The implementation of biofiltration systems, rainwater tanks and urban irrigation in a single-layer urban canopy model

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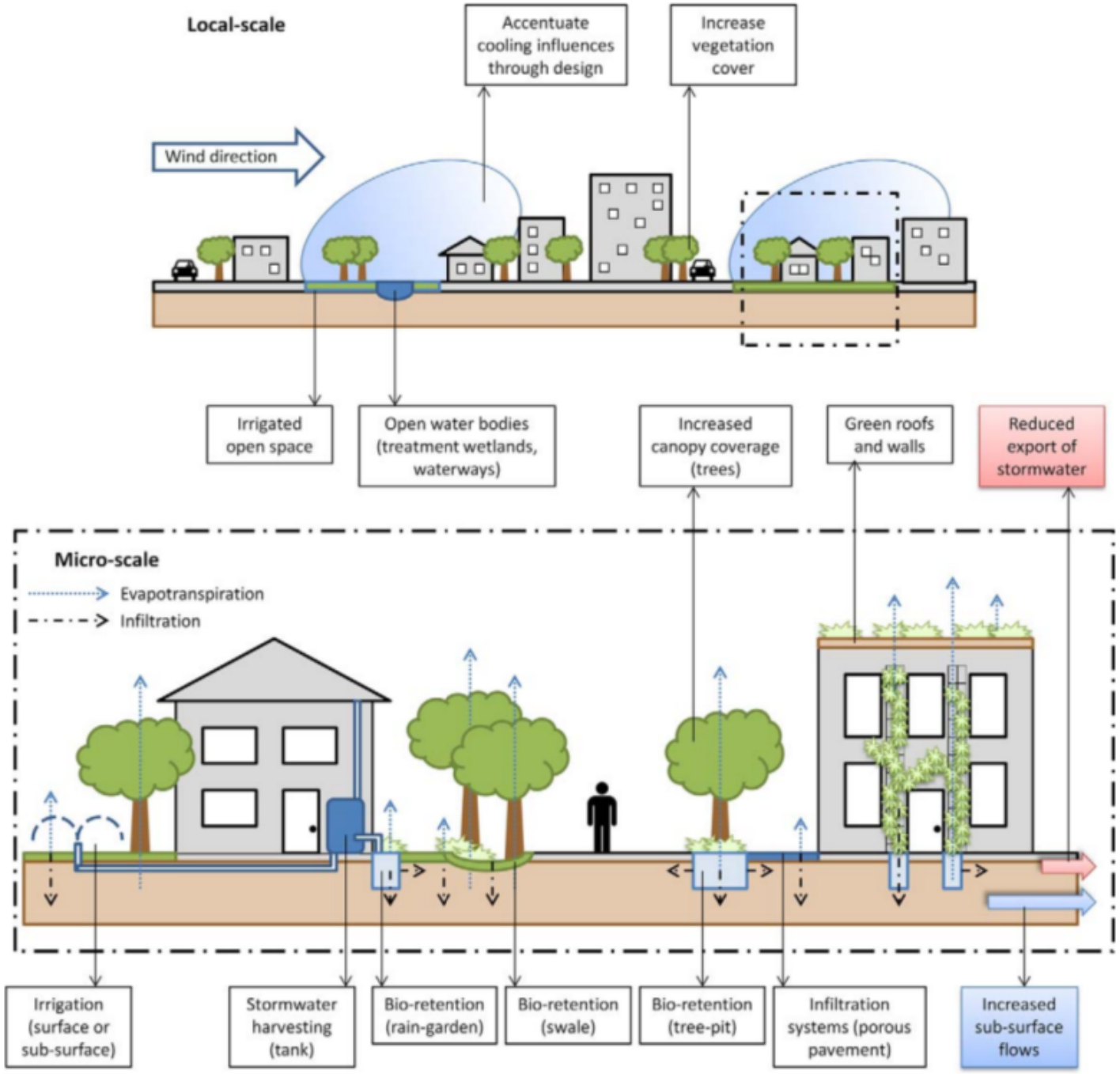

Coutts et al., PPG, 2013

But ...

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Tree deaths triple as city's soil turns to dust

August 24, 2009

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Kate Lahey

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MELBOURNE lost 900 trees last year - three times more than usual - and 40 per cent of the remaining trees are stressed, council data shows.

Water authorities will be asked to consider altering restrictions for Melbourne's parks and boulevards as the city council increases its use of mulch, catches more rainwater and installs more underground irrigation.

The City of Melbourne wants enough water to ensure soil moisture levels don't drop below 40 per cent this summer, and to be able to use extra water in the lead-up to extremely hot days.

In February's heatwave, council officers decided to breach their water restrictions to turn on turf sprays in the middle of the night, fearing they would lose more trees without the extra watering.

The City of Melbourne is asking water authorities to ease restrictions on tree watering. *Photo: Craig Abraham*

Information from the council shows 40.2 per cent of the 63,000 trees in the city's parks and streets are stressed, and soil moisture levels have been reaching perilously low levels - close to 20 per cent.

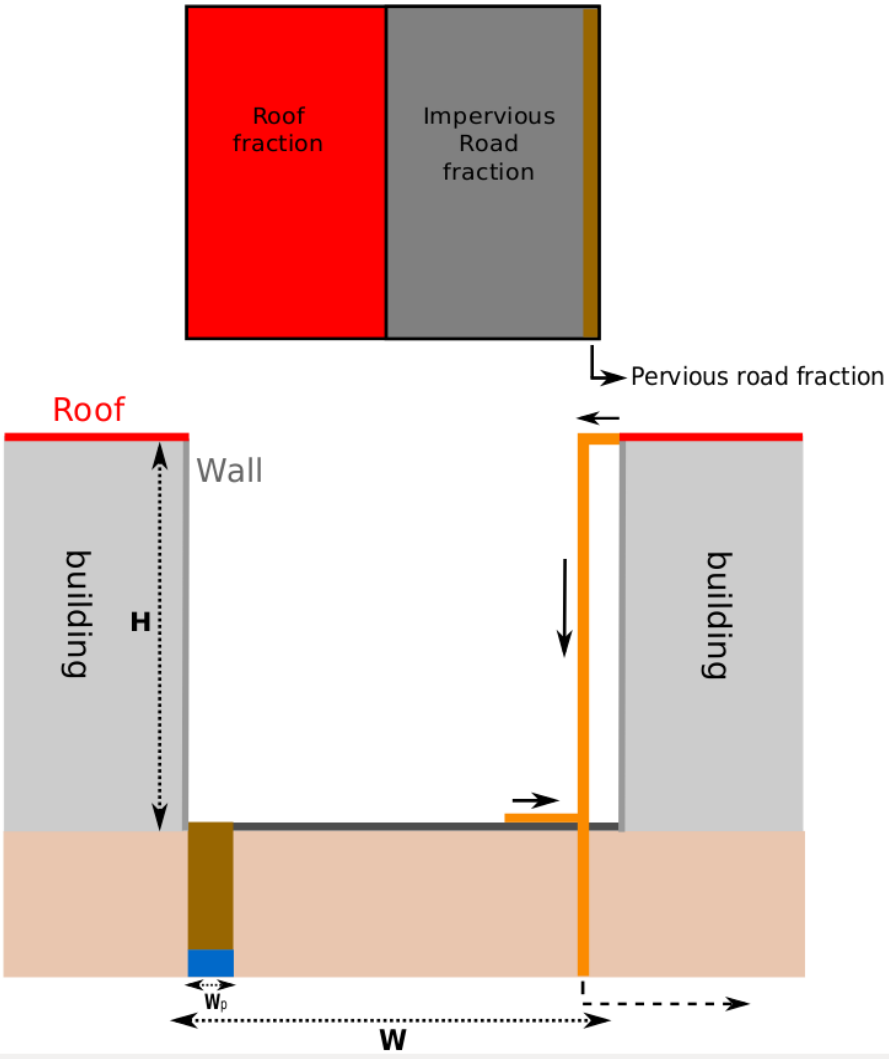
The Sydney Morning Herald, August 24, 2009

I. Can we implement such WSUD features in a current state-of-the-art urban canopy model?

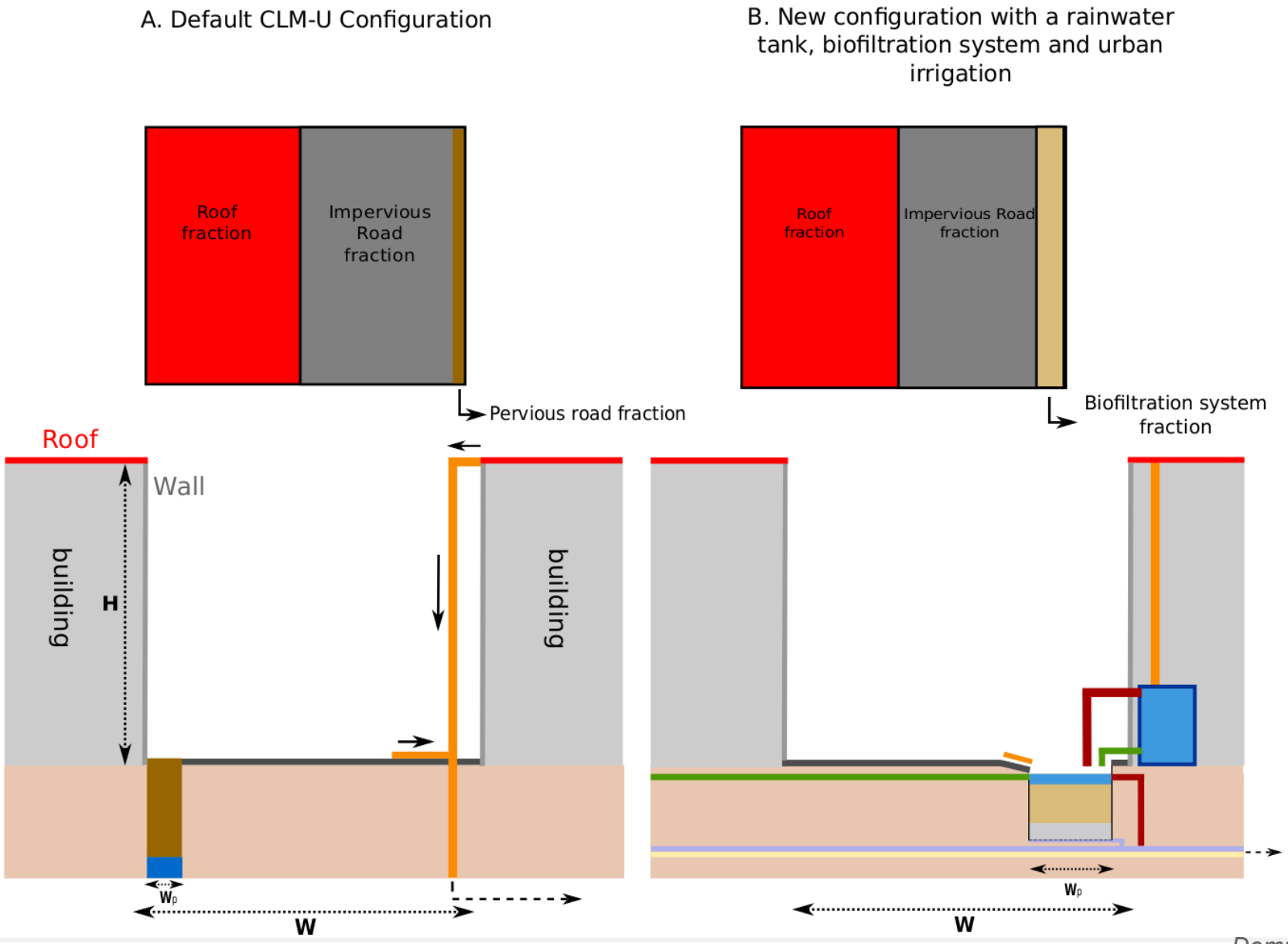
I. Can we implement such WSUD features in a current state-of-the-art urban canopy model?

II. What is the impact of such features in terms of water availability and evapotranspiration?

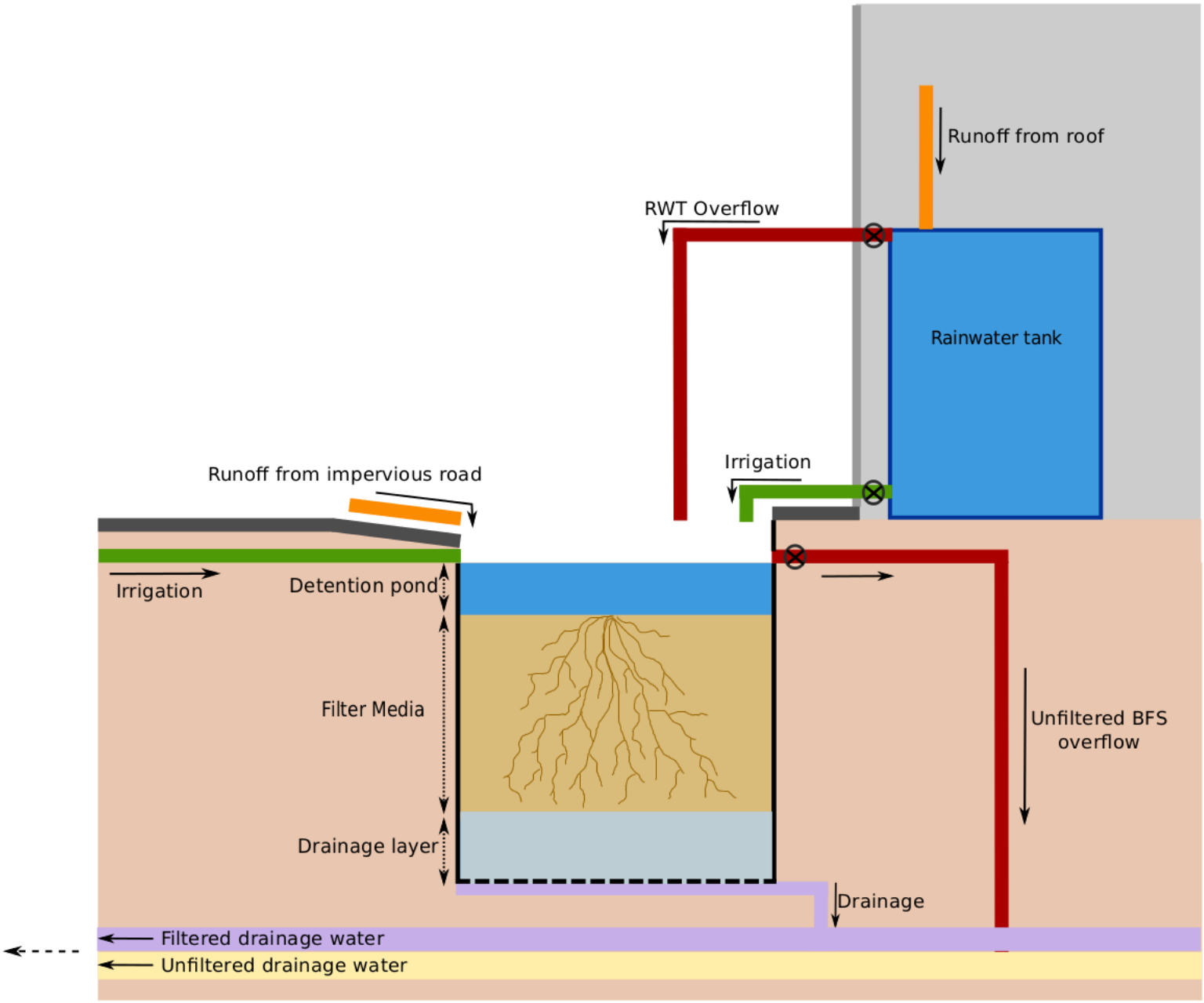
A. Default CLM-U Configuration



Demuzere et al., UC, 2014



Demuzere et al., UC, 2014


Runoff from roof
RWT Overflow
Rainwater tank
Irrigation
Runoff from impervious road
Irrigation
Detention pond
Filter Media
Drainage layer
Unfiltered BFS
overflow
Drainage
Filtered drainage water
Unfiltered drainage water

Optimized sub-surface irrigation system (Oleson et al. 203):

- Define target soil moisture

$$w_{target,i} = (1 - \alpha_{irr})w_{o,i} + \alpha_{irr} w_{sat,i}$$

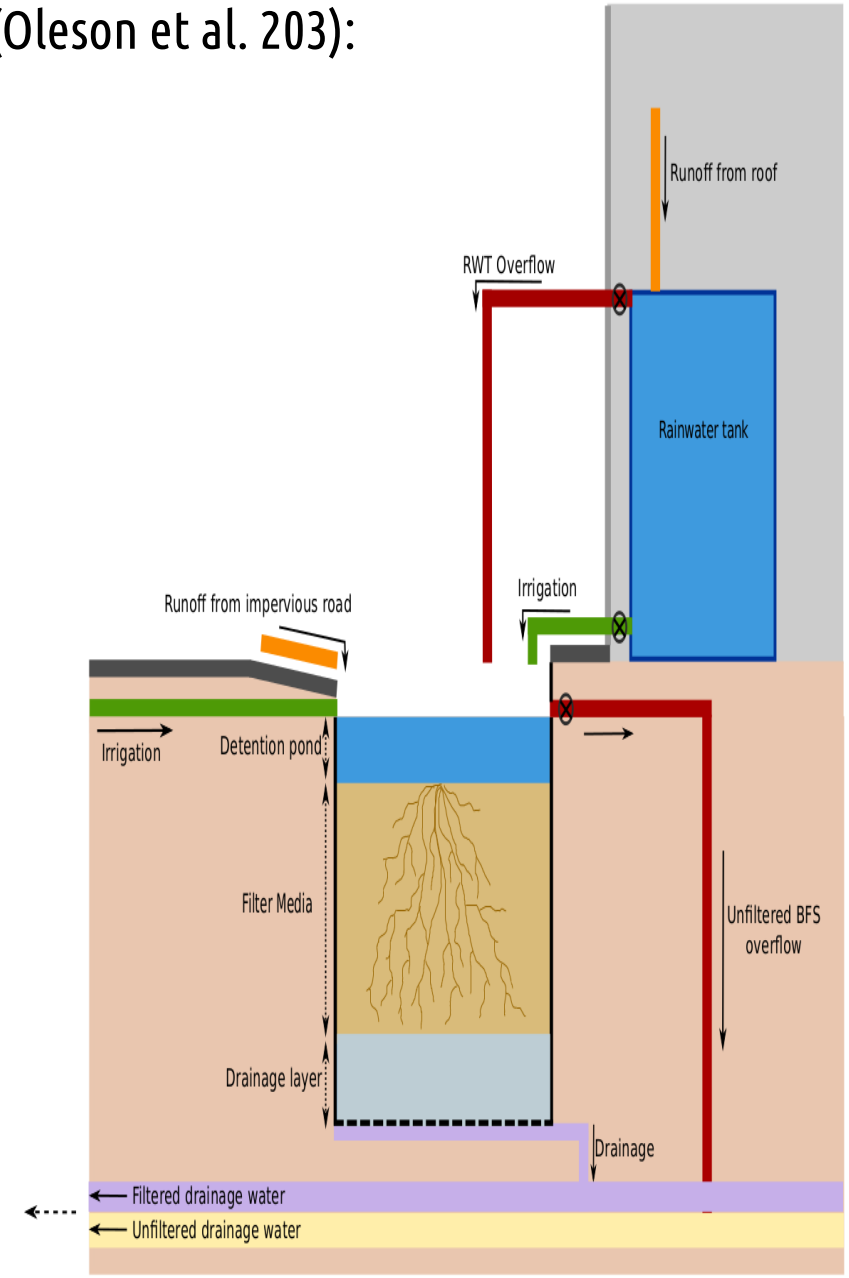
- Calculate the deficit

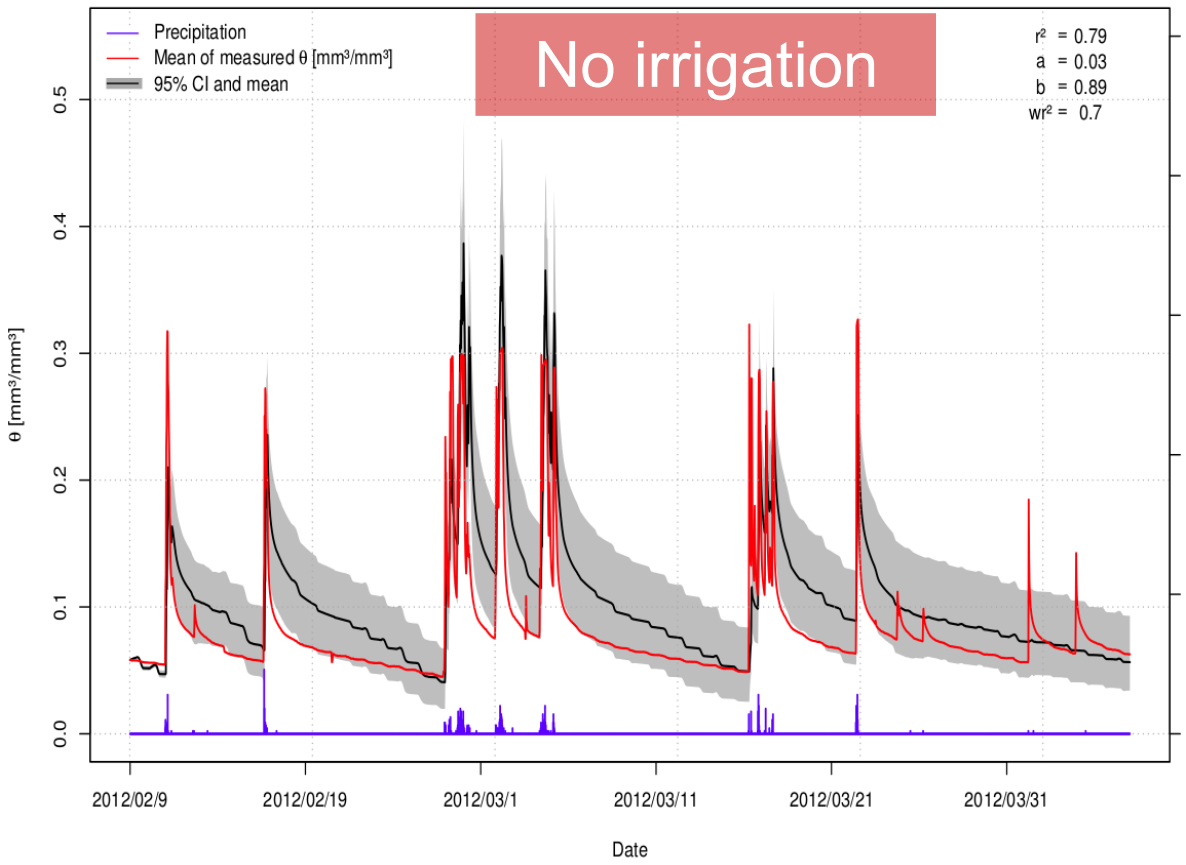
$$I_d = \sum_{i=1}^{7} (max(w_{target,i} - w_i), 0)$$

- Add deficit to soil moisture levels in filter media

Sources of water:

- Rainwater tank (harvested)
- External (Unlimited)



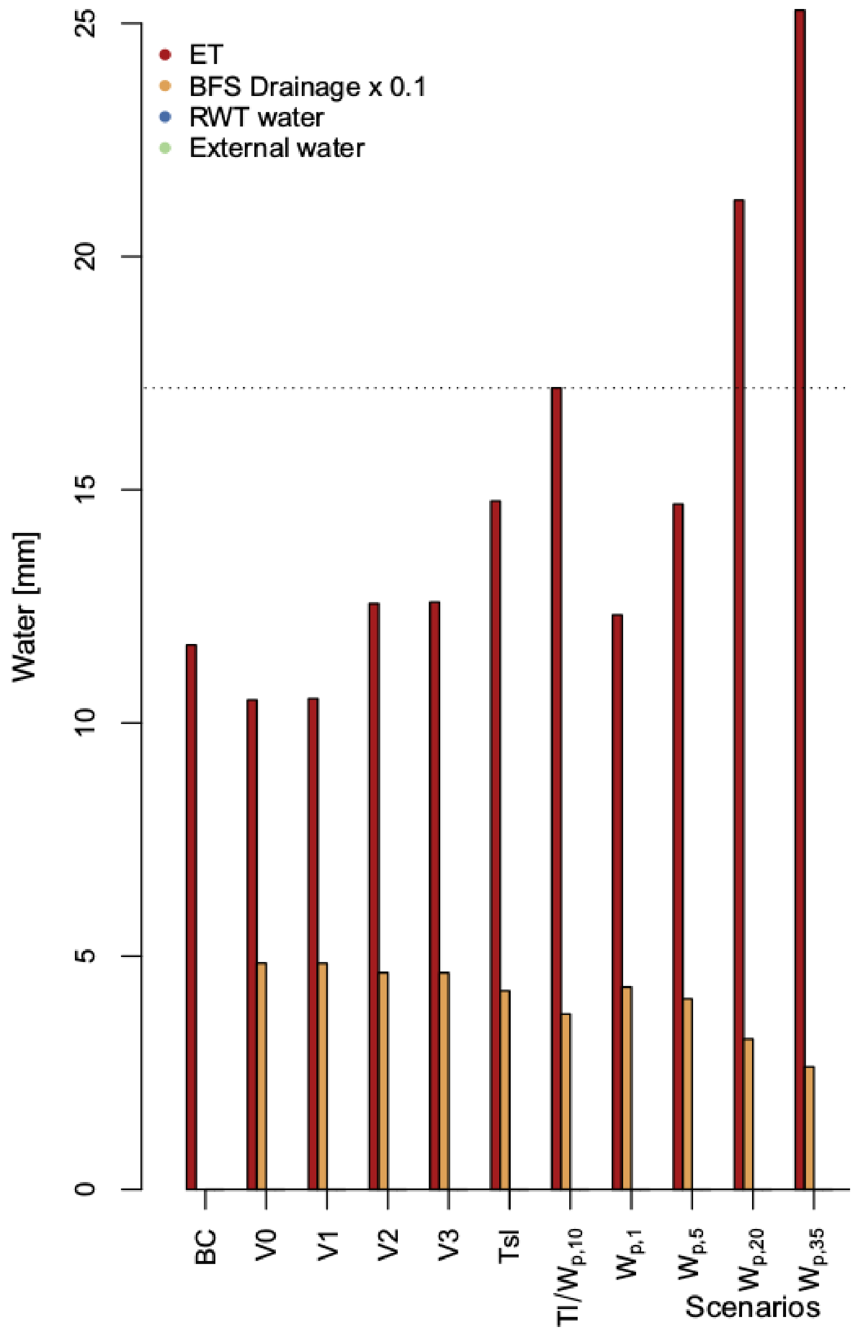

No irrigation
Precipitation
Mean of measured θ [mm³/mm³]
95% CI and mean
r² = 0.79
a = 0.03
b = 0.89
wr² = 0.7
θ [mm³/mm³]
0.0
0.1
0.2
0.3
0.4
0.5
0
10
20
30
40
50
2012/02/9
2012/02/19
2012/03/1
2012/03/11
2012/03/21
2012/03/31
Date

Gebert, 2012


1
2
3
4
5
6
7
8
N
W
E
S
(a)
0 m
40 m

	Evaluation	BC	V0	V1	V2	V3	Tsl	Tl	$W_{p,x}$
BFS geometry & characteristics									
Connected to impervious canyon floor	Yes	No	Yes				Yes		
% Pervious of canyon floor	2	0	10				10		1–100
Depth detention pond [m]	0.16	–	0.2				0.2		
Depth Filter Media [m]	0.7	–	0.7				0.7		
Depth Drainage Layer [m]	0.3	–	0.3				0.3		
Soil texture characteristics									
Soil texture	Sand	–	Loamy sand				Sandy loam	Loam	Loam
θ_r [$mm^3\ mm^{-3}$]	0.047	–	0.057				0.064	0.078	0.078
θ_s [$mm^3\ mm^{-3}$]	0.43	–	0.41				0.41	0.43	0.43
α [mm^{-1}]	0.015	–	0.013				0.0076	0.0037	0.0037
λ [mm^{-1}]	1.67	–	1.27				0.89	0.56	0.56
K_s [$mm\ s^{-1}$]	0.08	–	0.04				0.017	0.0029	0.0029
Vegetation characteristics									
Species	Eucalyptus Olivacea/Olea Europaea	–	–	Melaleuca Argentea	Carex Appressa	V1 + V2	V3	V3	V3
% Roots	2	–	–	0.1 to 0.8(a)	0 to 37(b)	0.1 to 37	0.1 to 37	0.1 to 37	0.1 to 37

I.c. Sensitivity



Volume of tank

% of households having a tank

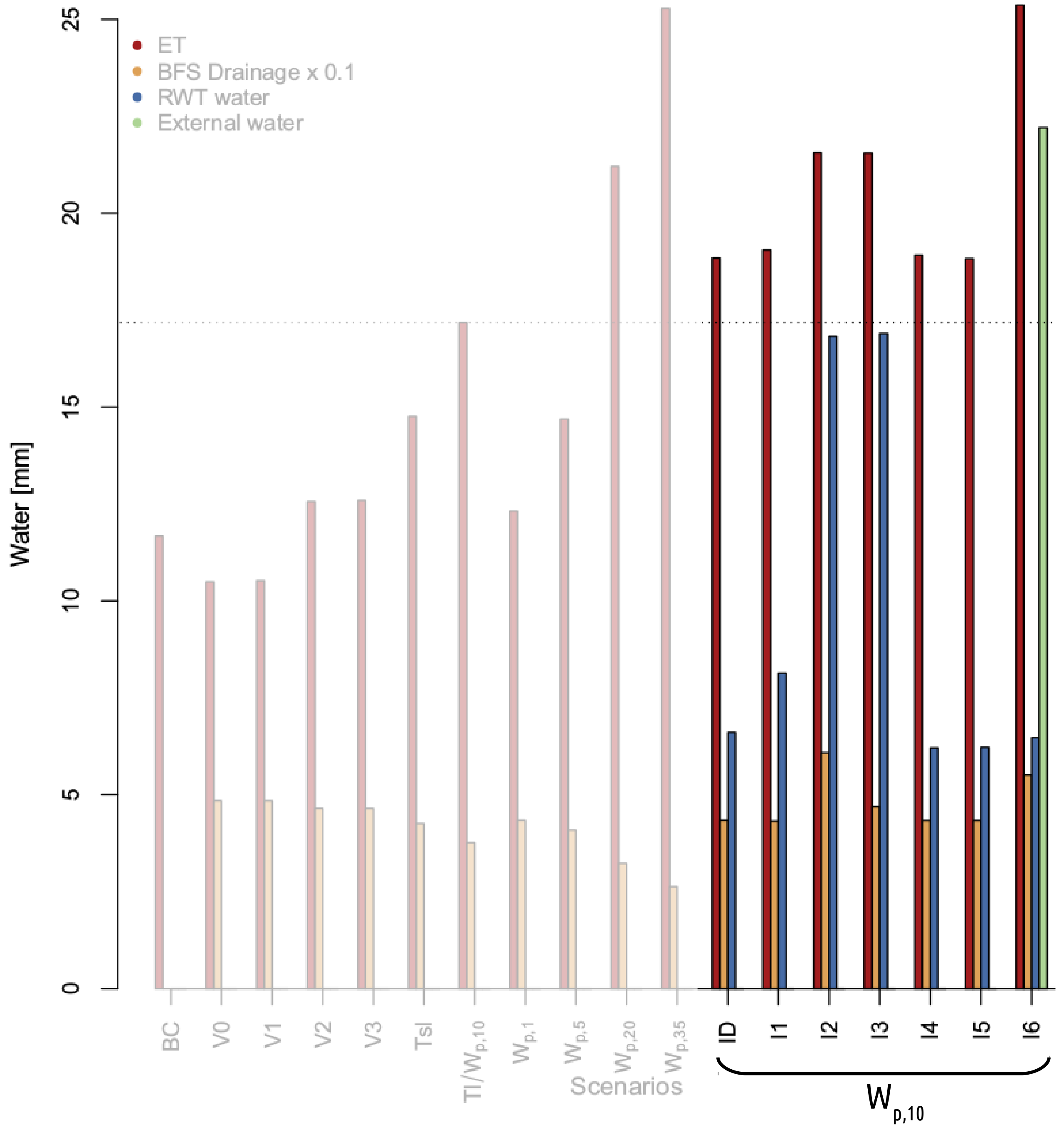
Time of irrigation

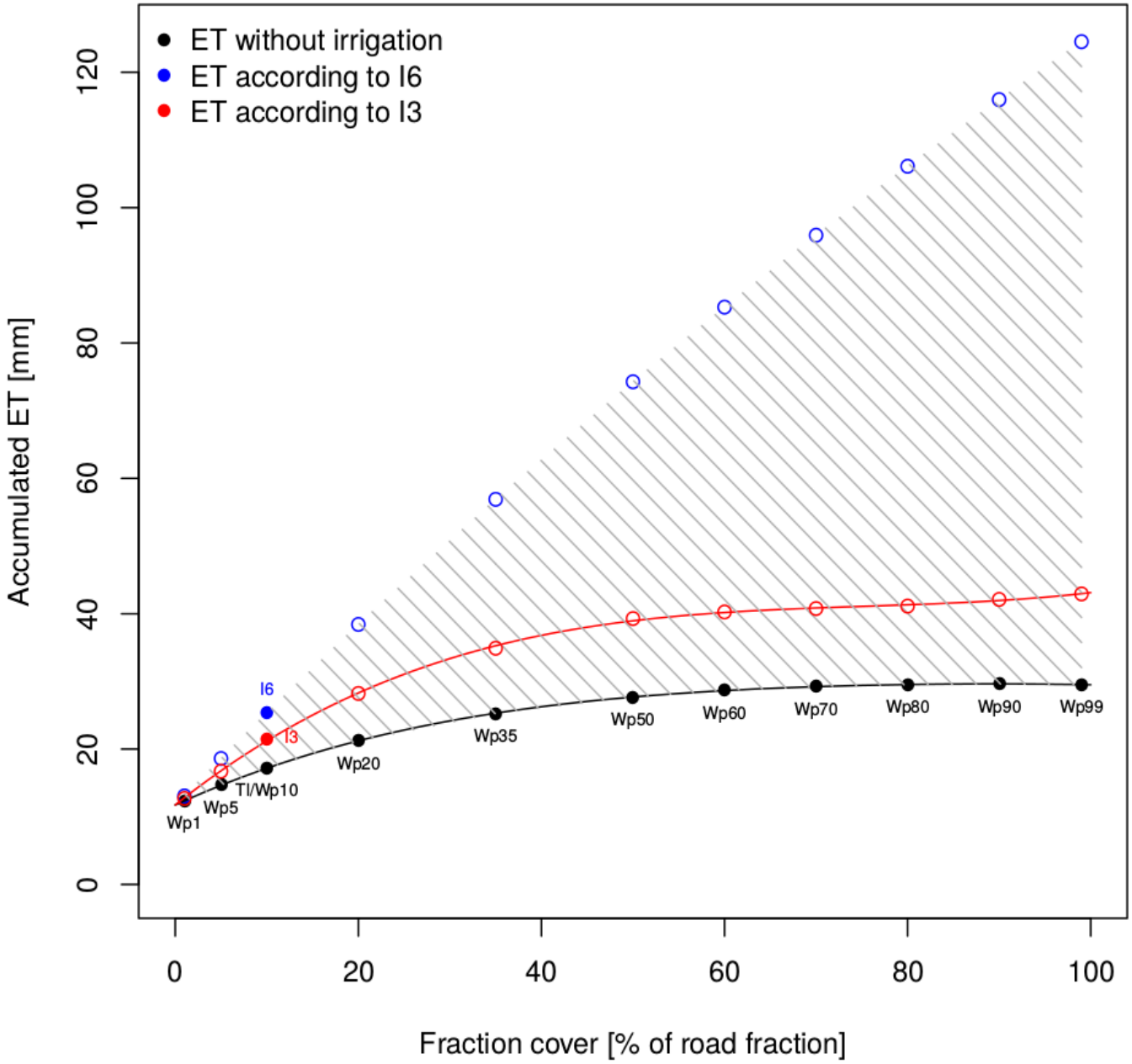
Number	RWT_{vol} (mm)	$RWT_{vol,ini}$ (mm)	RWT_{prop} (%)	External water (mm)	I_t
ID	25	0	22	–	8 AM
I1	100	0	22	–	8 AM
I2	25	0	100	–	8 AM
I3	100	0	100	–	8 AM
I3hf	100	50	100	–	8 AM
I4	25	0	22	–	2 PM
I5	25	0	22	–	8 PM
I6	25	0	22	Unlimited	Every model time step

Amount of water in tank at start

External water allowed?

II. Impact – Scenario's




ET without irrigation
ET according to I6
ET according to I3
Accumulated ET [mm]
0
20
40
60
80
100
120
Fraction cover [% of road fraction]
0
20
40
60
80
100
I6
I3
Wp1
Wp5
TI/Wp10
Wp20
Wp35
Wp50
Wp60
Wp70
Wp80
Wp90
Wp99

Conclusions I

- There is a **non-negligible impact of water intercepted on impervious surfaces and its effect on ET**. As such, urban canopy layer models developments should take into account the water retention capacity of built surfaces.

- A **large amount of stormwater is potentially available to service** both indoor and outdoor **water demands**, including irrigation of urban vegetation.

- The **choice of vegetation** (represented here by % of root fraction) is based on biofiltration guidelines which focus on hydraulic and chemical characteristics. These do **not necessarily reflect the type of vegetation species known for improving the urban climate**.

- The argument above is **also valid for the selected types of soil textures** tested in this study.

- As such, the benefits of WSUD strategies should be **integrally assessed** in order **to determine an optimal strategy** from a hydraulic, biochemical -and physical point of view.

Conclusions II

- There is a **large impact of the BFS fraction cover** on ET.

- In the case of **22% of the households** contribute to **a rainwater tank of 25 mm**, **not enough rainfall can be harvested** to support a continued optimal soil moisture for vegetation.

- Having **a larger fraction of roof tops contributing** to rainwater tanks is **only relevant when the tanks are scaled accordingly**. If not, water overflows into the BFS (at times that it is not needed) and is lost for irrigation during dry periods.

Thank you!

Any questions?

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