RESILIO

BLUE-GREEN ROOFS

ARE SMART BLUE-GREEN ROOFS DROUGHT-PROOF?

Zoom-In article No.2 by UIA expert Leon Kapetas, September 2022

URBAN INNOVATIVE ACTIONS
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ARE SMART BLUE-GREEN ROOFS DROUGHT-PROOF?

Article Outline

1. Introducing RESILIO and its co-benefits
2. Framing drought resilience for RESILIO's smart Blue-Green roofs
3. Understanding and managing drought risk in Blue Green roof projects
4. Take away message

INTRODUCING RESILIO

What are the co-benefits of the approach?

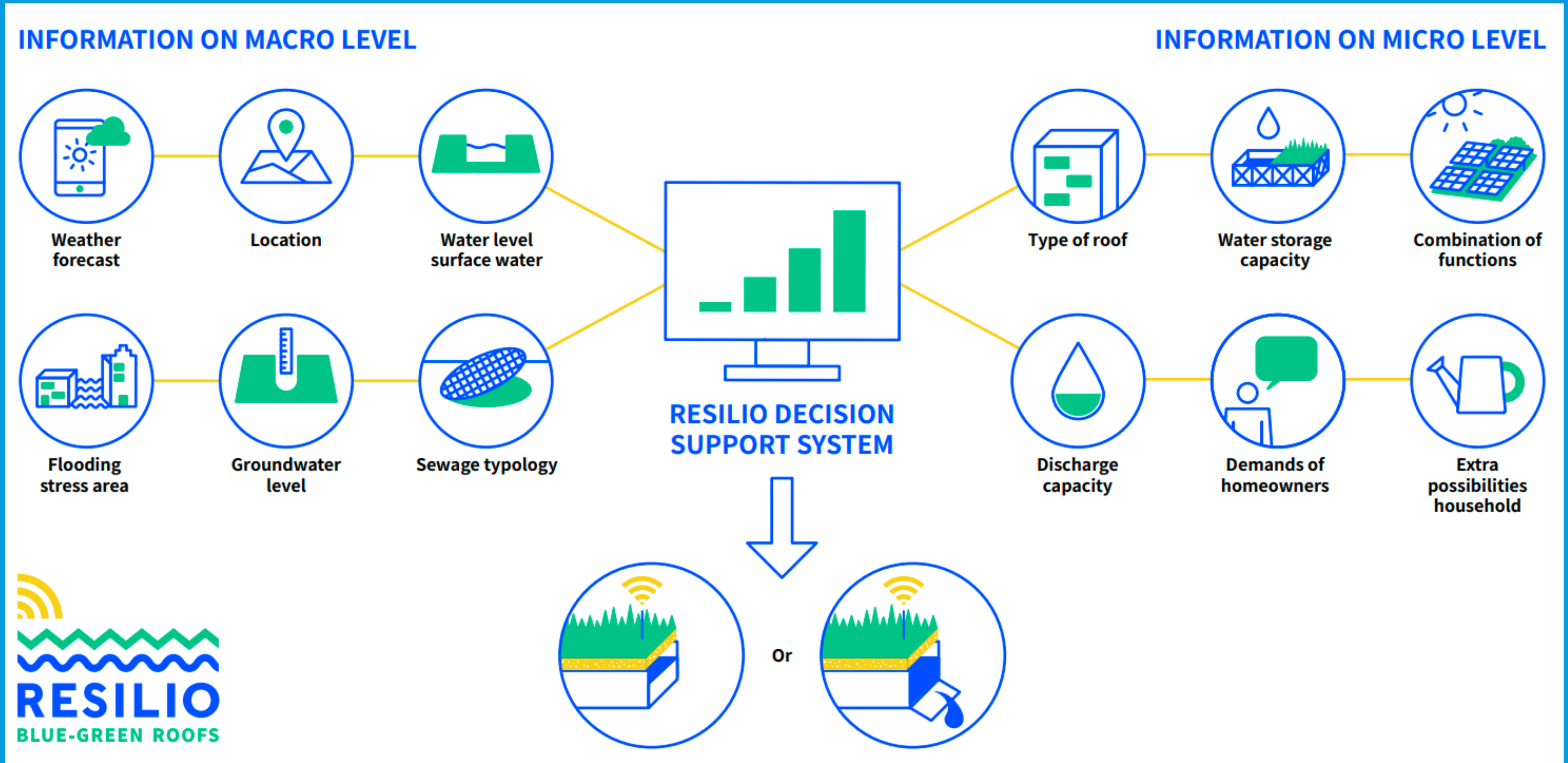
RESILIO is the smart Blue-Green roof project of Amsterdam, funded by Urban Innovative Actions (part of ERDF). The key concept is that by adding an additional water storage layer underneath the green layer, these roofs can significantly reduce runoff by retaining even extreme precipitation (>70mm), that can later support the maintenance of vegetation. The BG roofs also mitigate heat stress, thanks to the increased evapotranspiration and a higher albedo effect of pebbled or black tar roofs (i.e. the ability of surfaces to reflect sunlight). BG roofs also offer opportunities for biodiversity recovery in cities by supplying water to native vegetation, as well as amenity opportunities for their visitors.

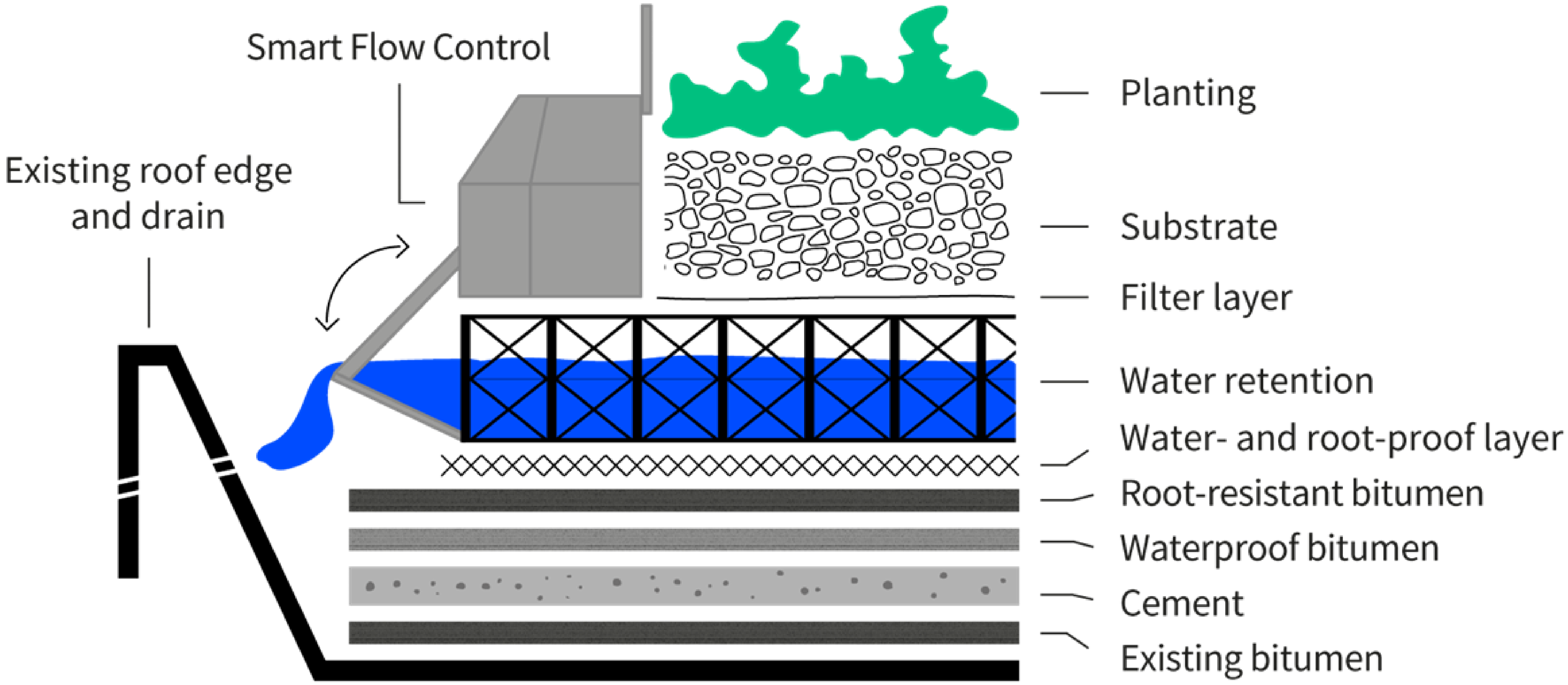
Benno Premselahui,
Source: final report, Wieke

INTRODUCING RESILIO

Why is it a smart approach?

RESILIO roofs are also smart in the sense that they can control the level of available storage when extreme rainfall is predicted to balance between the need for flood protection now and the need to meet future water demand (e.g. from vegetation or other potential uses). Effectively, the roofs turn Amsterdam into a dynamic squeezable sponge city!





How a RESILIO roof looks like (1/2)

Check out this video for more details!

How a RESILIO roof looks like (2/2)

RESILIO SITES

The RESILIO roofs were built on 7 **social housing** buildings as well as on 5 **private roofs** and 2 **innovation labs** to reach a total surface of over 10,000 m2 (source: final report)

HOUSING CORPORATION ROOFS


ROOF 1 AND 2 (STADGENOOT)


ROOF 6 (DE ALLIANTIE)


ROOF 7 (LIEVEN DE KEY)

		ROOF AREA AND RETENTION CAPACITY	
1	**STADGENOOT** Sparrenweg 80-100 Tweede Oosterparkstraat 80-86	463 m²	18,960 L
2	**STADGENOOT** Derde Oosterparkstraat 39-67 Iepenplein 19-21	935 m²	55,475 L
3	**STADGENOOT** Tweede Oosterparkstraat 252-258 Derde Oosterparkstraat 241-253 Kastanjeplein 60	1,160 m²	45,350 L
4	**STADGENOOT** J.F. Berghoefplantsoen 32-46 Noordzijde 353-423	679 m²	38,025 L
5	**DE ALLIANTIE** Riouwstraat 5-57	1,151 m²	N/A
6	**DE ALLIANTIE** Makassarstraat 230-296 Javastraat 521-597	1,286 m²	82,940 L
7	**LIEVEN DE KEY** Bijltjespad 2-82 Kattenburgerstraat 10-28	1,757 m²	118,125 L

INNOVATION LABS

		ROOF AREA AND RETENTION CAPACITY	
I	**BENNO PREMSELAHUIS** Rhijnspoorplein 1	450 m²	32,640 L
II	**ITE BOEREMASTRAAT** Ite Boeremastraat 1-57	700 m²	25,000 L

GRANT SCHEME ROOFS

		ROOF AREA AND RETENTION CAPACITY	
A	**KOP WEESPERTREKVAART** Solitudolaan 414 Lindenhoevestraat 11-81	900 m²	45,000 L
B	**LYCKA (EIGEN HAARD)** Lutonhof 3-237 Zaventemweg 67-89	325 m²	36,000 L
C	**ROYAL TROPICAL INSTITUTE DEPOT** Linnaeusstraat 2	2,110 m²	102,000 L
D	**VVE BOS EN LOMMER** Bos en Lommerplein / Leeuwendalersweg	276 m²	31,600 L
E	**MANNOURY** Koningin Wilhelminaplein 880-1008	491 m²	N/A

HOW DROUGHT-RESILIENT ARE RESILIO ROOFS?

Though this was not a question that RESILIO set out to answer, the project can offer insights based on the experience acquired. Answering this key question would mean inquiring also about the following:

- How long will water last for?
- What type of maintenance should I expect?
- What type of vegetation will work for my roof (e.g. wind, shade, location) and will vegetation remain healthy?
- What biodiversity benefits should I am for?
- Can this work in the climatic zone where I am?

As integrated assessment of the above can help prospective roof owners/developers to co-optimize across co-benefits and minimize drought risks. The experimental work of Smart Roof 2.0 - the precursor of RESILIO – is described below to offer a better technical understanding of the eco-hydrological functioning of BG roofs.

EXPERIMENT ON DROUGHT RESILIENCE OF BG ROOFS

The most comprehensive evidence demonstrating the ability of BG roofs to withstand droughts comes from the research of Cirkel et al., run during the Smart Roof 2.0 project. The scientific team set up a rooftop research lab where they compared:

(i) Three setups: green roof vs. shallow substrate BG roof vs. thick substrate BG roof (figures showing plan and cross-sectional views of the setup)
(ii) Assessed for two different types of vegetation: sedum vs. grass/herbs

In parallel they monitored meteorological conditions over a year long period to understand the behaviour of the system.

Plan view of the setup including instrumentation

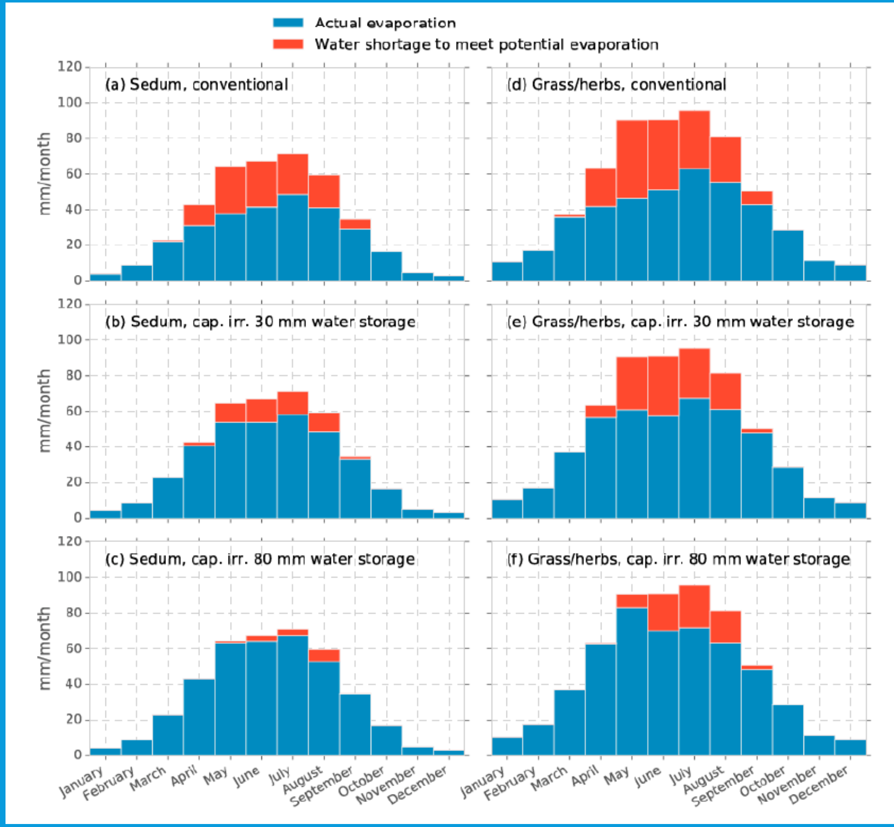
Cross-sectional view of the setup showing differences in layers between setups. Left and right setups have a substrate of 80 and 40 mm respectively to hold water.

Source: Cirkel et al - doi:10.3390/w10091253

EXPERIMENTAL FINDINGS ON DROUGHT RESILIENCE
Interannual Analysis

Observations allowed to model Evapotranspiration (ET). Potential ET is the ET when there is abundance of water to meet the demand of the plants. Actual ET is the ET that takes place given that there might not be sufficient water. When this happens, Actual ET is lower than Potential ET, and the plants undergo stress. Results were fascinating:

- Green roofs are more often under stress (i.e. potential ET not met), starting as early as April and lasting as late as September. This is true for both vegetation types.
- Blue Green roofs help mitigate this by reducing stress periods. This is particularly the case for the high storage BG roof
- Herbs show higher demand for water than sedum, and this means that even the BG roofs struggle to cater for this demand.



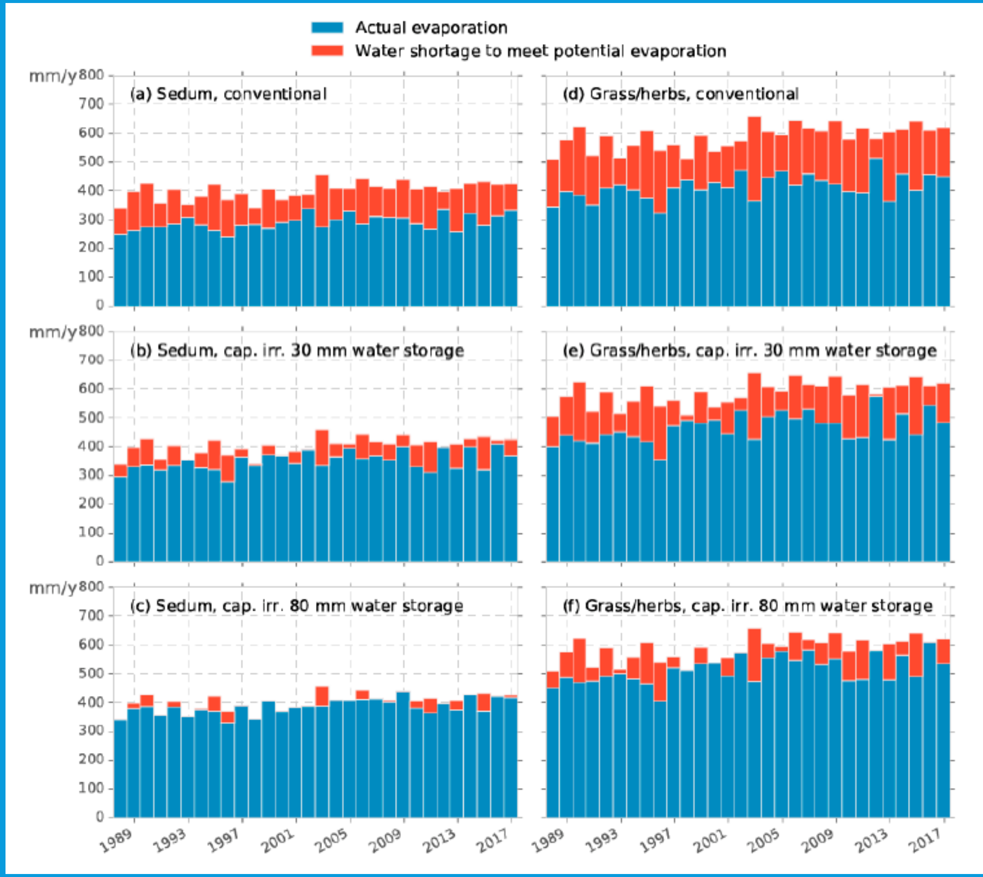
Monthly mean evaporation data - Source: Cirkel et al - doi:10.3390/w10091253

EXPERIMENTAL FINDINGS ON DROUGHT RESILIENCE
Intra-annual Analysis

What happens though in years with lower or higher precipitation and temperatures? The same study simulated ET using historical data for a 30 year period. As seen in the figure, they find that:

- actual evapotranspiration is not met in any year in the simple green roof
- The blue component helps reduce the evaporation deficit (shown in orange), i.e. meet demand much better, particularly for the 80 mm water storage.
- Grass/herbs are more water demanding and therefore going more frequently under some water stress.

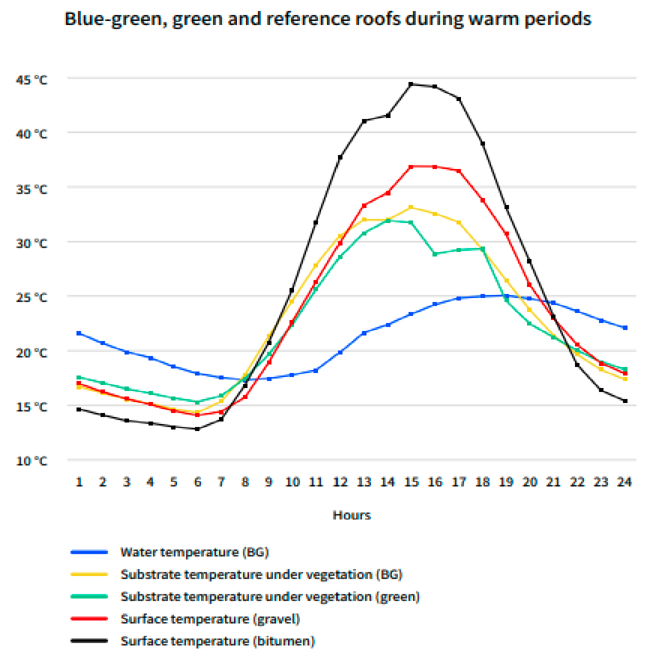
For reference, it is worth mentioning that rainfed vegetation does go under some stress (not meeting potential demand) and different plant types have varying capacity to withstand this deficit. Irrigation systems help bridge this evaporation gap.



Simulated yearly evaporation data - Source: Cirkel et al - doi:10.3390/w10091253

CONSIDERATION BEYOND DROUGHTS

While drought-proofing is important, one needs to carefully consider the synergies or trade-offs with the co-benefits offered by the roofs:



Source: final report, 2022

Source: final report, 2022

- Biodiversity (right figure)
- Runoff reduction, particularly during potential flood events
- Cooling ability of each vegetation cover in combination with the blue component of the roof (left figure)

THE TAKE-AWAY
How drought-resilient are RESILIO roofs?

It Depends… A more nuanced evaluation of drought resilience is needed, that will depend on:

- On your primary objectives that will control plant selection (e.g. cooling, biodiversity)
- On the limitations of your application, e.g. potential for irrigation and maintenance (BG roofs offer great water management efficiency, particularly important during droughts or pricier water supply)
- Consideration of present, but also future climate, in your particular climate zone
- Structural constraints need to be evaluated (roof load bearing capacity)

Tip: Cities that wish to develop Green or Blue-Green roofs will need to co-evaluate their priorities before proceeding and consult with experts.

More information at:
https://www.uia-initiative.eu/en/uia-cities/amsterdam
https://resilio.amsterdam/en/

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