

SMART WATER MANAGEMENT IN URBAN FORESTS: THE APPROACH OF LIFE URBANGREEN

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Kraków
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UNIVERSITÀ
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DI MILANO

ProGea^{4D}



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Project coordination



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Project Coordinator
LIFE UrbanGreen



R3GIS develops Web-GIS and mobile applications to manage geospatial data and provides innovative tools for the smart cities of the future.

Team of 20 people, based in Bolzano, South Tyrol, Italy

Operating in Italy, Austria, Germany, Switzerland, Poland, Finland, Slovenia, Hungary, Taiwan

The LIFE URBANGREEN Project

LIFE URBANGREEN

INNOVATIVE TECHNOLOGICAL PLATFORM TO IMPROVE
MANAGEMENT OF GREEN AREAS FOR BETTER CLIMATE
ADAPTATION



www.lifeurbangreen.eu

R3GIS
managing spaces

Kraków

ProG^{4D}ea



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Rimini

Anthea



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€ 2.5 M Total budget
€ 1.3 M EU contribution

07/2018

12/2021



Three main project pillars

RESEARCH



- Leaf transpiration measurements
- Pollutant deposition analysis
- LiDAR survey
- Meteo data analysis
- IOT sensors integration
- Satellite data analysis

SOFTWARE TOOLS



- Ecosystem services calculation
- Meteo data integration
- **Smart irrigation tool**
- IOT sensors integration
- Improved job planning
- Public portal for citizens

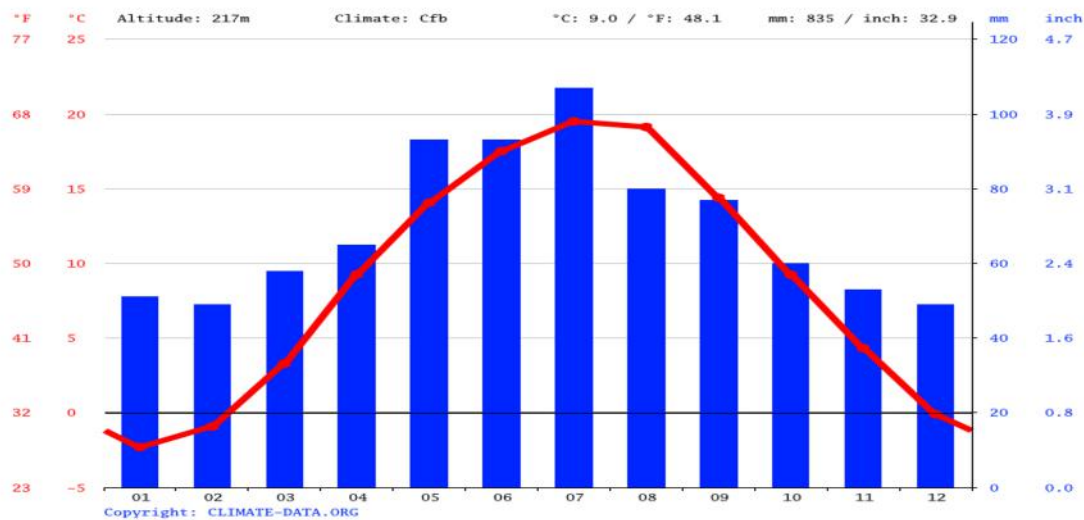
TEST ON PILOT SITES



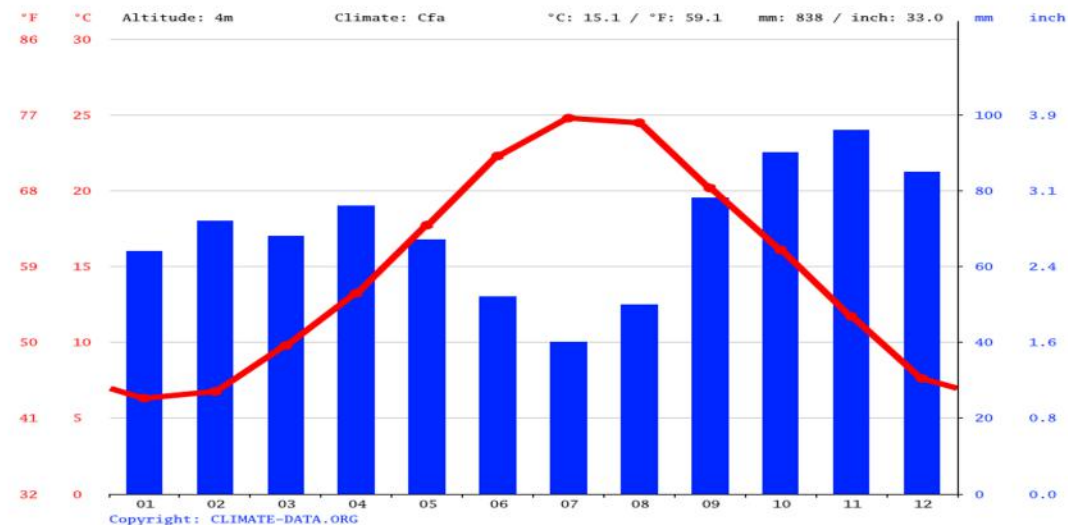
Test new tools and assess effect of best practices on trees:

- Target pruning
- Irrigation
- Soil decompaction
- Mulching

Sites and species













<https://en.climate-data.org/europe/poland/lesser-poland-voivodeship/krakow-715022/#climate-graph>













<https://en.climate-data.org/europe/italy/emilia-romagna/rimini-1176/#climate-graph>

The studied species

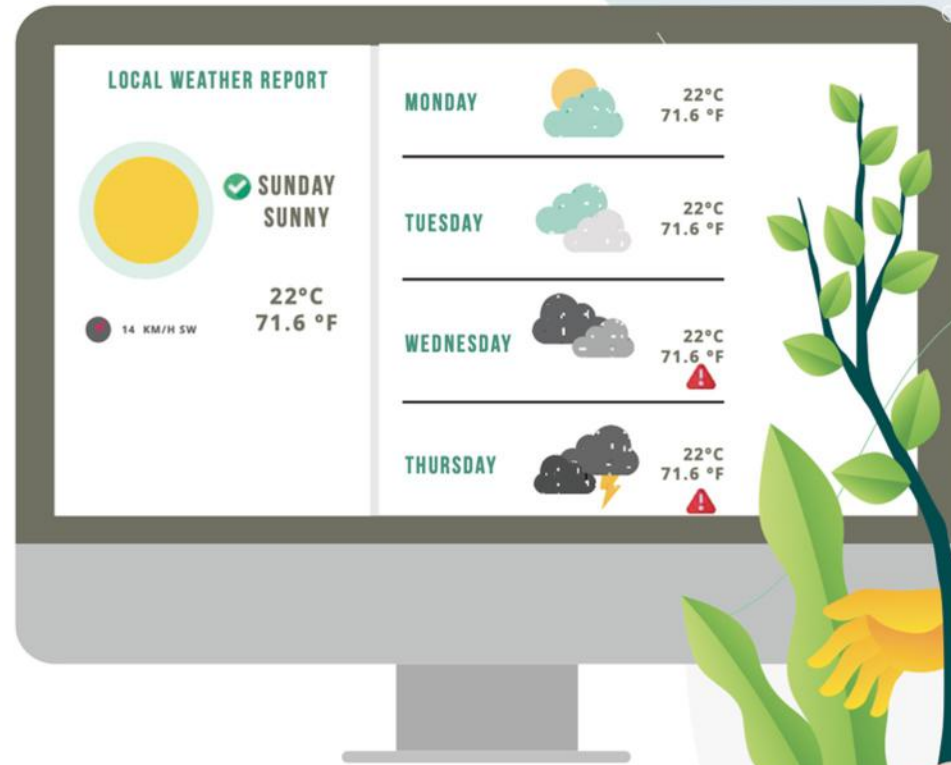
Kraków (PL): 500 ha

 <p>Norway maple <i>Acer platanoides</i></p>	 <p>Horse chestnut <i>Aesculus hippocastanum</i></p>
 <p>European ash <i>Fraxinus excelsior</i></p>	 <p>Rowan <i>Sorbus aucuparia</i></p>
 <p>Little-leaf linden <i>Tilia cordata</i></p>	 <p>Austrian pine <i>Pinus nigra</i></p>
 <p>Pedunculate oak <i>Quercus robur</i></p>	 <p>Black poplar <i>Populus nigra</i></p>
 <p>European white elm <i>Ulmus laevis</i></p>	 <p>White dogwood <i>Cornus alba</i></p>

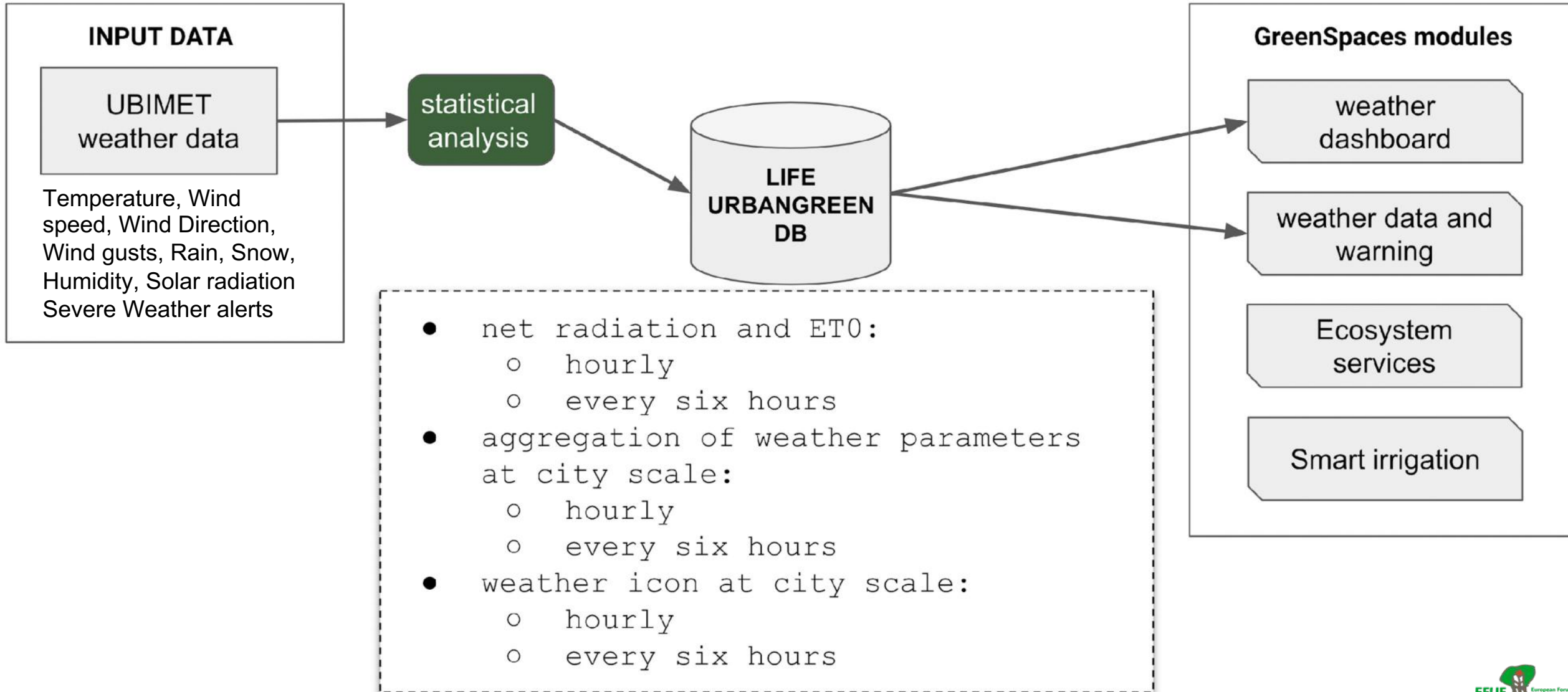
Rimini (IT): 250 ha

 <p>Platano <i>Platanus xacerifolia</i></p>	 <p>Ippocastano <i>Aesculus hippocastanum</i></p>
 <p>Tiglio <i>Tilia xeuropaea</i></p>	 <p>Ligustro lucido <i>Ligustrum lucidum</i></p>
 <p>Pino domestico <i>Pinus pinea</i></p>	 <p>Farnia <i>Quercus robur</i></p>
 <p>Acer americano <i>Acer negundo</i></p>	 <p>Pioppo nero <i>Populus nigra</i></p>
 <p>Leccio <i>Quercus ilex</i></p>	 <p>Lauroceraso <i>Prunus laurocerasus</i></p>

Use of meteorological data



Weather data management



Weather dashboard



Severe weather alerts



Calculation of benefits of trees



Measurement campaigns

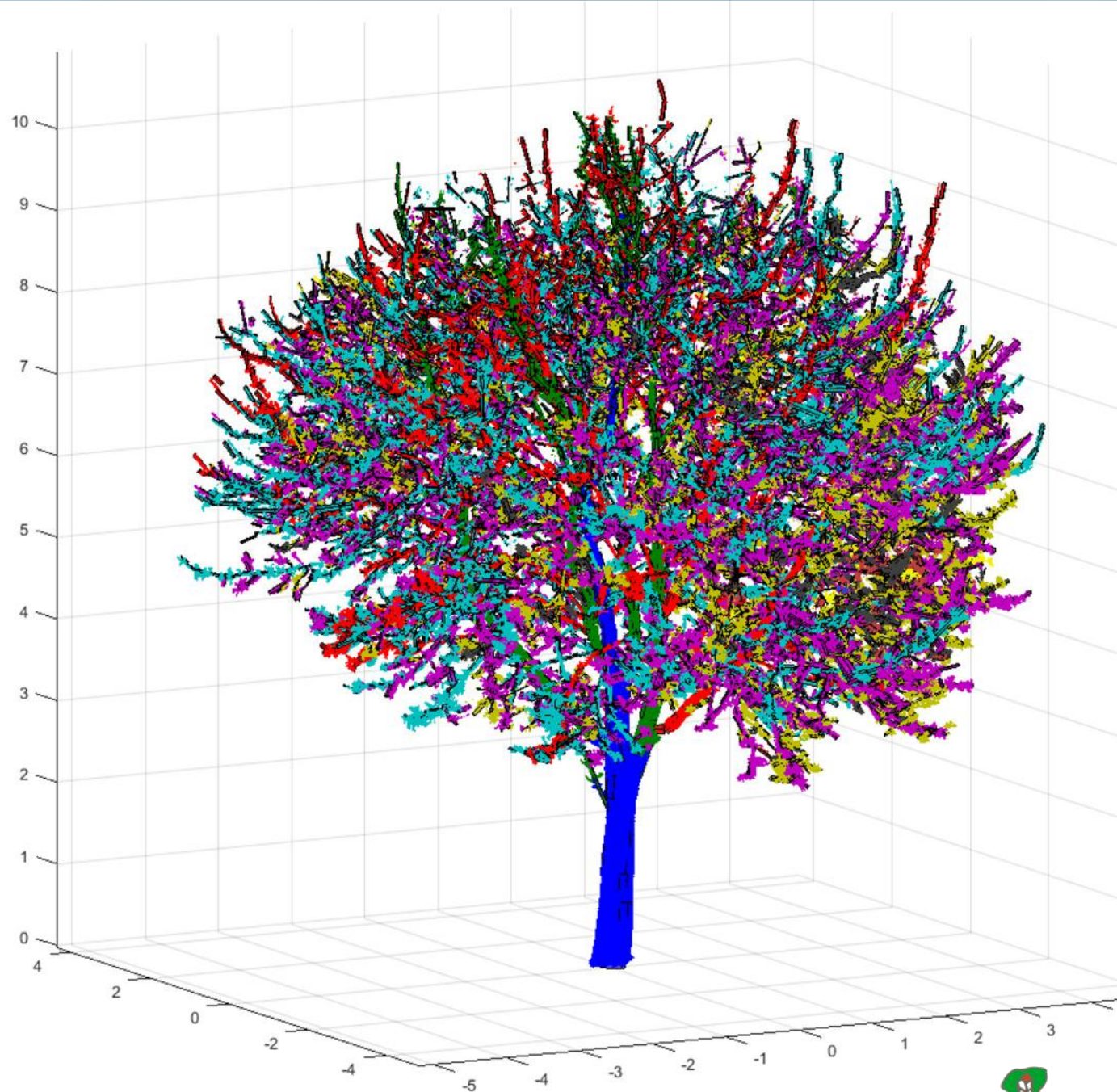
- 500 trees in Rimini and Krakow
- Four growing seasons (2018-2021)
- 17 species (10 Rimini, 10 Krakow, 3 in common)
- More than 50% of the tree population of the two cities
- Leaf transpiration was measured to derive CO₂ adsorption and water transpiration
- LAI was measured by means of radiometric method



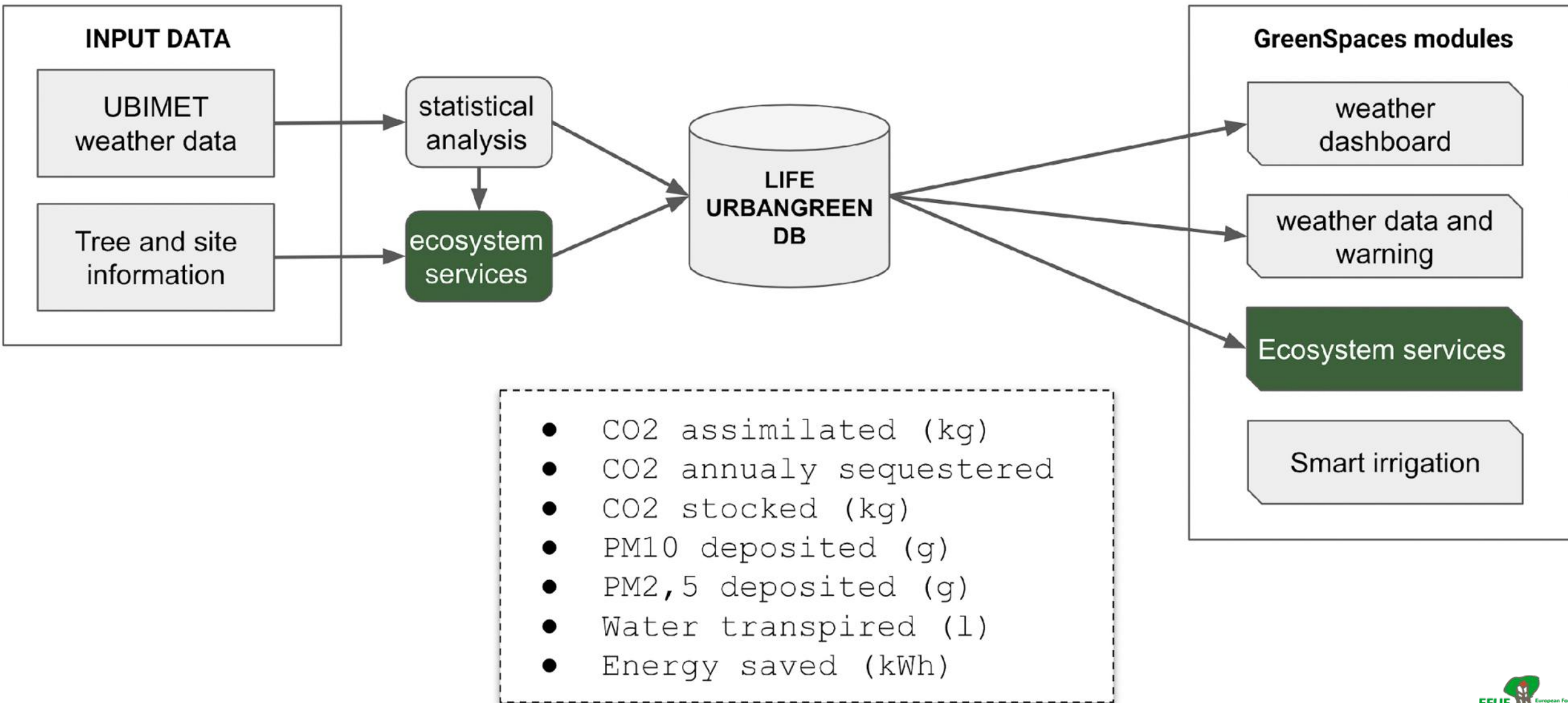
LiDAR TLS surveys

Accurate LiDAR measurement on selected trees was used to derive trunk volume, total leaf area and its distribution at different heights.

In addition, leaf samples were collected and analyzed in laboratory for deposition of pollutants (PM_{10} , $PM_{2.5}$).




Ecosystem services calculation




Tree benefits


Benefits extended to other species with similar behaviour:




Norway maple
Acer platanoides




10,969 ⓘ
Number of trees



3/10 ⓘ
CO₂ assimilation



4/10 ⓘ
Air quality amelioration



2/10 ⓘ
Cooling by transpiration

Description

Norway maple is a native species in Europe, widespread from Spain to Scandinavia. It is a fast-growing deciduous species that can grow up to 25 m tall at maturity and develop a rounded, broad, or pyramidal canopy, depending on the cultivar used. It can live up to 75 years in cities, but the lifespan is often shortened by stress factors, like fungi. Palmate leaves are opposite on shoots and usually have 5 lobes. Some cultivars show permanently or transiently red leaves. The yellowing of leaves during fall is extremely attractive. Flowers are yellow and flowering occurs in April- early May, before the foliation. The fruit is a di-samara, with a broad angle (>120°C) between the samaras. Grows well in mild shade. It is extremely hardy (up to -40°C) and well adapted to poor and compacted soils in the pH range 5.5-8.0. It is extremely easy to transplant.

Assimilated species

- Acer platanoides 'Drummondii'
- Acer platanoides 'Faassen's Black'
- Acer platanoides 'Globosum'
- Acer platanoides 'Princeton Gold'
- Acer platanoides 'Royal Red'
- Acer platanoides 'Schwedleri'
- Acer sp.
- Acer pseudoplatanus
- Acer pseudoplatanus 'Atropurpureum'
- Acer pseudoplatanus 'Aureum'
- Acer pseudoplatanus 'Erectum'
- Acer pseudoplatanus 'Leopoldii'
- Acer pseudoplatanus 'Negenia'
- Acer pseudoplatanus 'Purpureum'
- Acer pseudoplatanus 'Rotterdam'
- Acer rubrum
- Acer rubrum 'Red Sunset'

Tree benefits

Greenspaces - Ecosystem Services | krakow.r3gis.com | Administrator

Ecosystem Services (1534)

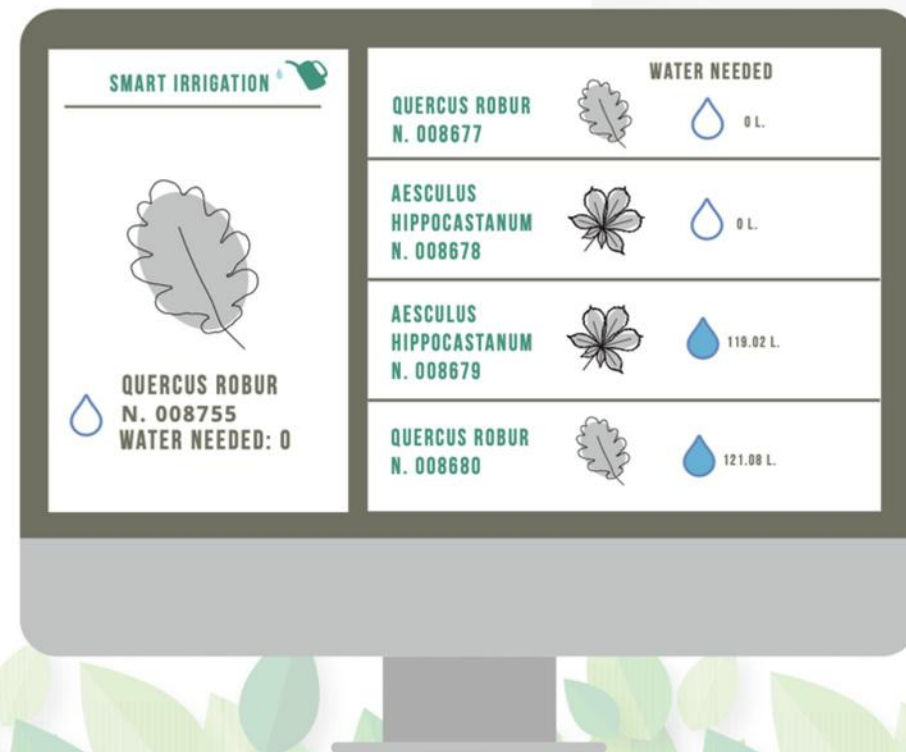
Filter active

Date	Site	Tree Nr.	Tag Nr.	Taxonomy	↑ Calculated tree age	CO2 absorbed (kg)	CO2 annually sequestered (kg)	CO2 stocked (kg)	PM10 deposited (g)	PM2.5 deposited (g)	NOx absorbed (g)	Water transpired (l)
20/07/2022	1.001 - Planty Krakowskie	2349		Acer platanoides 'Drummondii' (Norway maple 'Drummondii')		1.10	36.45	125.10	0.71	0.17	0.00	69.10
20/07/2022	1.001 - Planty Krakowskie	129878		Acer platanoides 'Faassen's Black' (Norway maple 'Faassen's Black')		1.68	58.87	291.11	1.08	0.26	0.00	105.40
20/07/2022	1.001 - Planty Krakowskie	103063		Acer platanoides 'Globosum' (Acero globoso)		2.47	81.30	628.28	1.59	0.38	0.00	154.85
20/07/2022	1.001 - Planty Krakowskie	104159		Acer platanoides 'Globosum' (Acero globoso)		1.57	53.27	255.69	1.02	0.24	0.00	98.78
20/07/2022	1.001 - Planty Krakowskie	103166		Acer platanoides 'Schwedleri' (Common maple 'Schwedleri')		17.11	333.62	9,931.92	9.51	2.26	0.01	924.39
20/07/2022	1.001 - Planty Krakowskie	1616	!	Acer platanoides 'Schwedleri' (Common maple 'Schwedleri')		18.02	350.44	11,025.06	10.02	2.38	0.01	973.93
20/07/2022	1.001 - Planty Krakowskie	001429		Acer platanoides (Norway maple)		19.58	378.48	13,009.38	10.88	2.59	0.01	1,057.95
20/07/2022	1.001 - Planty Krakowskie	001435		Acer platanoides (Norway maple)		13.90	271.94	6,562.04	7.73	1.84	0.01	751.37
20/07/2022	1.001 - Planty Krakowskie	001437		Acer platanoides (Norway maple)		16.10	311.19	8,798.19	8.95	2.13	0.01	870.03
20/07/2022	1.001 - Planty Krakowskie	001438		Acer platanoides (Norway maple)		16.19	311.19	8,898.99	9.00	2.14	0.01	875.00
20/07/2022	1.001 - Planty Krakowskie	001524		Acer platanoides (Norway maple)		2.57	86.91	682.27	1.66	0.39	0.00	161.36
20/07/2022	1.001 - Planty Krakowskie	001526		Acer platanoides (Norway maple)		6.86	131.77	1,597.39	3.81	0.91	0.00	370.72
20/07/2022	1.001 - Planty Krakowskie	001527		Acer platanoides (Norway maple)		9.24	176.62	2,897.81	5.14	1.22	0.00	499.31
20/07/2022	1.001 - Planty Krakowskie	001528		Acer platanoides (Norway maple)		21.59	417.73	15,820.43	12.00	2.85	0.01	1,166.66
20/07/2022	1.001 - Planty Krakowskie	001531		Acer platanoides (Norway maple)		15.37	299.98	8,018.44	8.54	2.03	0.01	830.58
20/07/2022	1.001 - Planty Krakowskie	001532		Acer platanoides (Norway maple)		9.60	0	3,131.27	5.34	1.27	0.00	519.03
20/07/2022	1.001 - Planty Krakowskie	001613		Acer platanoides (Norway maple)		15.51	0	8,166.05	8.62	2.05	0.01	838.19
20/07/2022	1.001 - Planty Krakowskie	001615		Acer platanoides (Norway maple)		20.80	406.51	14,687.38	11.56	2.75	0.01	1,124.11
20/07/2022	1.001 - Planty Krakowskie	001620		Acer platanoides (Norway maple)		11.86	0	4,775.03	6.59	1.57	0.00	640.95
20/07/2022	1.001 - Planty Krakowskie	001631		Acer platanoides (Norway maple)		15.97	0	8,654.30	8.87	2.11	0.01	862.88
20/07/2022	1.001 - Planty Krakowskie	001632		Acer platanoides (Norway maple)		1.99	64.48	410.47	1.29	0.31	0.00	125.16

Legend: Living tree Dead tree Tree stump Felled Tree being processed

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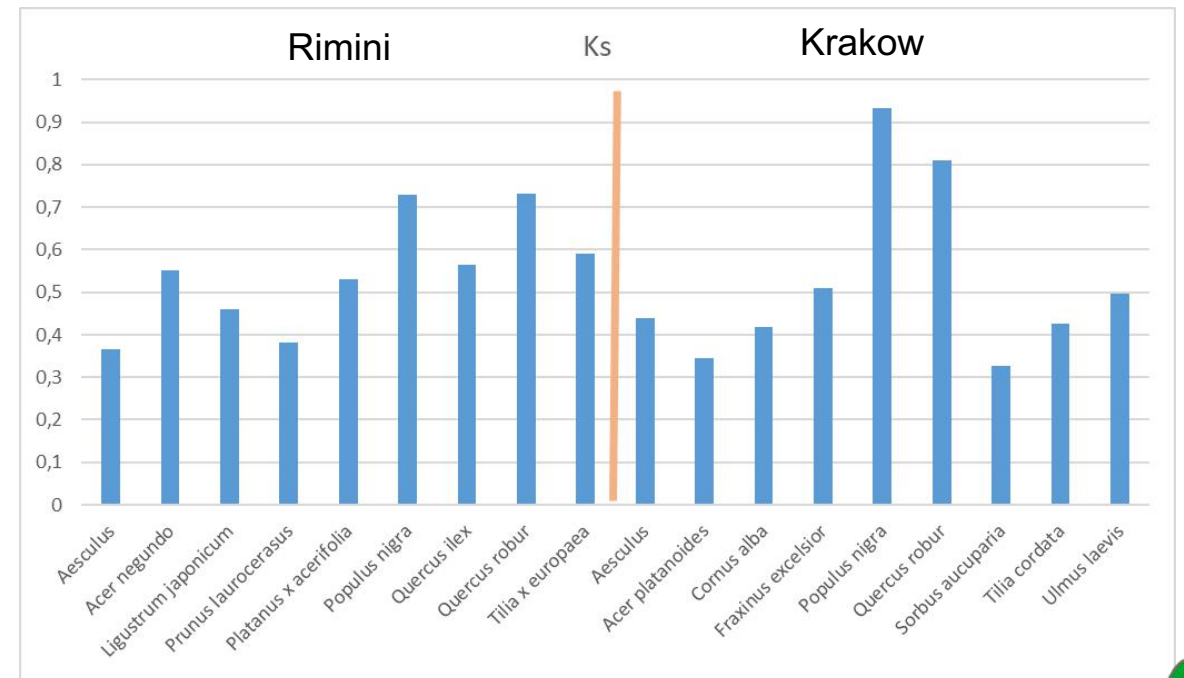
Smart irrigation tool



Irrigation requirements

- The ratio between whole tree water use (E_{tree} , $\text{dm}^3 \text{ tree}^{-1} \text{ h}^{-1}$) and crown projection area (CPA, $\text{m}^2 \text{ tree}^{-1}$) yielded water use per unit CPA, or **effective transpiration** ($E_{cpa} = ETE$, $\text{dm}^3 \text{ m}^{-2} \text{ soil h}^{-1} = \text{mm h}^{-1}$)
- Meteo data was used to calculate site-specific **potential evapotranspiration** (ET_0 , mm h^{-1}) using the FAO modified Penman-Monteith equation.
- Ks was calculated as ETE/ET_0**

Species	Ks Rimini	Ks Krakow
<i>A. hippocastanum</i>	0,367	0,438
<i>Populus nigra</i>	0,730	0,933
<i>Q. robur</i>	0,733	0,809
<i>Acer</i> spp.	0,551	0,344
<i>Tilia</i> spp.	0,590	0,426



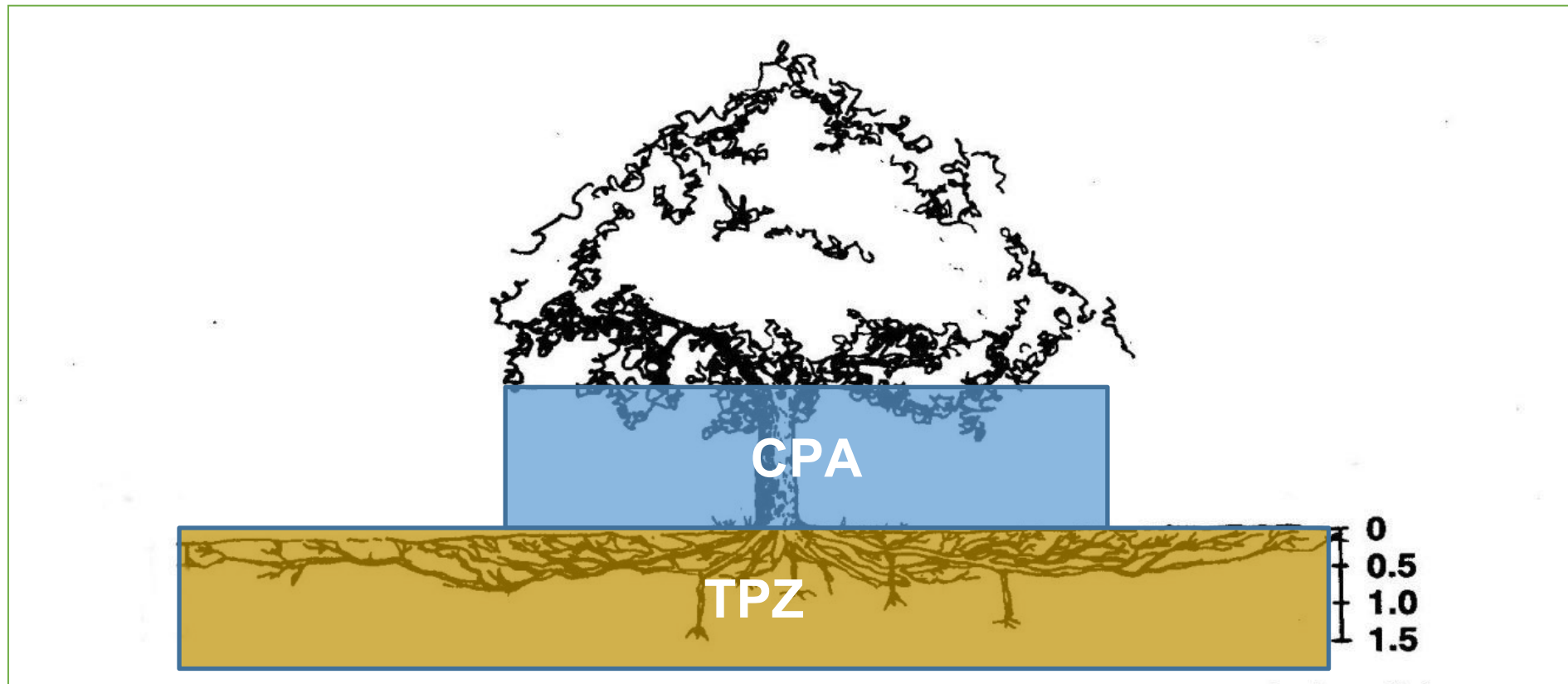
Irrigation requirements

Ks were used to estimate irrigation needs and to schedule the filling of water-bags

$$K_s * E_{t0} * CPA/TPZ$$

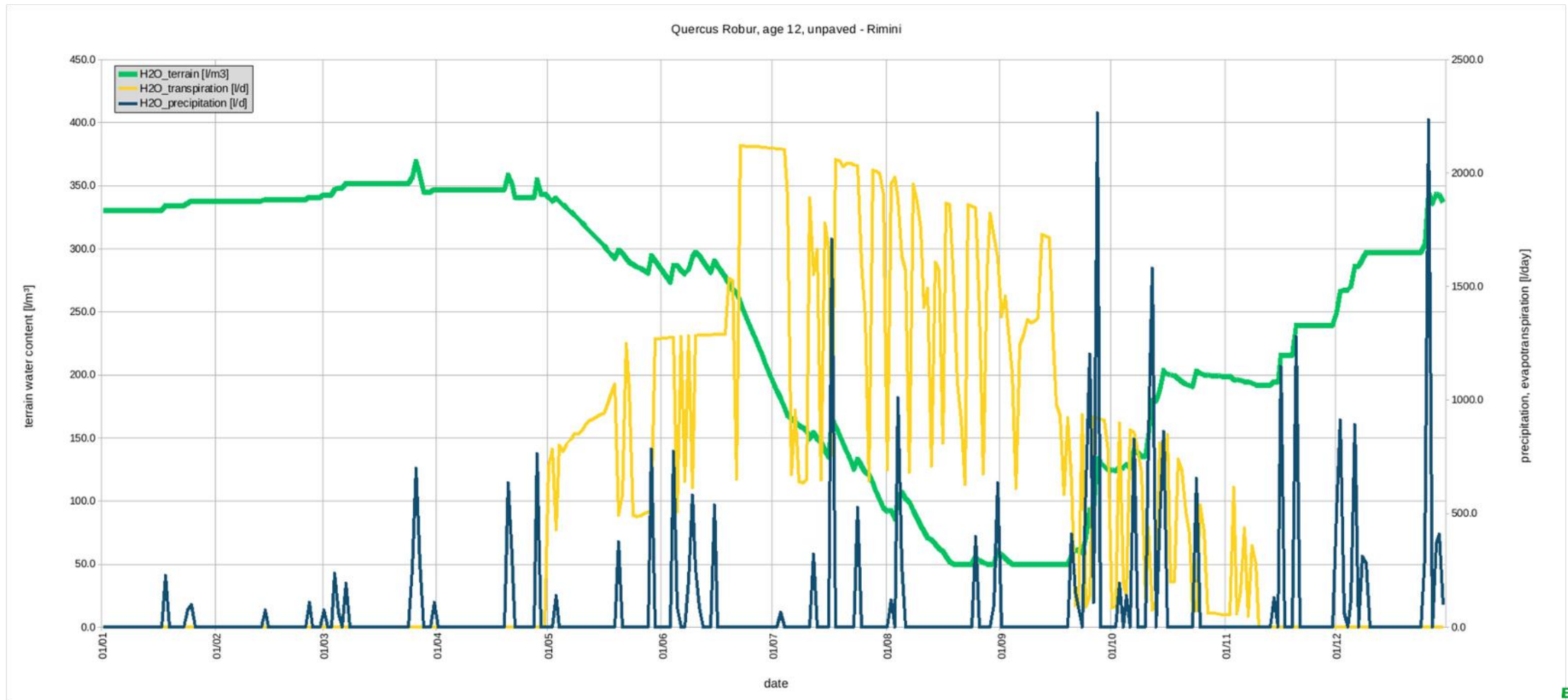
Where CPA/TPZ (i.e. the ratio between crown projection area and tree protection zone) takes into account the different absorbing and transpiring surface area of trees.

TPZ radius was estimated according to Day and Wieseman (2010)

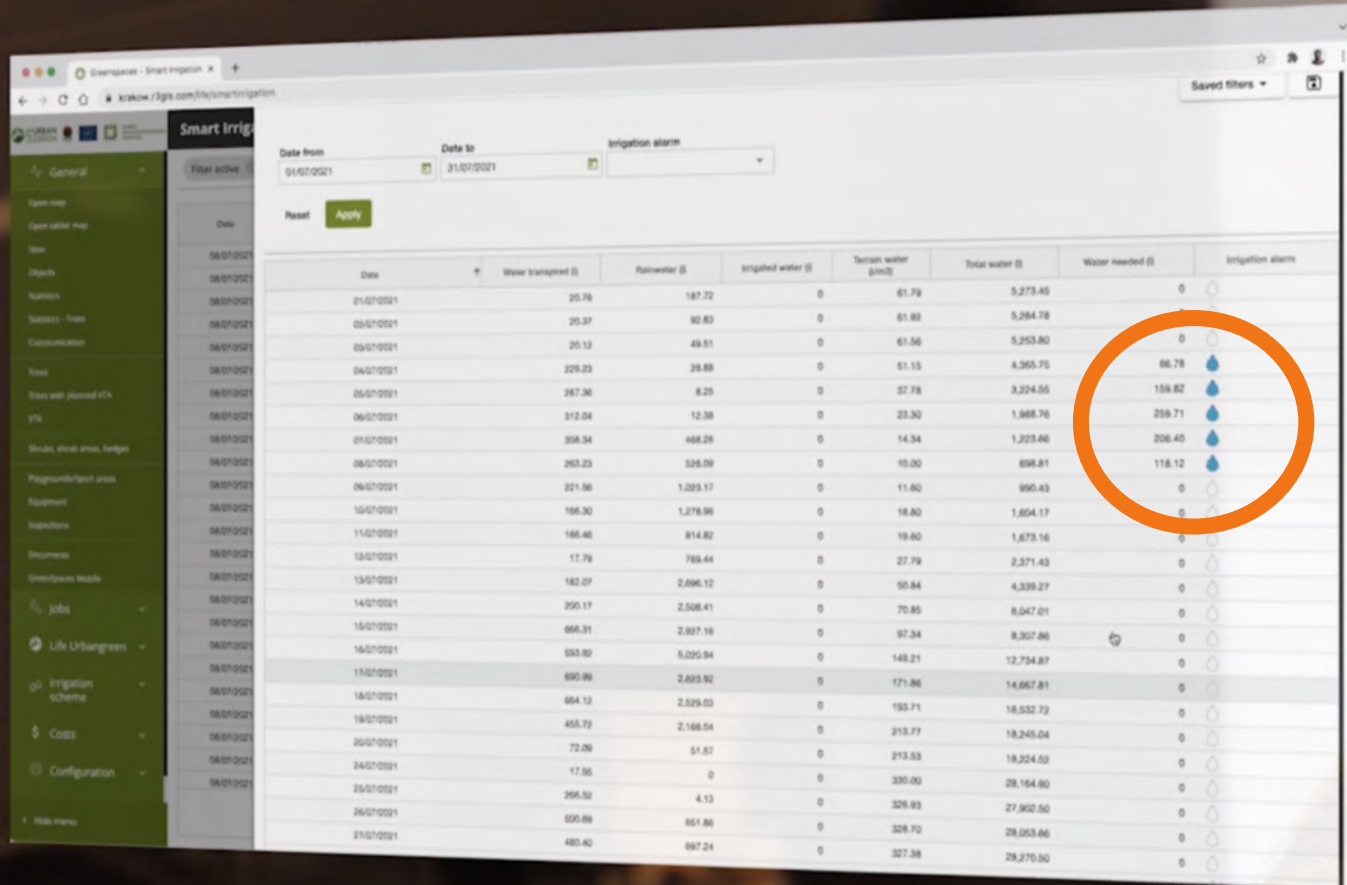


Smart irrigation

With transpiration, precipitation and irrigation GreenSpaces calculates the water available to the tree and when a tree needs water



Smart irrigation

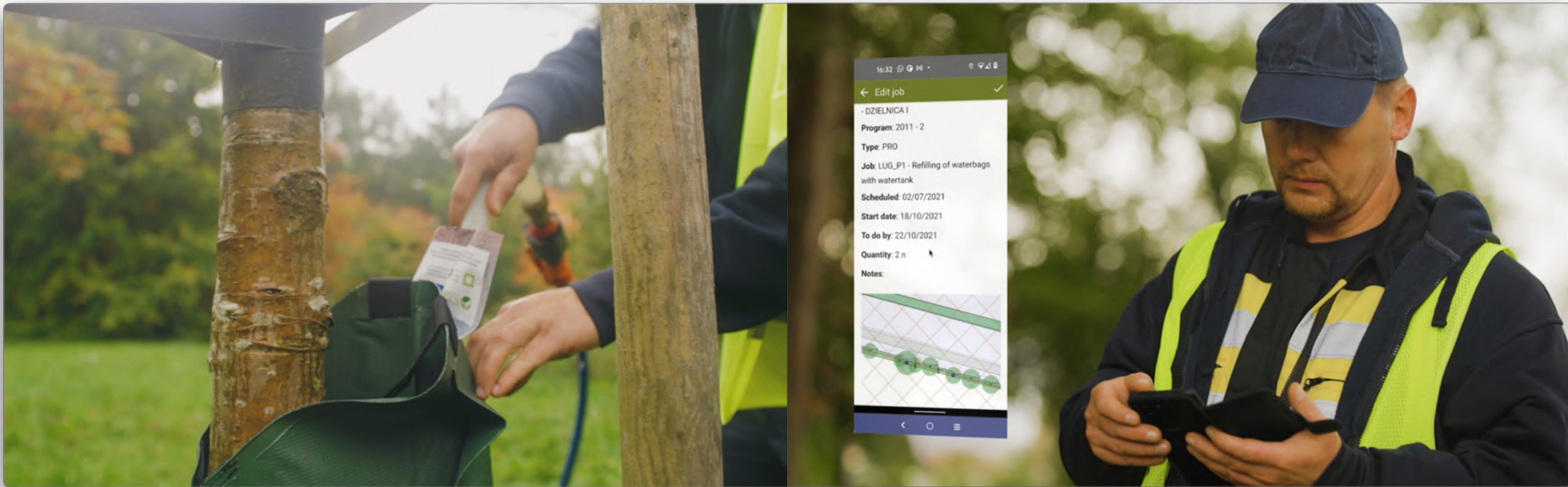


The screenshot displays a web-based interface for smart irrigation management. The main area is a data table with columns for Date, Water transpired (€), Rainwater (€), Irrigated water (€), Terrain water (mm), Total water (€), Water needed (€), and Irrigation alarm. An orange circle highlights a specific section of the table, including the 'Water needed' column and the 'Irrigation alarm' column for several rows.

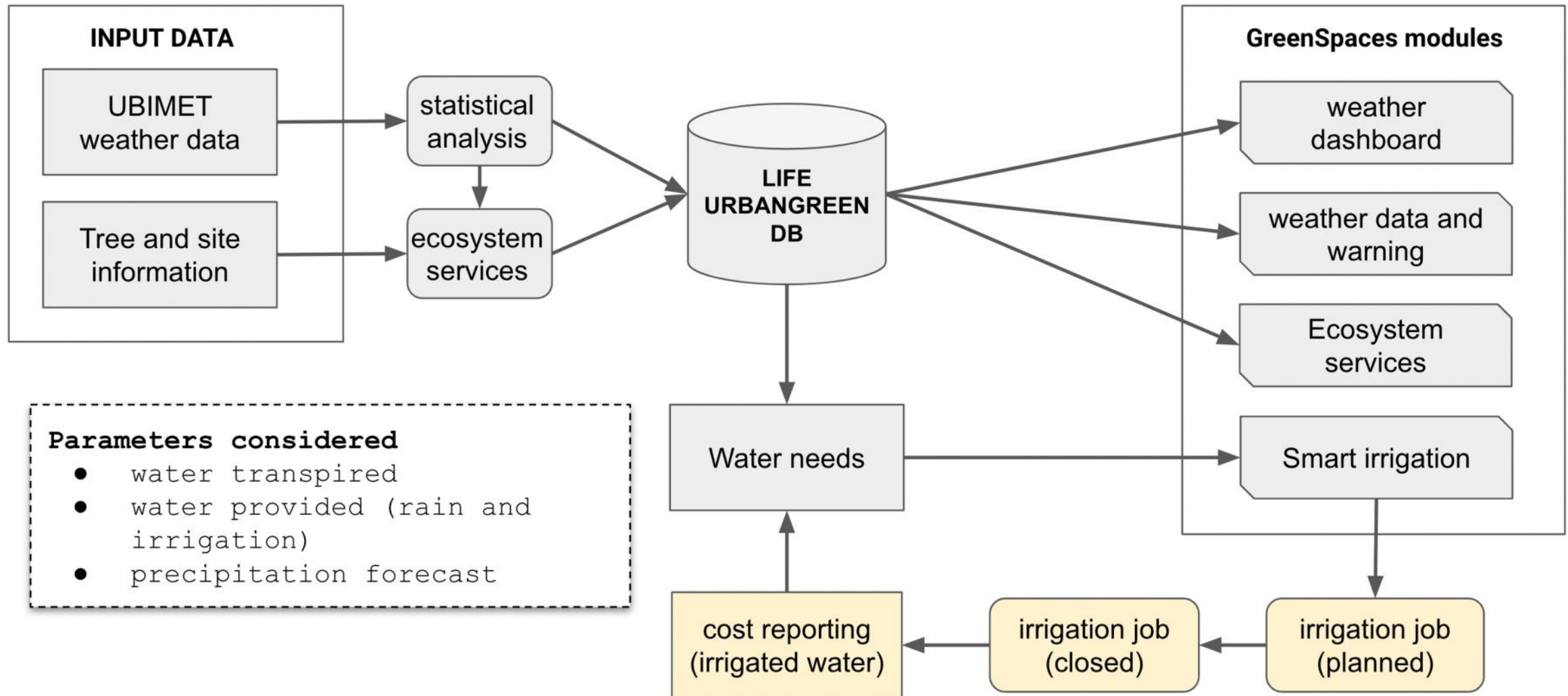
Date	Water transpired (€)	Rainwater (€)	Irrigated water (€)	Terrain water (mm)	Total water (€)	Water needed (€)	Irrigation alarm
01/07/2021	20.78	187.72	0	61.79	5,273.45	0	🚰
02/07/2021	20.37	92.83	0	61.82	5,284.78	0	🚰
03/07/2021	20.12	49.31	0	61.56	5,253.80	0	🚰
04/07/2021	229.23	28.89	0	51.15	4,365.75	86.78	💧
05/07/2021	287.36	8.25	0	37.78	3,224.85	159.82	💧
06/07/2021	312.04	12.38	0	23.30	1,885.76	259.71	💧
07/07/2021	308.34	468.28	0	14.34	1,223.86	206.40	💧
08/07/2021	263.23	528.09	0	10.00	898.81	118.12	💧
09/07/2021	221.36	1,023.17	0	11.80	990.43	0	🚰
10/07/2021	166.30	1,278.96	0	18.80	1,854.17	0	🚰
11/07/2021	186.46	814.82	0	18.80	1,873.16	0	🚰
12/07/2021	17.79	788.44	0	27.79	2,371.43	0	🚰
13/07/2021	182.07	2,896.12	0	50.84	4,339.27	0	🚰
14/07/2021	200.17	2,508.41	0	70.85	8,047.01	0	🚰
15/07/2021	866.31	2,897.18	0	97.34	8,307.86	0	🚰
16/07/2021	593.82	5,020.84	0	148.21	12,734.87	0	🚰
17/07/2021	890.86	2,893.92	0	171.86	14,867.81	0	🚰
18/07/2021	684.12	2,529.03	0	198.71	16,532.72	0	🚰
19/07/2021	455.72	2,168.04	0	213.77	18,245.04	0	🚰
20/07/2021	72.09	51.87	0	213.53	18,224.52	0	🚰
21/07/2021	17.36	0	0	330.00	28,164.80	0	🚰
22/07/2021	296.52	4.12	0	326.93	27,950.50	0	🚰
23/07/2021	550.89	651.86	0	328.70	28,053.66	0	🚰
24/07/2021	480.40	687.24	0	327.38	28,270.90	0	🚰

Smart irrigation

Based on the calculations of the smart irrigation tool trees are watered and the delivered amount of water is recorded.



Smart irrigation



Conclusions

Next steps

- Use of Open Meteo Data instead of proprietary data to calculate ecosystem services and irrigation needs.
- Test of different type of sensors to calibrate smart irrigation: TreeTalker and TreeSense sensors
- Extension of Ks calculation to new species and new climatic zones, with new research carried out by the University of Milano and the University of Firenze.

THANK YOU!

www.lifeurbangreen.eu

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