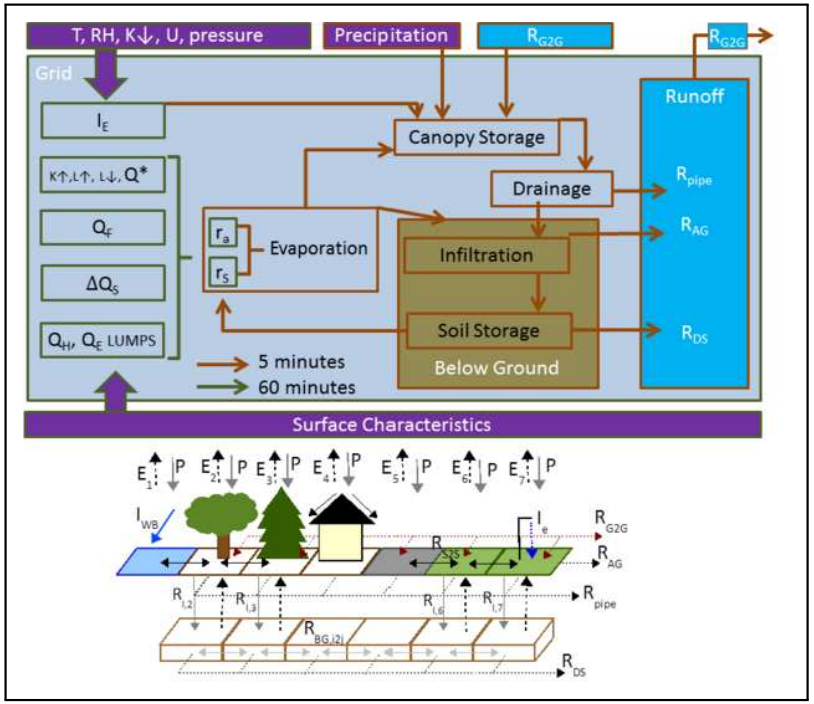
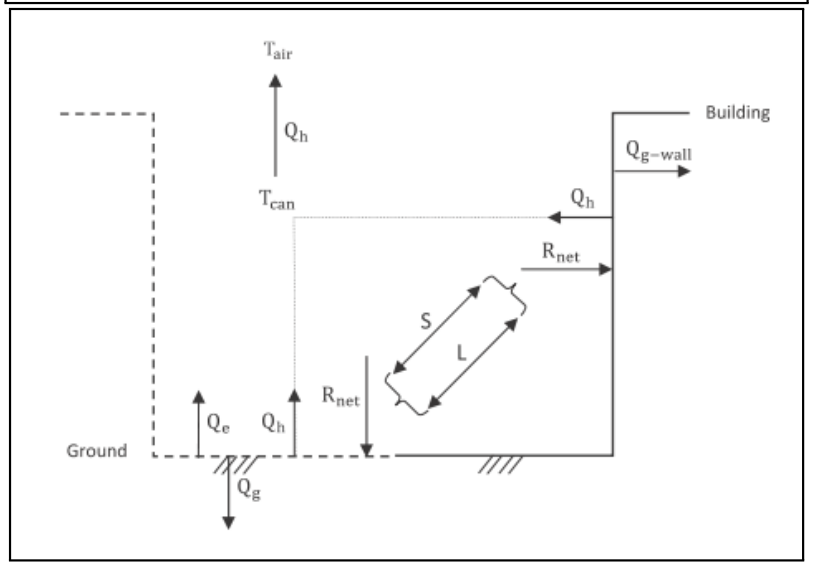


Fig. 2 An example TUF-3D domain with a bounding wall and the sub-domain S_d (chosen to coincide with the central urban unit) in lighter shades

(Krayenhoff & Voogt 2007)

Future work - Additions to TUF-3D

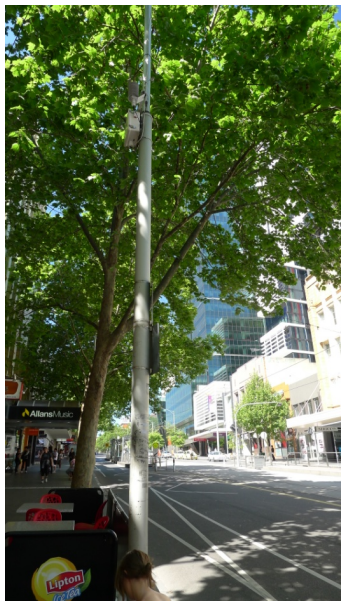




(Jarvi & Grimmond 2011; Yaghoobian et al. 2010)

- Water cycle (as modelled in the SUEWS model)
- Latent energy flux additions (schematic of energy balance components in TUF-3D)
- Vegetation and vegetation processes

WSUD assessments and best practice



Use of new tool to model WSUD features (green roof/walls, biofiltration pits, tree pits) and different WSUD scenarios