# Rooftop gardens for urban vegetable production: impact on food security, ecological footprint and biodiversity. A case study for the city of Bologna.

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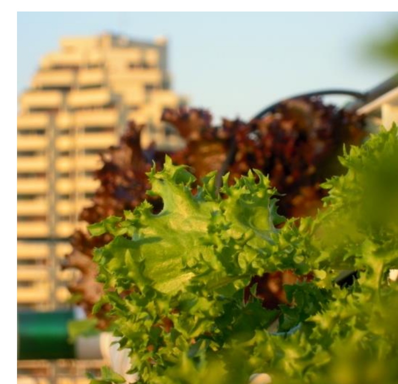
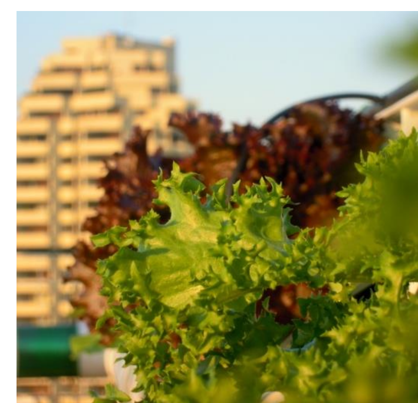


# Outline of the Presentation

- Multifunctionality of Urban horticulture
- Case study: RoofTop Gardens (RTGs) for food security, biodiversity and other ecosystem services
- Yield of RTGs
- Definition of city vegetable requirements
- Available surfaces for RTG implementation
- RTGs for
  - city food security
  - Green corridors
  - Ecosystem services



# Urban Horticulture (UH) and Food Security

More than half of world population lives in cities
*(Dubbelling et al., 2010)*

More than half of world poor live in cities
*(Shackleton et al., 2009)*

Urban Horticulture may enhance food access in cities as well as a range of ecosystem services
*(Orsini et al., 2013)*

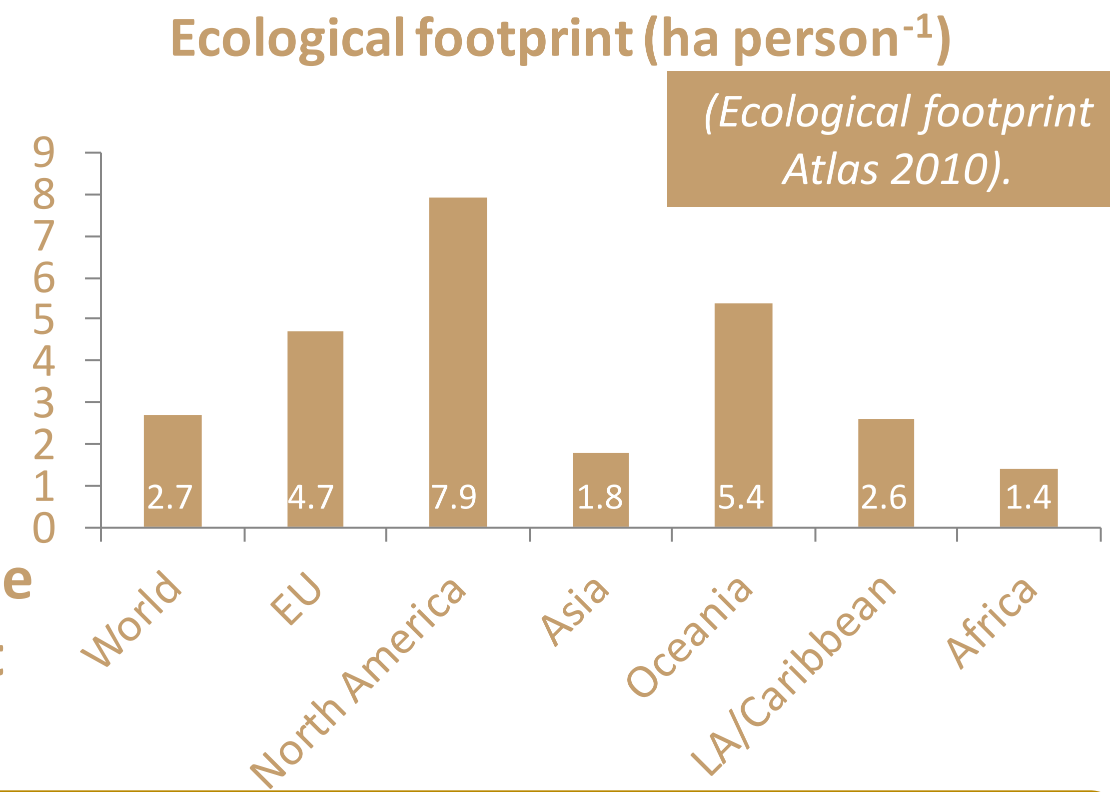
SkyGreens vertical farm, Singapore

# Urban population and ecological citizenship

Each of us is responsible for taking up a certain amount of ecological 'space' (both for resource use and capacity burden), expressed as a personal footprint left on the Earth.
*(Wackernagel and Rees 1996)*

**Urban Agriculture may reduce the city Ecological Footprint**
***(Orsini et al. 2013)***

Global availability: **1.8 ha person$^{-1}$**




*(Ecological footprint Atlas 2010).*

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# Soilless urban vegetable gardens

In cities, difficult access to **available fertile non-contaminated soil** *(Orsini et al., 2013)*

Hydroponics may enable to turn urban concrete into green infrastructures for vegetable cultivation *(Vittori Antisari et al. 2015; Pennisi et al. 2016)*

Soilless system in Abidjan (Ivory Coast) and Simplified Hydroponics in Bologna (Italy)

# Vertical farming vs Rooftop Gardens

## Vertical farms

-First green skyscrapers ready after 2020 (Despommier, 2009)

-Cost = 10 to 12.5 Euros $kg^{-1}$ (Schubert, 2012)

Gotham Green rooftop greenhouse, NYC

## Rooftop gardens

-Possibility to adapt already existing buildings to vegetable cultivation (Grewal and Grewal 2011)

-Possibility to use Simplified Hydroponics (Orsini et al, 2014)

-Improve the resource efficiency of the building (heat, cooling, water, etc.) (Specht et al, 2013)

Vertical farm Render and current building status, Singapore

# Multifunctionality

PARTICIPATION, DECISION-MAKING, RECREATION, HEALTH, WELL-BEING

ENERGETIC EFFICIENCY, FLOOD MANAGEMENT, FOOD SECURITY AND SAFETY

RTGs

BIODIVERSITY RESERVOIRS, GREEN CORRIDORS, RECYCLING

# Case study

## Potential impact of RoofTop Gardens (RTGs) on Food Security and other Ecosystem Services in the city of Bologna, Italy

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# Social housing buildings, via Gandusio, Bologna

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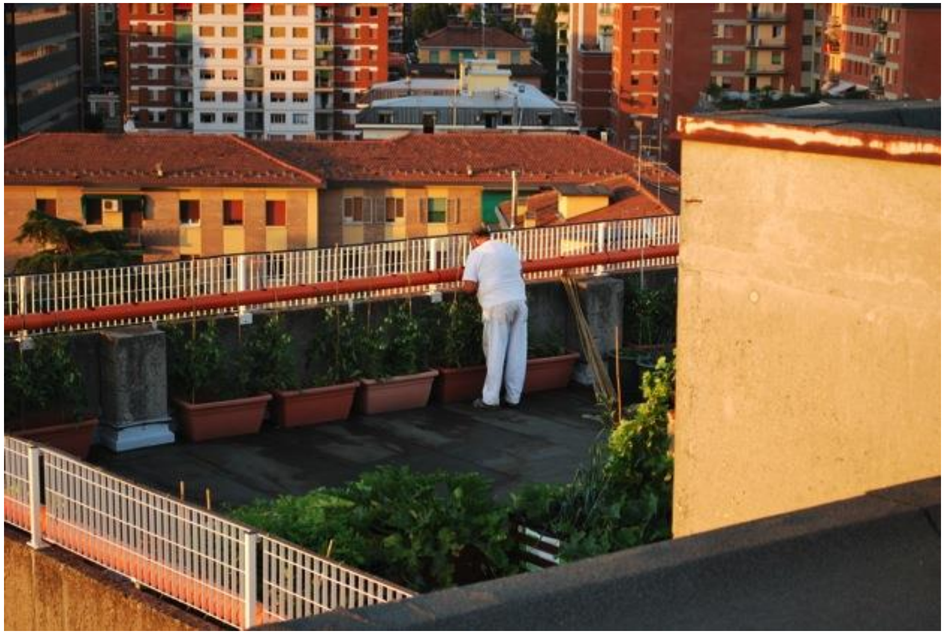

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# Building social relations in social housing building in Gandusio, Bologna

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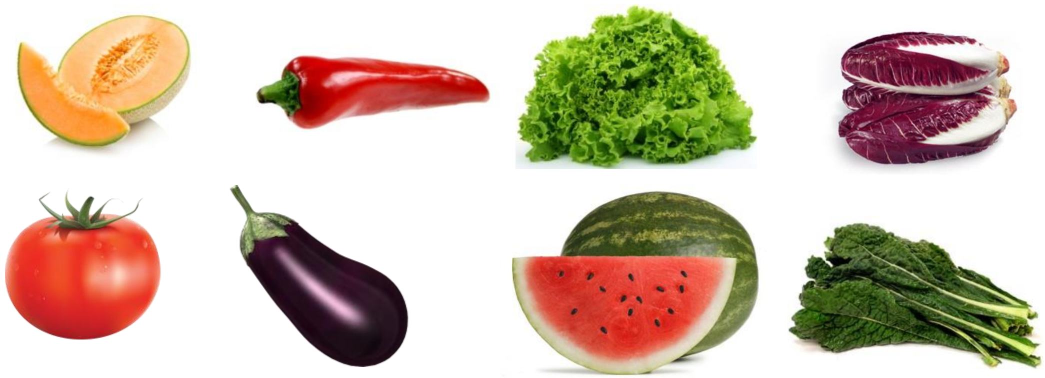
# Yield of Simplified Hydroponics RTGs

## 3 growing systems, 8 species, 3 years

*Modified NFT*

*Floating system*

*Substrate container*



**2011**

**2012**

**2013**

| Crop | Cultivar | Season | System | DAT | Yield | Daily productivity |
|---|---|---|---|---|---|---|
| **Lettuce** | Batavia | Su | Floating | 21 | 2.5 | 119.0 |
| | Gentilina | Su | NFT | 21 | 1.1 | 52.4 |
| | Gentilina | Su | Floating | 25 | 1.3 | 52.0 |
| | Gentilina | Su | NFT | 62 | 1.5 | 24.2 |
| | Canasta | Au | Floating | 44 | 1.8 | 40.9 |
| | Canasta | Au | NFT | 44 | 1.3 | 29.5 |
| | Canasta | Au | Substrate | 44 | 1.5 | 34.1 |
| | Canasta | Au-Wi | Substrate | 62 | 0.5 | 8.1 |
| **Black cabbage** | Riccio toscano | Au-Wi | Substrate | 89 | 0.5 | 5.6 |
| **Chicory** | Treviso | Au, Wi | Floating | 83 | 1.5 | 18.1 |
| | Treviso | Au, Wi | NFT | 62 | 0.1 | 1.6 |
| | Treviso | Au, Wi | Substrate | 83 | 0.6 | 7.2 |
| **Tomato** | San Marzano | Sp, Su | Substrate | 99 | 13.4 | 135.4 |
| | Caramba | Sp, Su | Substrate | 95 | 14.3 | 150.5 |
| **Eggplant** | Nilo F1 | Sp, Su | Substrate | 77 | 8.2 | 106.5 |
| **Chili pepper** | Cayenna F1 | Sp, Su | Substrate | 80 | 4.1 | 51.3 |
| **Melon** | Honeymoon | Sp, Su | Substrate | 101 | 3.8 | 37.6 |
| **Watermelon** | Sugar belle | Sp, Su | Substrate | 82 | 4.8 | 58.5 |

Yield =

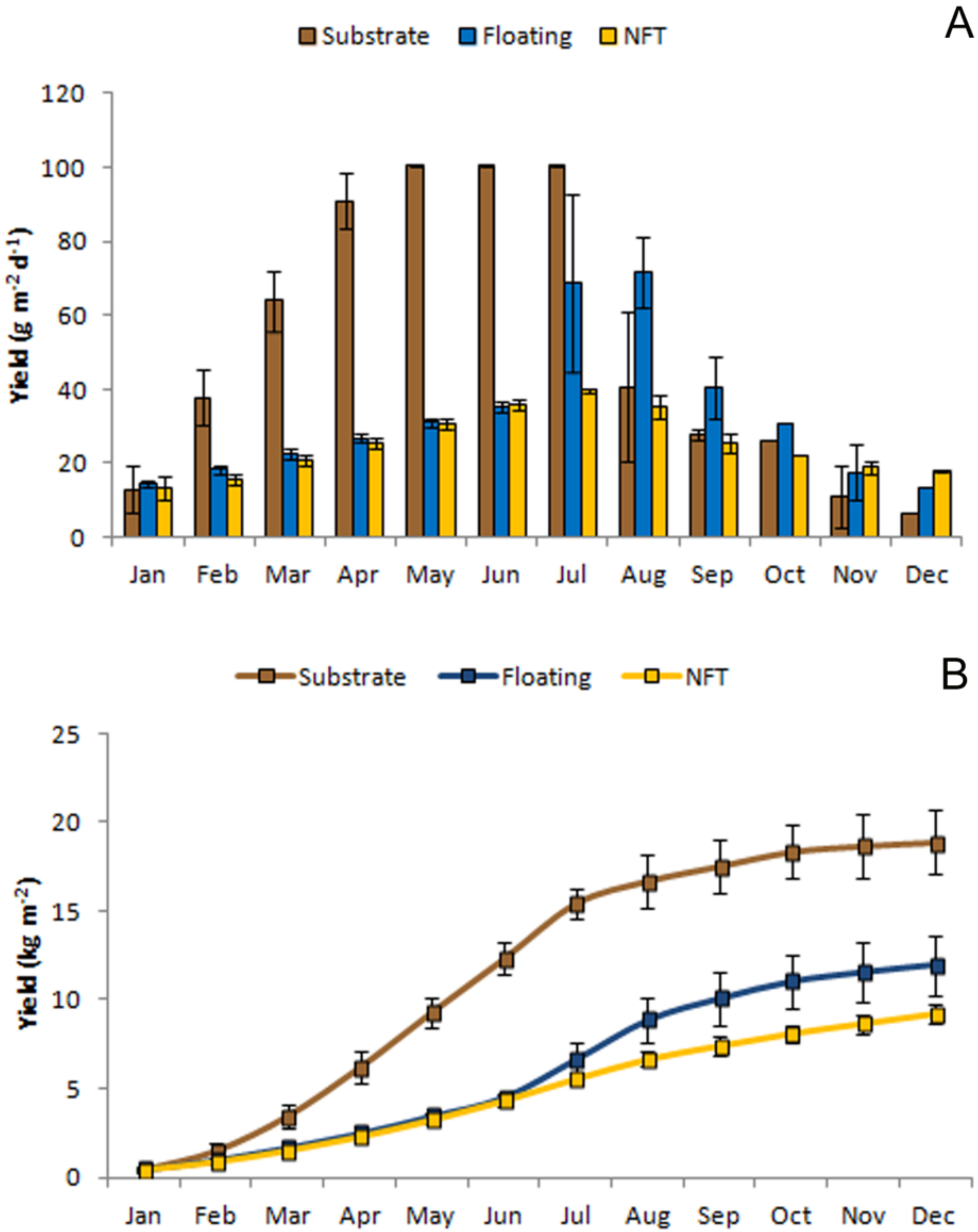
F

(cultivar)

(growing system)

(season)

Crop yield performances in the experimental trials. DAT, Days After Transplanting; Wi, Winter; Sp, Spring; Su, Summer; Au, Autumn. Yield expressed as kg $m^{-2}$. Daily productivity expressed as g $m^{-2}$ $d^{-1}$.




**Substrate**: greatest seasonal variability (10 – winter - to 98 g $m^{-2}$ $d^{-1}$ -spring-summer).

**MEAN: 52 g $m^{-2}$ $d^{-1}$ , 18.2 kg $m^{-2}$**

**Floating**: production peaks in summer (70 g $m^{-2}$ $d^{-1}$ as compared to 25 g $m^{-2}$ $d^{-1}$ in the remaining months).

**MEAN: 33 g $m^{-2}$ $d^{-1}$ , 12.0 kg $m^{-2}$**

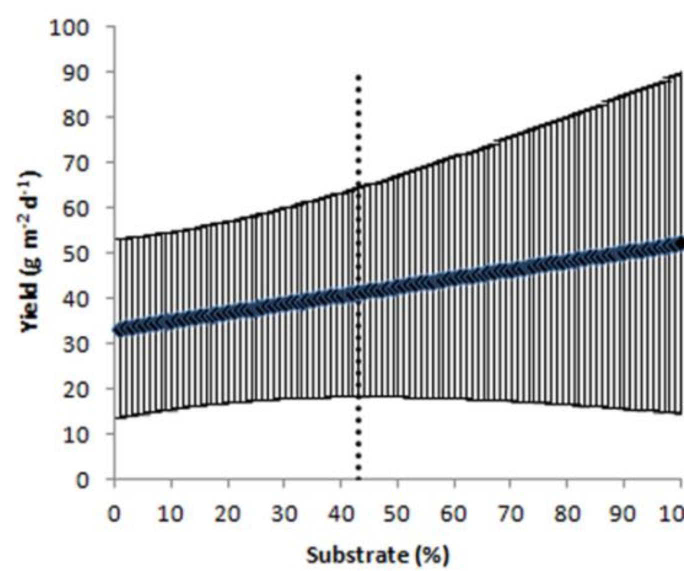
**NFT**: reduced productivity and seasonal variability (13 to 40 g $m^{-2}$ $d^{-1}$).

**MEAN: 25 g $m^{-2}$ $d^{-1}$ , 9.2 kg $m^{-2}$**

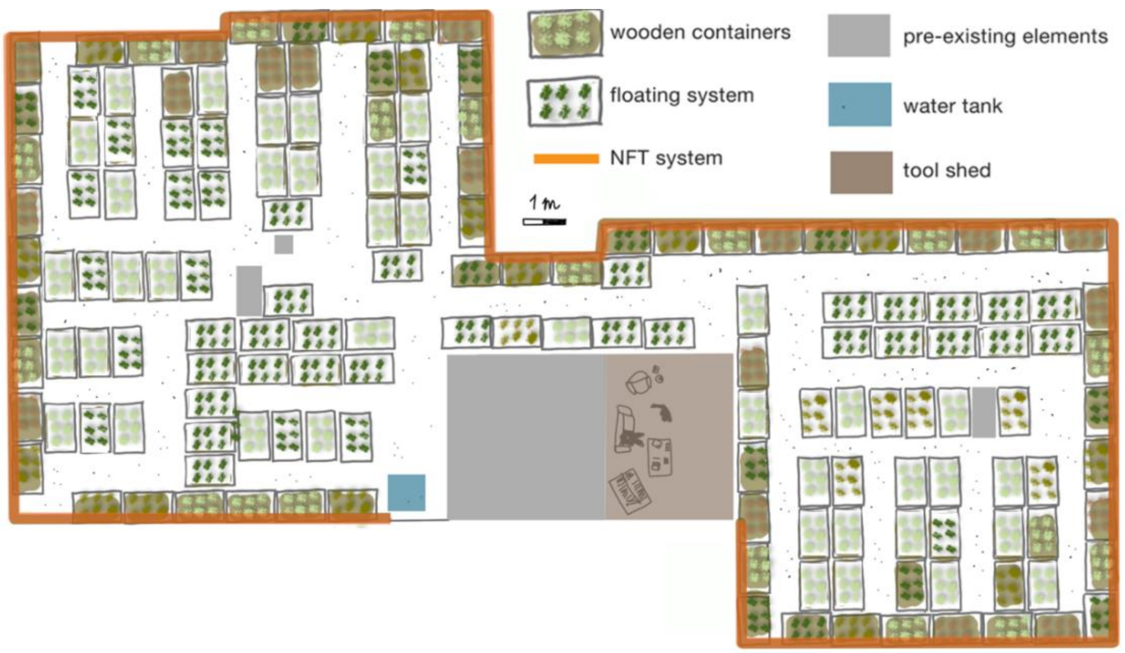
Daily (**A**, g $m^{-2}$ $d^{-1}$) and cumulated (**B**, kg $m^{-2}$) yield of the simplified hydroponic systems (Substrate, Floating and NFT) used in the experiments. Data calculated on mean values of tested crops in each growing system. Vertical bars indicate standard errors.

Optimal ratio between floating system and substrate cultivation system. Mean daily productivity (g $m^{-2}$ $d^{-1}$) across the year. Vertical bars indicate standard errors of mean yearly productivity.

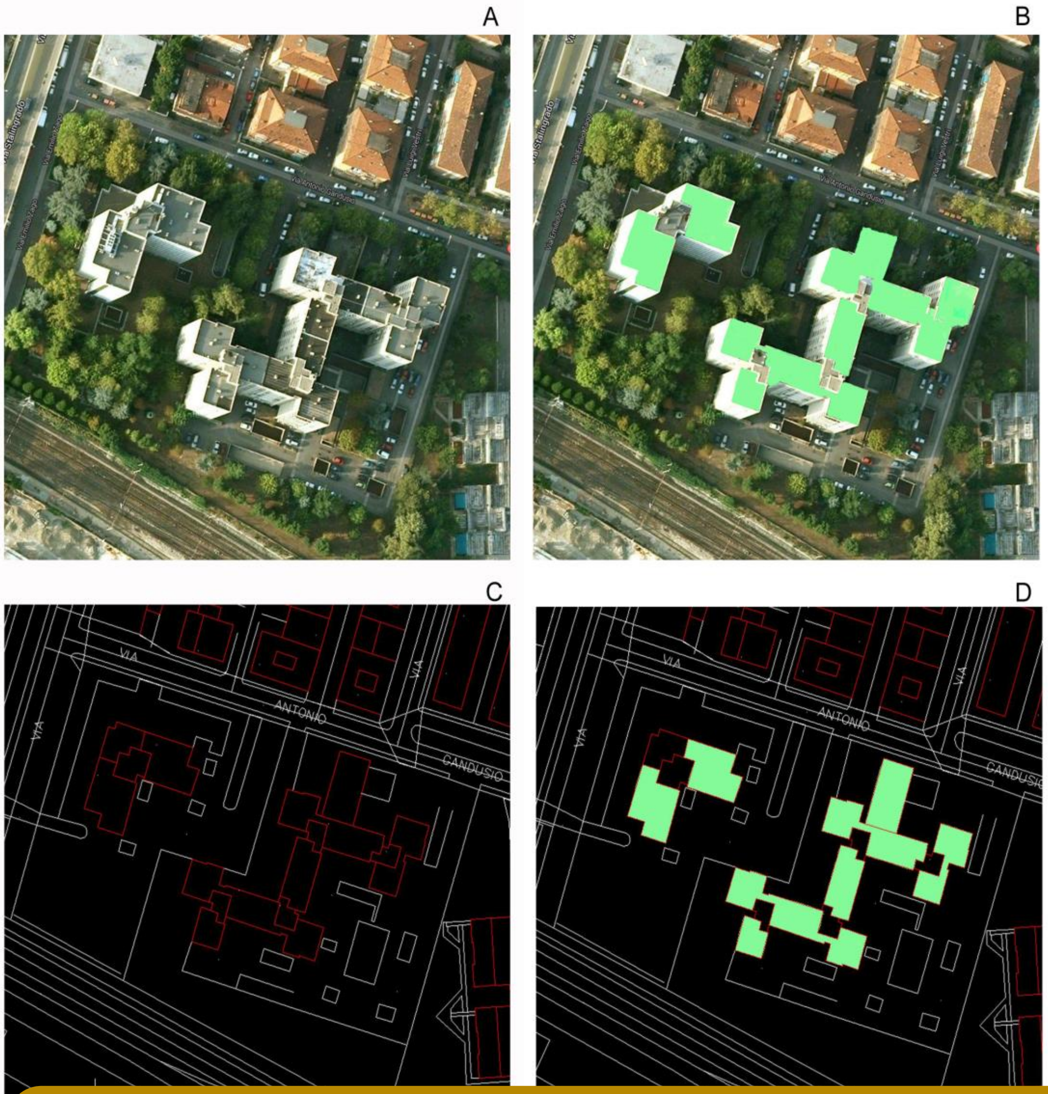
Dotted vertical bar represent optimal ratio (43:57 for substrate:floating system) enabling to ensure satisfactory yield (41.7 g $m^{-2}$ $d^{-1}$) and reduce seasonal fluctuations in productivity.




Graphical representation of the garden to be implemented in study case rooftop according to optimal growing system ratios.



# Available surface for RTGs




*Identification of flat rooftops on GoogleEarth® (A, B), and consistently on urban city maps (C), and calculation of available surfaces through Autocad® (D).*

3500 available rooftops
82 ha

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# City vegetables requirements


Public Health Nutrition: 12(12), 2504–2532 doi:10.1017/S1368980009005035

The Italian National Food Consumption Survey INRAN-SCAI 2005–06: main results in terms of food consumption

Catherine Leclercq*, Davide Arcella, Raffaela Piccinelli, Stefania Sette, Cinzia Le Donne and Aida Turrini on behalf of the INRAN-SCAI 2005–06 Study Group†
INRAN, National Research Institute for Food and Nutrition, Via Ardeatina 546, I-00178 Rome, Italy

Submitted 25 January 2008: Accepted 19 December 2008: First published online 12 March 2009

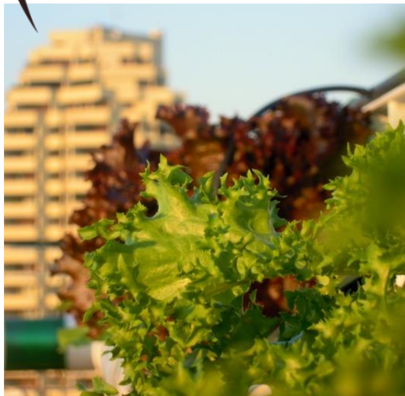
Diet composition was determined based on consumption data (Leclercq et al., 2009).

| Category | Age | Daily intake | Population | Total daily requirement |
|---|---|---|---|---|
| Male infant | 0-3 | 0.019 | 7,970 | 147.45 |
| Female infant | 0-3 | 0.019 | 7,449 | 137.81 |
| Male children | 3-9 | 0.060 | 7,574 | 457.47 |
| Female children | 3-9 | 0.060 | 6,846 | 413.50 |
| Male teenager | 9-18 | 0.091 | 13,843 | 1254.18 |
| Female teenager | 9-18 | 0.085 | 13,044 | 1112.65 |
| Male adult | 18-65 | 0.128 | 112,049 | 14308.66 |
| Female adult | 18-65 | 0.121 | 116,761 | 14081.38 |
| Male elderly | ≥65 | 0.131 | 39,703 | 5189.18 |
| Female elderly | ≥65 | 0.120 | 60,090 | 7198.78 |
| | | | | 44,301.05 |

Daily intake expressed as Kg $d^{-1}$ $person^{-1}$. Total daily requirement expressed as kg $d^{-1}$.

44’301 kg $d^{-1}$

16’169 t $y^{-1}$



# RTGs implementation

41.7 g $m^{-2}$ $d^{-1}$
820’000 $m^2$

34’233 kg $d^{-1}$
12’495 t $y^{-1}$

77% of city needs

# Identification, abundance and migration of aphidophagous Coccinellidae species in cultivated plant species.

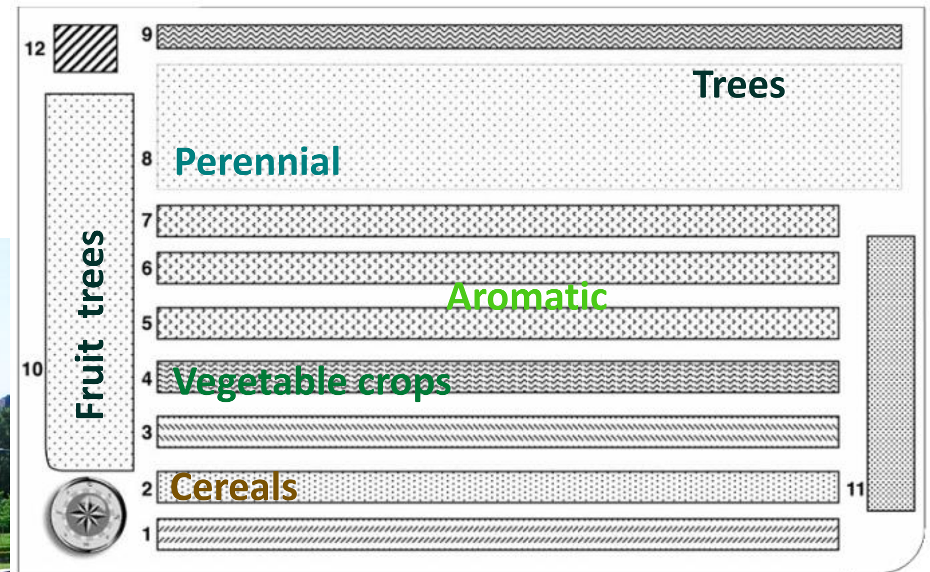
Bazzocchi, G., Frabetti, A., Pennisi, G., Orsini, F., Gianquinto, G.

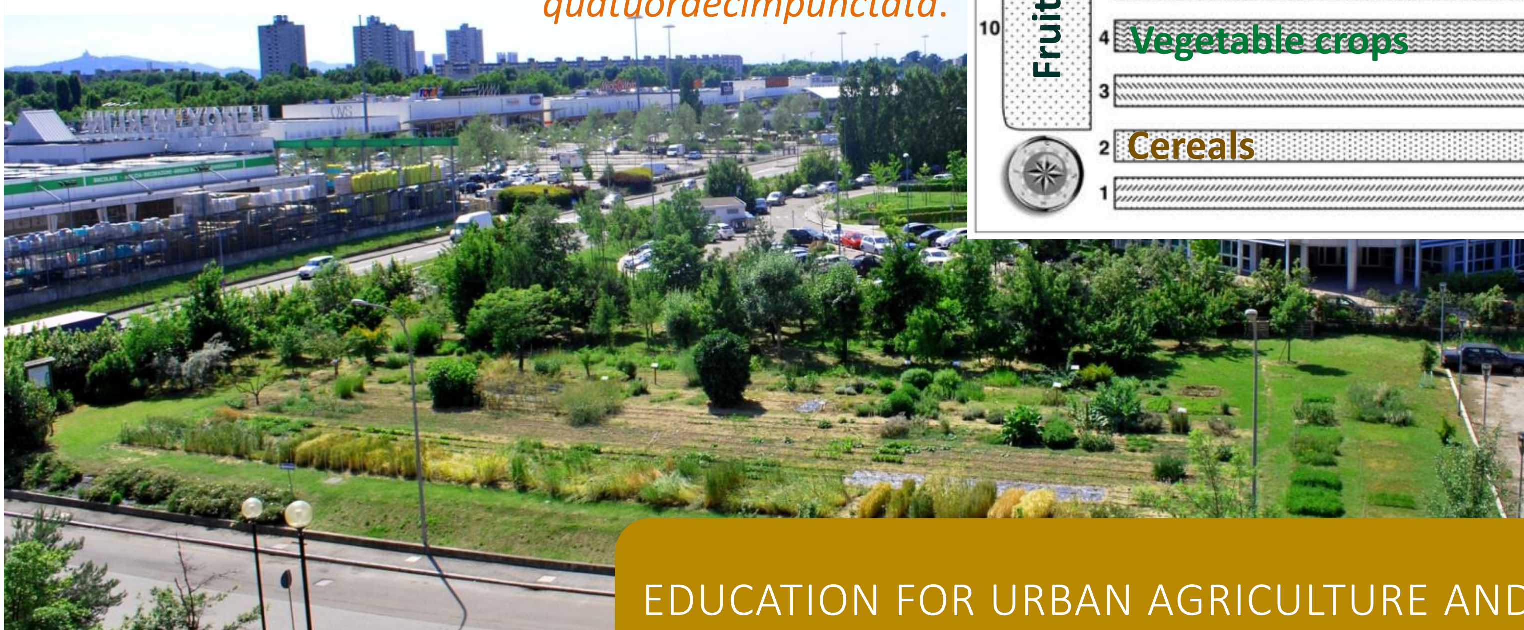


## Materials and Methods

**0.3 ha, 300 plots (3-4m$^2$), 90 trees**

- *Coccinella septempunctata ,*
- *Harmonia axyridis,*
- *Adonia variegata,*
- *Adalia bipunctata,*
- *Propylea quatuordecimpunctata.*



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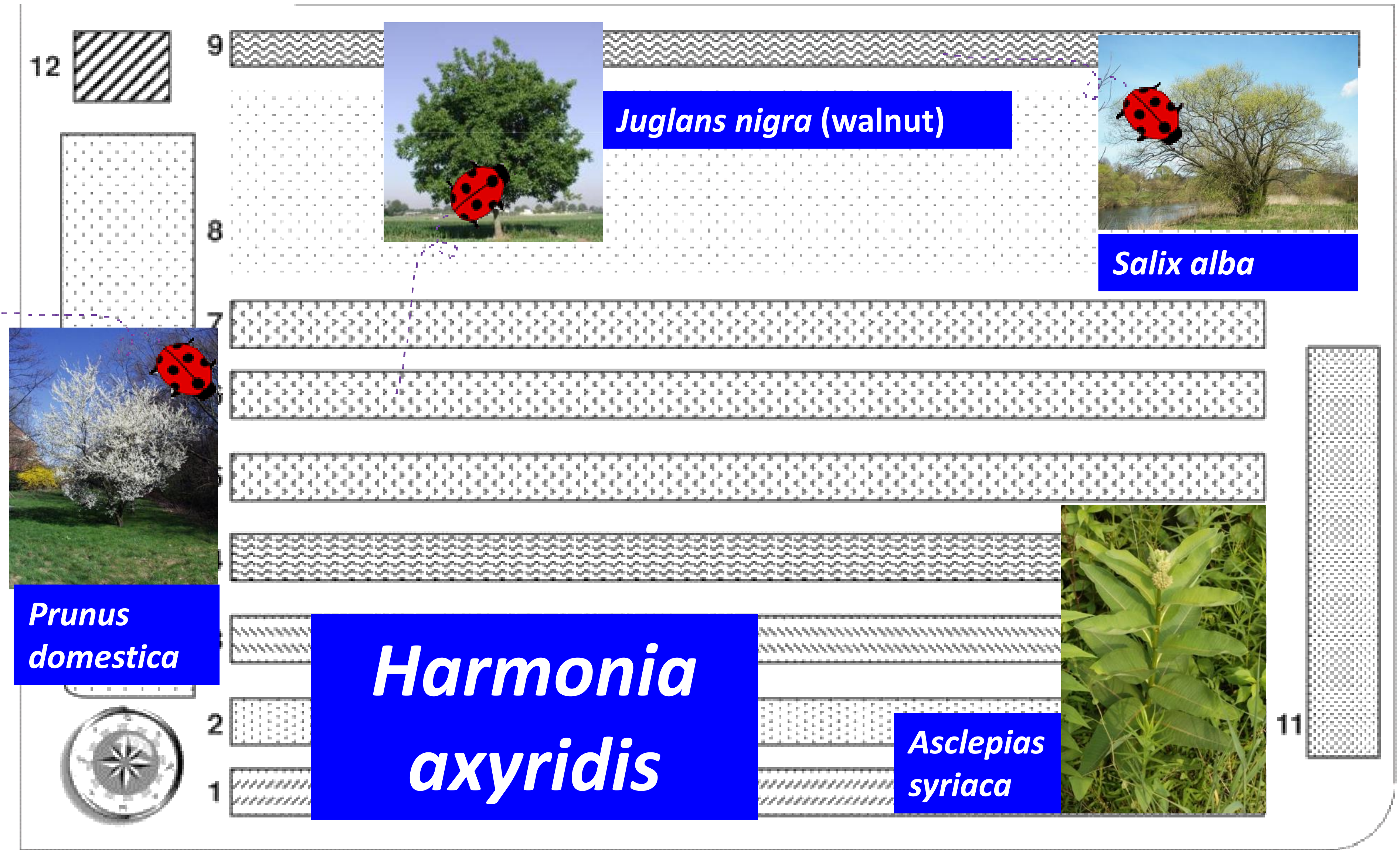
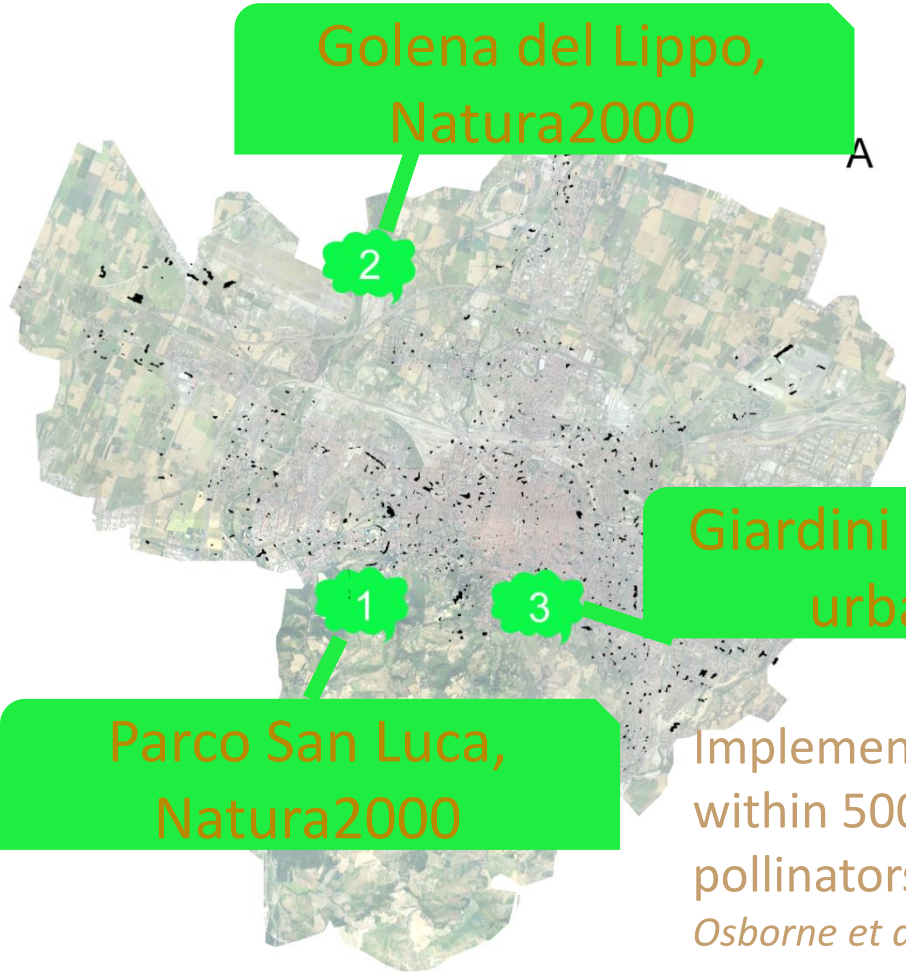
# Identification, abundance and migration of aphidophagous Coccinellidae species in cultivated plant species.

Bazzocchi, G., Frabetti, A., Pennisi, G., Orsini, F., Gianquinto, G.

6th International Conference on Landscape & Urban Horticulture



# RTGs and Green Corridors





94 km
0.67 km km$^{-2}$

Implementation of green corridors by connecting RTGs within 500 m distance (sufficient for most Apoidea pollinators and beneficial predators) *(Gathmann et al. 2002; Osborne et al. 2008; Zurbuchen et al. 2010; Ludgren 2009)*

# $CO_2$ sequestration

Urban vegetable gardens, being intensively cultivated, have generally higher $CO_2$ sequestration potential as compared to former rural areas or other Green Infrastructures *(Zhao et al., 2007)*

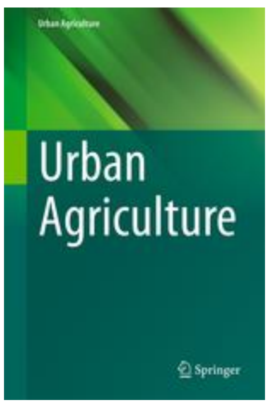
Domestic gardens have been estimated to sequester about 0.76 kg $CO_2$ $m^{-2}$ *(Davies et al., 2011)*

820’000 $m^2$

624.42 t $CO_2$

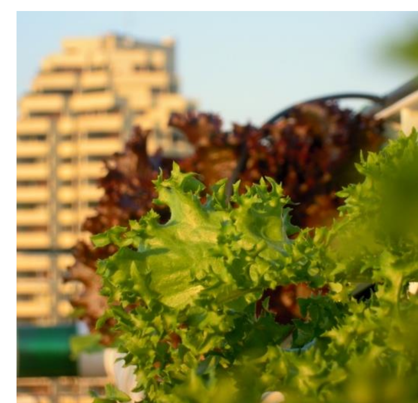
# Conclusions

Growing vegetables in RTGs may be a sustainable solution for improving the city food security, contribute to urban biodiversity and overall reduce the city ecological footprint.




**Orsini F., Dubbeling M., De Zeeuw H., Gianquinto G.** In press. **Rooftop Urban Agriculture.** Springer, The Netherlands.

*Thank you for your kind attention!*



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