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MULTI-SOURCE SPATIAL DATA FOR A BETTER MANAGEMENT OF RAINWATER AND URBAN CULTIVATED AREAS: A CASE STUDY IN ROME, ITALY

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Background

- Urban Agriculture (UA) is a growing phenomenon in metropolitan areas
- UA is considered an activity with several positive impacts (food security, temperature and storm water regulation, water and pollutant filtration, biodiversity, leisure, etc.)
- UA can be a sustainable urban land use but the impacts on the urban water budget should be evaluated to drive proper planning choices toward sustainability
- Impacts on urban water resources can be evaluated taking into account crops water requirements and irrigation water sources
- Identifying new sources for irrigation (e.g. rainwater) can
  - contribute to develop more productive agricultural activities
  - reduce the resort to other sources (i.e. aqueduct, wells, river or canals (often heavily contaminated))

Aim of the study

Evaluating the UA water requirements in a metropolitan area and the amounts of irrigation water that could be provided by the rainwater harvestable from roofs...*

... by using spatial data from different sources

**Residential food gardens*

Questions

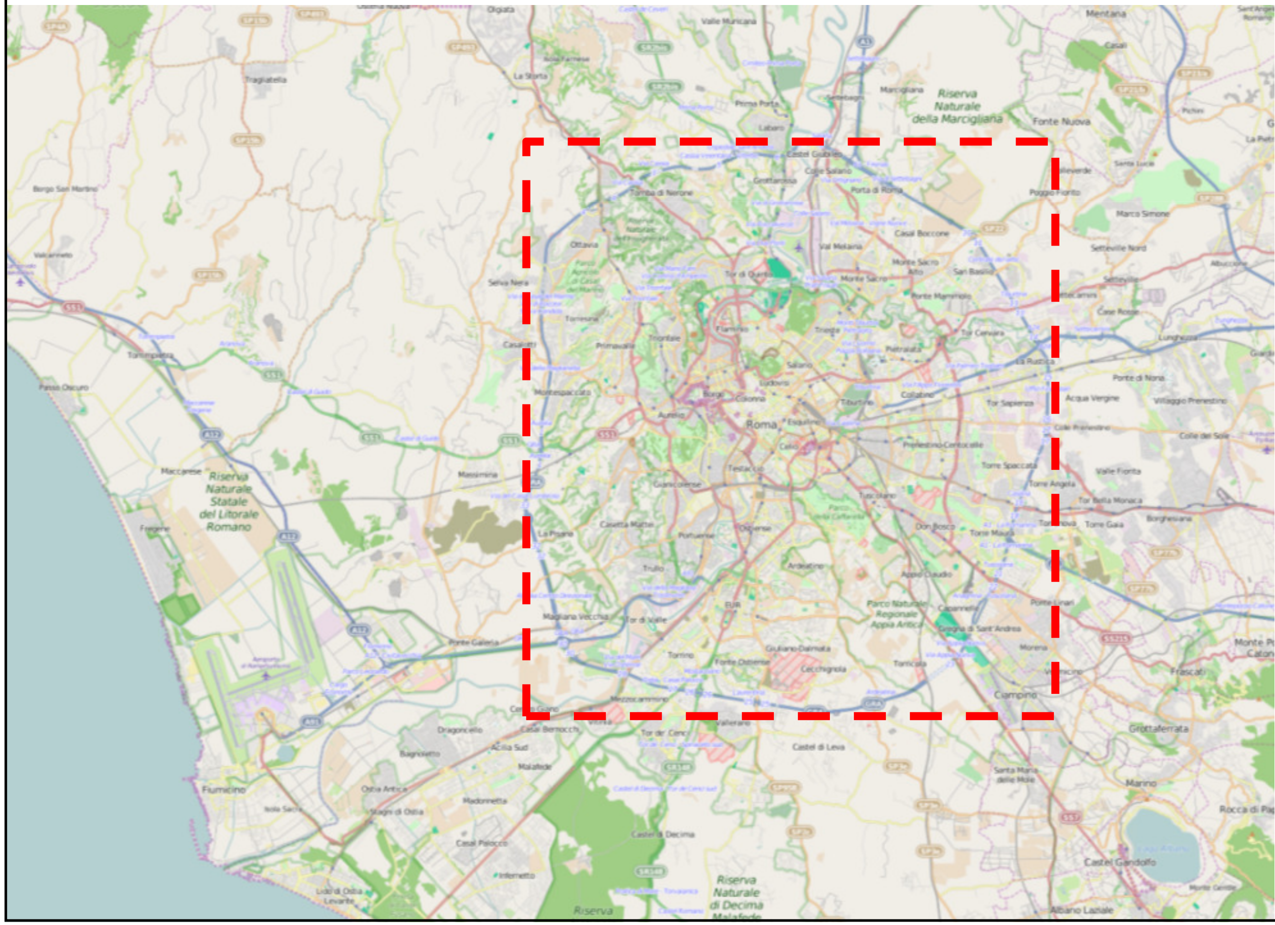
1. Which is the total amount of water required to irrigate the crops of residential food gardens (RGs) located in an urban area?

2. How much rainwater could be harvested from the buildings roofs located nearby each RGs?

3. Which is the degree of self-sufficiency in irrigation of RGs by comparing the irrigation requirements and the total annual rainwater harvestable from roofs?

Study area

- Rome urban area delimited by the GRA/A90 Motorway (*Grande Raccordo Anulare*) – 344 km^2
- Strong urbanization started in 1960 with increase in settlements and population
- A lot of urban agricultural activities (e.g. urban farms, community gardens, residential food gardens)

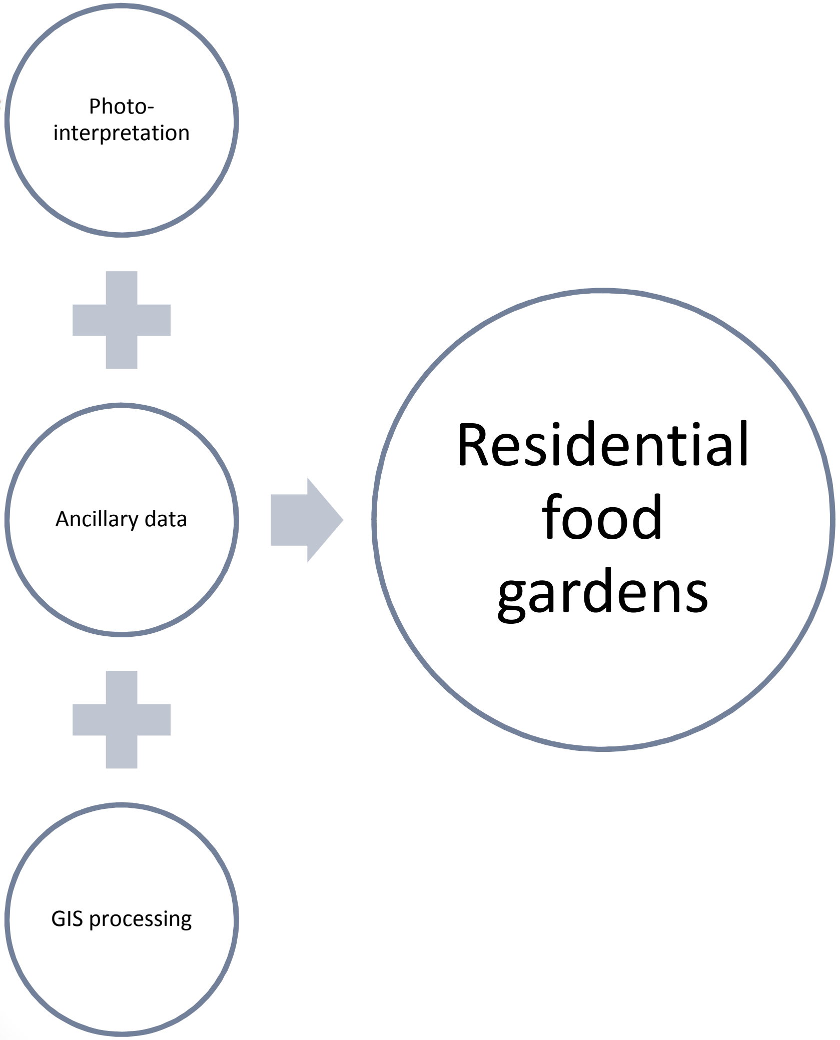


Datasets

- Three main datasets were used in this study:
  - Geodatabase of residential food gardens (RGs)
  - Geodatabase of average 1950-2000 monthly meteorological data
  - Geodatabase of buildings roofs

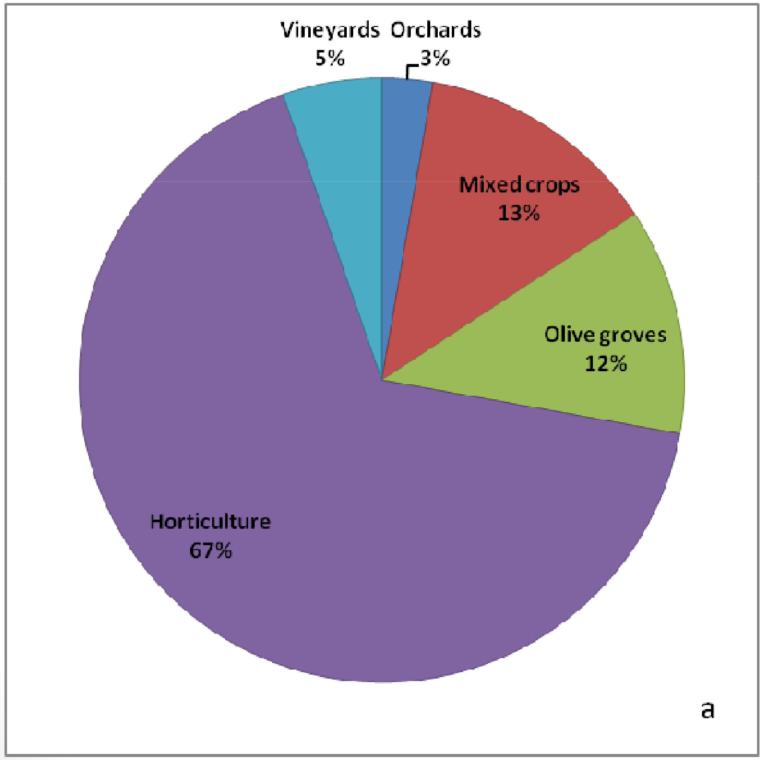
- In general, high resolution spatial datasets are required for this kind of evaluation
  - but, these are often not available or difficult to acquire
  - using data from different sources and/or produced with different methodologies can be a possible approach to overcome the issue

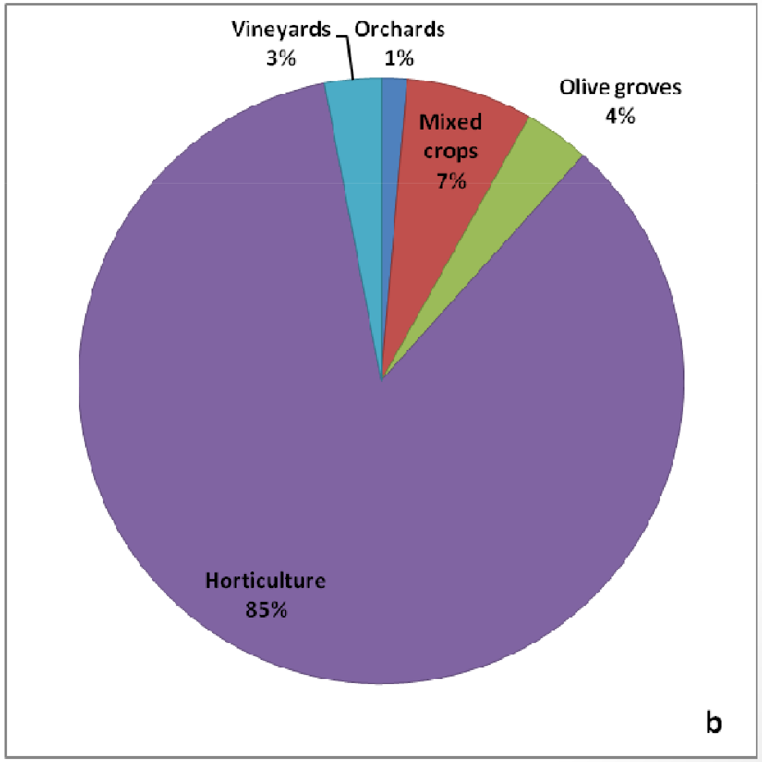
RGs – geodatabase creation



RGs – statistics

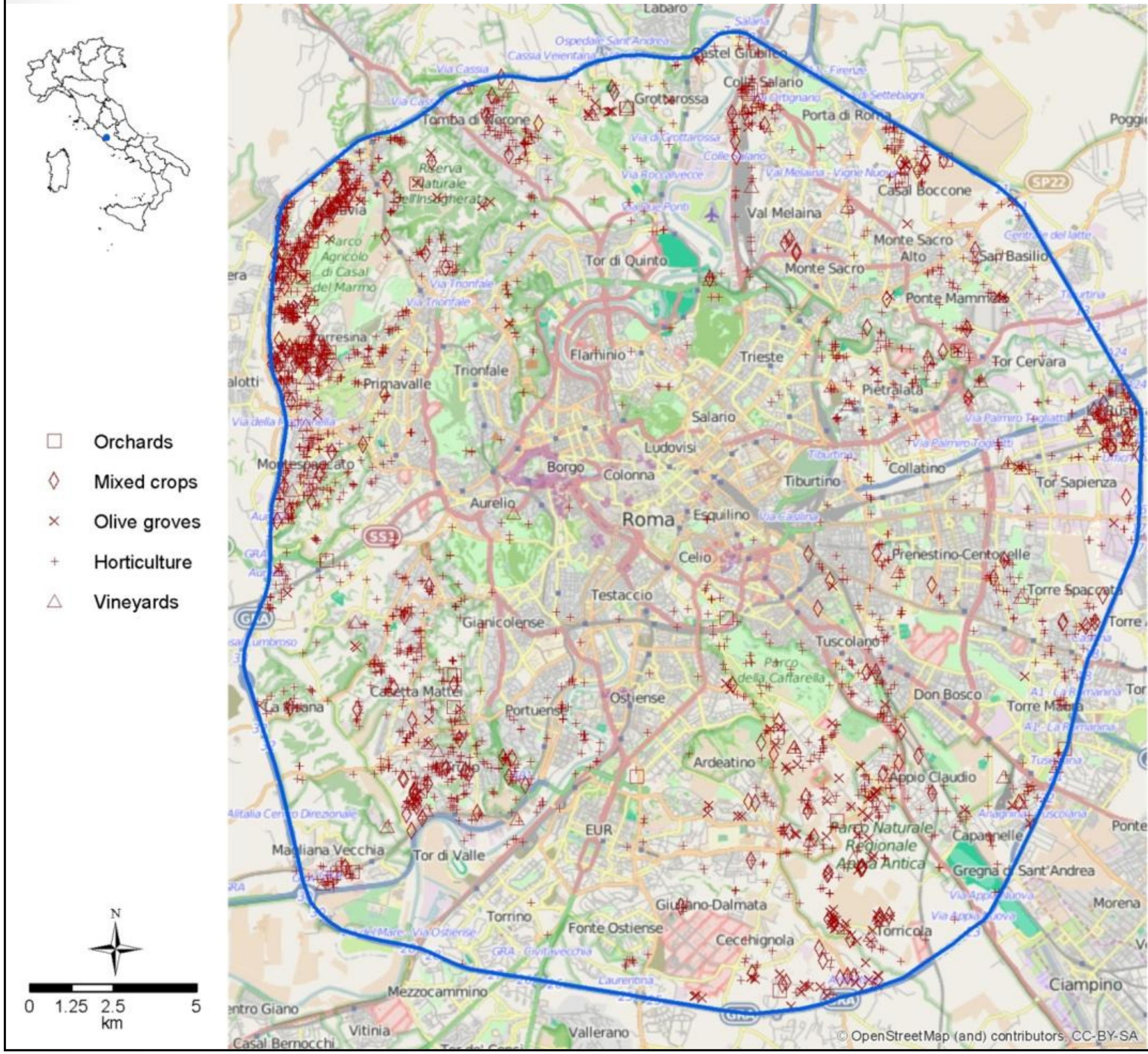
- 2631, the cultivated polygons in 2013
- 720,000 m^2 (72 ha), the total cultivated area
- 6 – 2,000 m^2, the polygons area range
- 5, the land uses



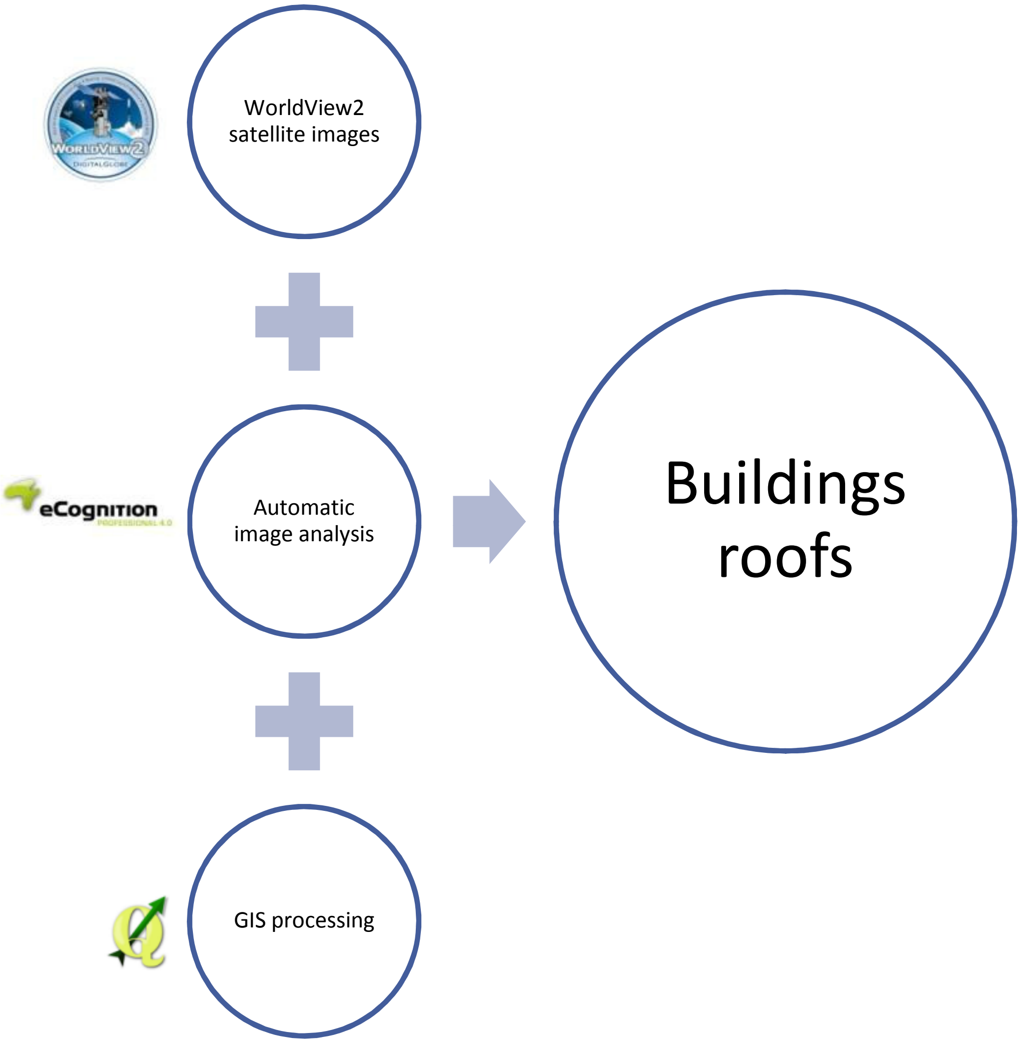


Percentage over the total: area (a) and number of parcels (b)

RGs – spatial distribution



Buildings roofs – geodatabase creation

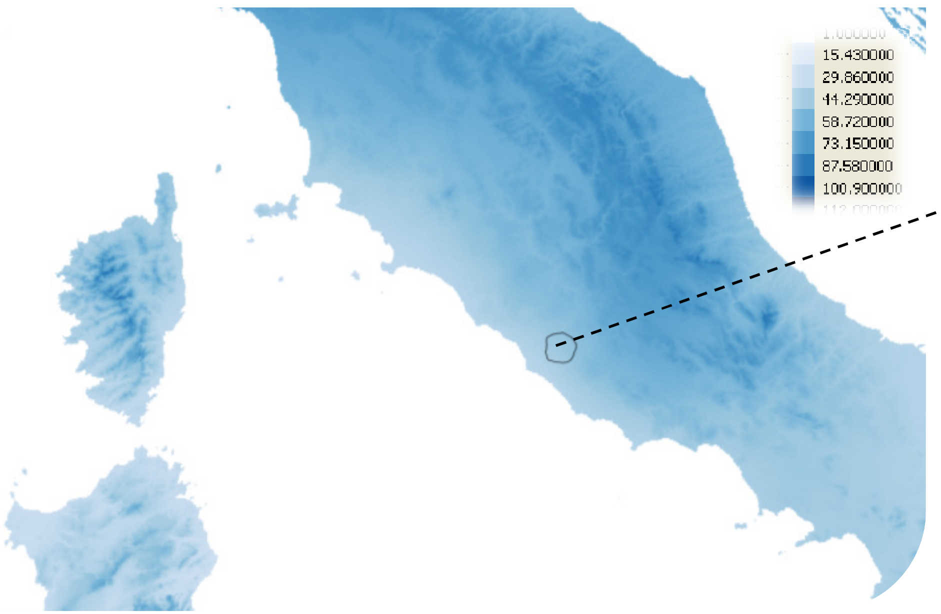


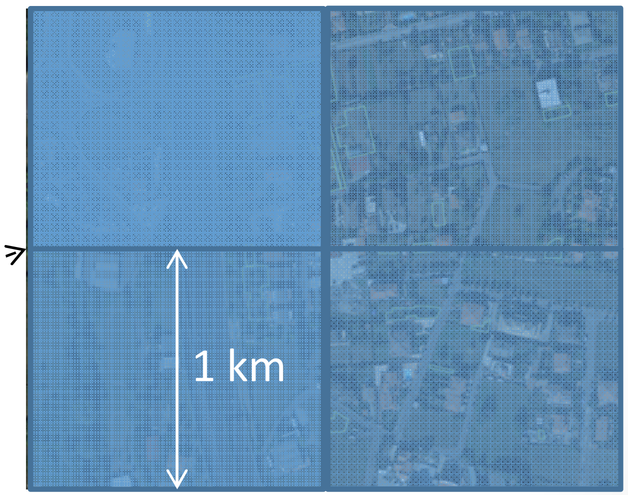
Buildings roofs – RGs association

- Each RG is associated with the closest building roof

Meteorological data

- Data extracted from the web portal WorldClim* containing global climate layers (spatial resolution of 1 km^2), routinely used for mapping and spatial modelling in a GIS as raster grids
- Monthly average (1950-2000) precipitation and evapotranspiration grids were extracted for the study area, the values were assigned to the RGs polygons inside the corresponding 1 km^2 grid



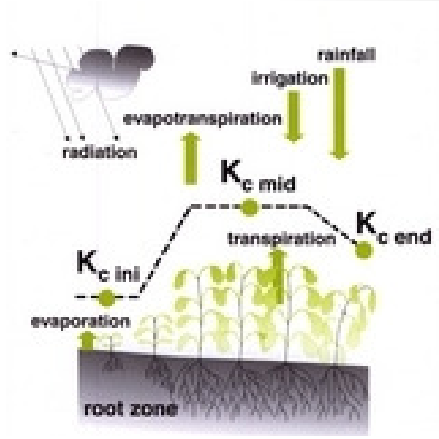


*http://www.worldclim.org/

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. International journal of climatology, 25(15), 1965-1978.

Irrigation water requirement at parcel level

- **Irrigation water requirement** (**IWR**) is estimated by:
  - considering crops cultivated during the irrigation season April-September
  - considering the classical FAO paper no.56 approach based on effective precipitation (**P_{eff}**), reference evapotranspiration (**ET_o**) and crop coefficient (**k_c**)



$$IWR = \sum_{i=4}^{9} (k_c \cdot ET_{o(i)} - P_{eff\,(i)})$$

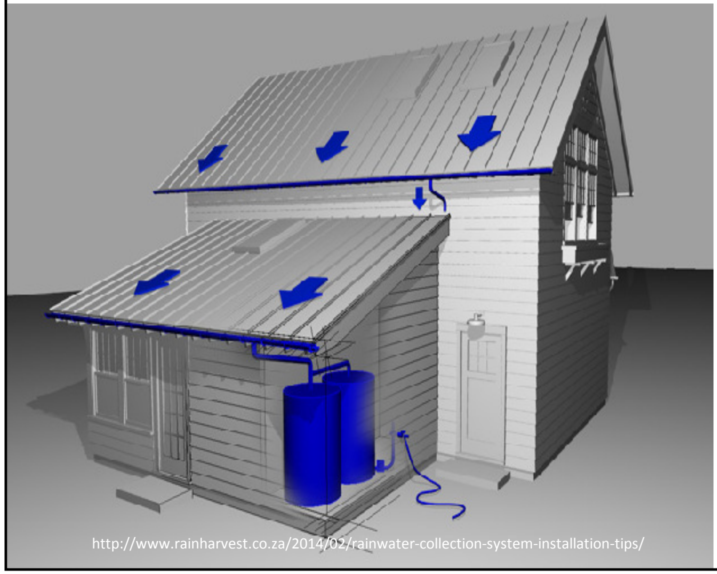
- **Gross irrigation water requirement** (**GIWR**):
  - takes into account the application efficiency (**E**) of the irrigation system used
  - estimated for each RG for two irrigation systems: surface (E=90%) and localized (E=45%)

$$GIWR = \frac{1}{E} \cdot IWR$$

Allen, R. G., Pereira, L. S., Raes, D., & Smith, M. (1998). Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56. FAO, Rome, 300, 6541.

Rainwater harvestable from roofs

- Estimated by using:
  - building roof size [$\mathbf{A_{roof}}$ in m^2]
  - total precipitation [$\mathbf{P_{tot}}$ in m]
  - harvesting efficiency (a portion of the rain is captured by the roof) [$\mathbf{H_{eff}}$]
- Simplifications:
  - no evaluation on the tank to be used for storing water
  - no evaluation on the tank water budget (i.e. the balance among irrigation demand, rainwater collected and tank overflow)



$$RH = P_{tot} \cdot A_{roof} \cdot H_{eff}$$

Rainwater harvestable from roofs - statistics

- 2 - 2,511 m^2, the range of buildings roofs size
- 0.93 – 1,188 m^3, the range of rainwater annually harvestable from roofs

		Orchards	Mixed crops	Olive groves	Horticulture	Vineyards	RGs dataset
Roof area	Minimum	11.00	7.00	15.00	2.00	7.00	2.00
	Maximum	208.00	1,567.00	1,566.00	2,511.00	543.00	2,511.00
	Average	92.36	152.06	162.35	147.64	150.44	147.78
	Standard dev.	55.48	190.93	209.33	193.46	114.13	190.78
	Sum	3,325.00	27,067.00	14,936.00	331,593.00	11,885.00	388,806.00
	%	0.86%	6.96%	3.84%	85.28%	3.06%	100.00%
RH	Minimum	5.45	3.20	7.12	0.93	3.38	0.93
	Maximum	95.22	728.25	745.10	1,188.99	262.59	1,188.99
	Average	43.45	71.98	77.30	69.63	70.96	69.74
	Standard dev.	26.14	91.41	99.75	92.08	54.38	90.85
	Sum	1,564.23	12,813.12	7,111.64	156,397.90	5,605.63	183,492.53
	%	0.85%	6.98%	3.88%	85.23%	3.05%	100.00%

Source: Authors calculations.

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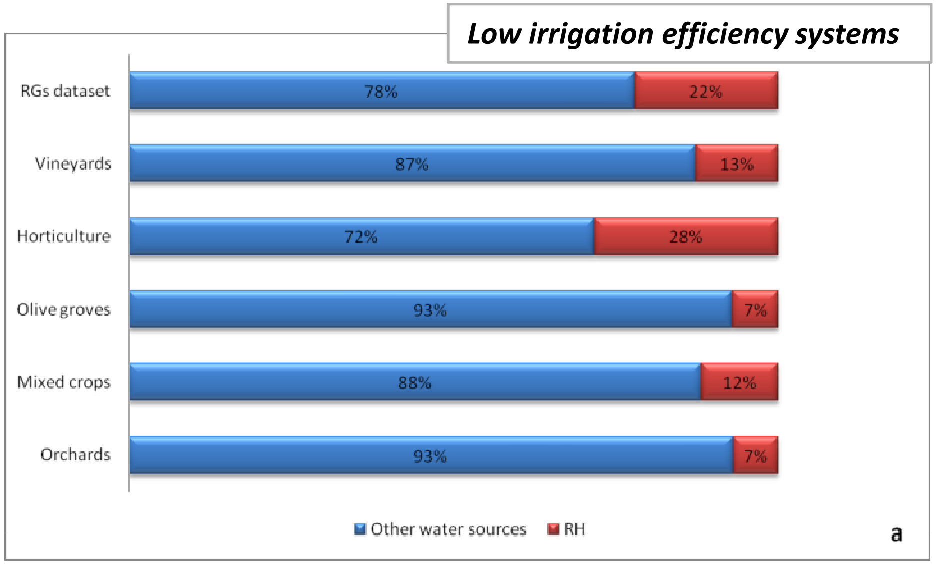
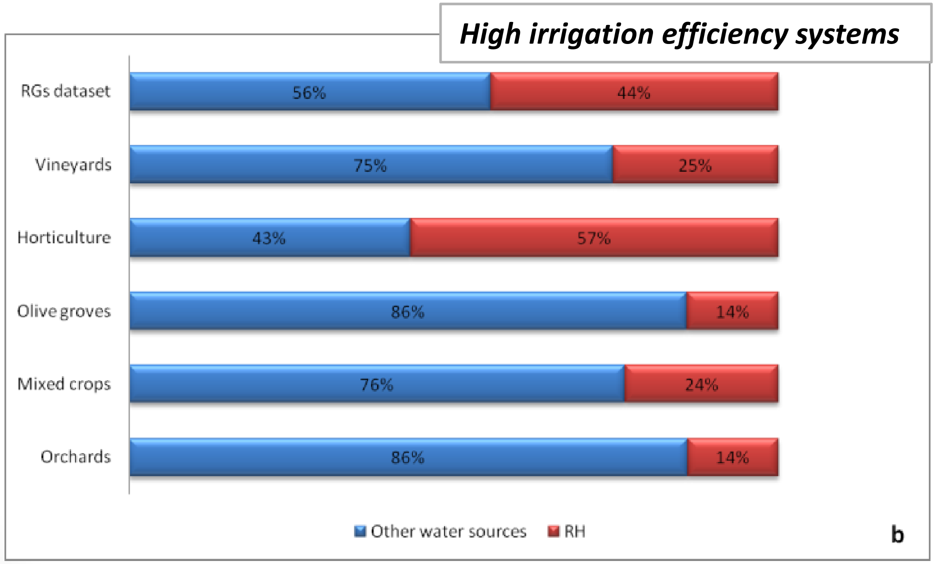
Results: Self-sufficiency in irrigation - volumes





Share (percentage over the total) of irrigation that could be provided by rainwater and other sources for each land use typology and for the whole residential gardens (RGs) dataset.

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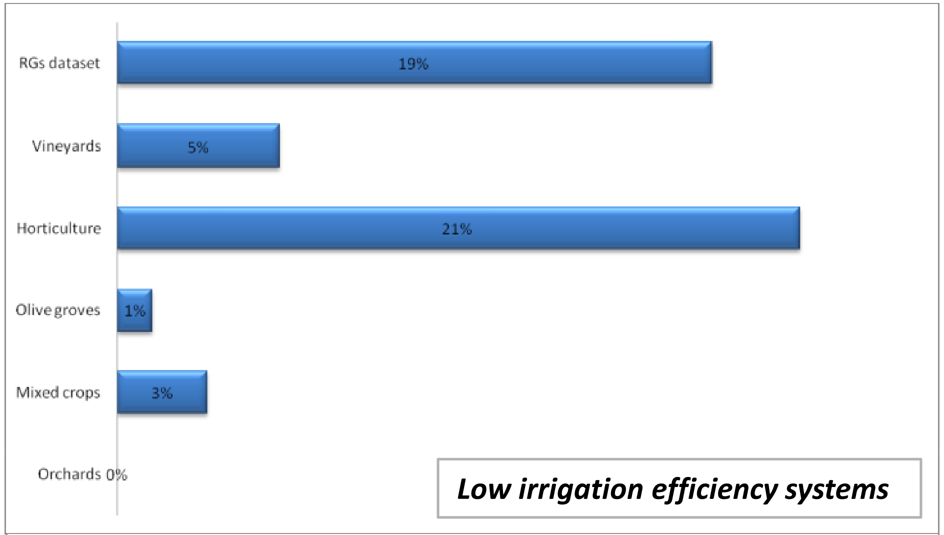
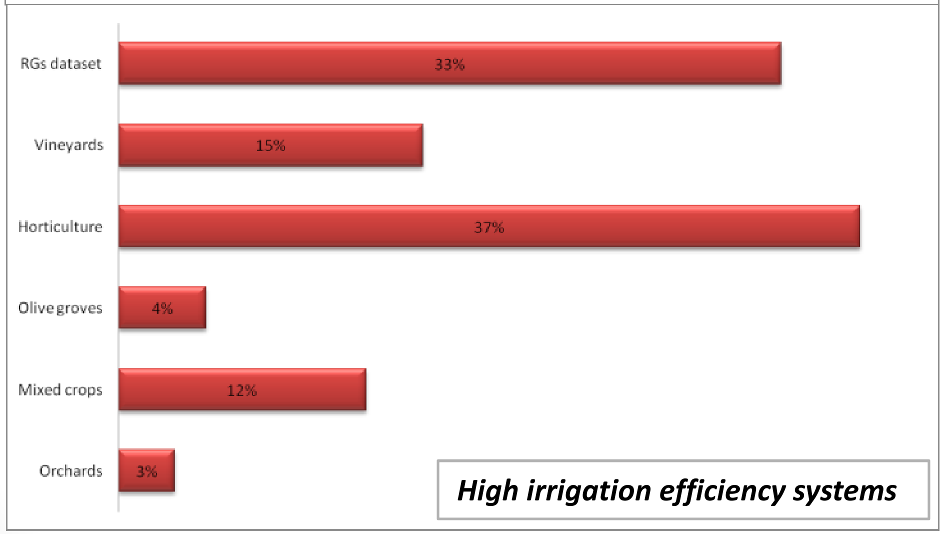
Results: Self-sufficiency in irrigation – no. of parcels





Number of polygons (percentage over the total), by land use typology and for the whole residential gardens (RGs) dataset, that could be irrigated without resorting to additional water sources by using rainwater.

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Conclusions

- The results obtained show
  - to which extent RGs with different land use types can be irrigated with rainwater harvestable from nearby roofs
  - how many RGs could be self-sufficient in irrigation
- The methods applied
  - are based on several simplifications more sophisticated modelling would help to produce reliable estimates and precise evaluation for implementing planning strategies.
  - however, we obtained a preliminary picture of one of the component of the water use in urban areas
  - can be easily applied to other cities
- The lack of data with adequate spatial resolution in urban areas can be overcome by using multi-source dataset
- This kind of assessment is relevant due to growing interest on urban agriculture and to the expected pressures on water resources driven by Climate Change, especially for those cities with policies supporting UA development

Grazie per l'attenzione

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