Unlocking the potential of municipal solid waste compost for urban and peri-urban agriculture: Nutrient recirculation in metropolitan areas

Juan David Arosemena[1], Susana Toboso-Chavero[1] , Gara Villalba[1,2]

[1] Sostenipra Research Group, Institute of Environmental Science and Technology, Z Building, Universitat Autònoma de Barcelona (UAB), Bellaterra, Barcelona, Spain.

[2] Department of Chemical, Biological and Environmental Engineering, Universitat Autònoma de Barcelona (UAB), Bellaterra, Barcelona, Spain

URBAG Integrated System Analysis of Urban Vegetation and Agriculture

sostenipra Sostenibilitat i Prevenció Ambiental

ICTA Institut de Ciència i Tecnologia Ambientals - UAB

UAB Universitat Autònoma de Barcelona

URBAG Integrated System Analysis of Urban Vegetation and Agriculture

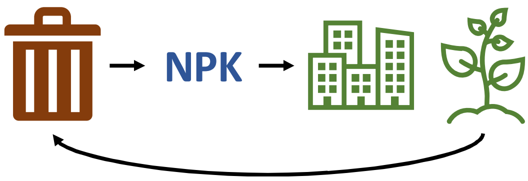
↓

Urban agriculture (UA)

↓

UA + ⟳ = More benefits for the city

(EEA, 2015; Rufí-Salís et al., 2020)



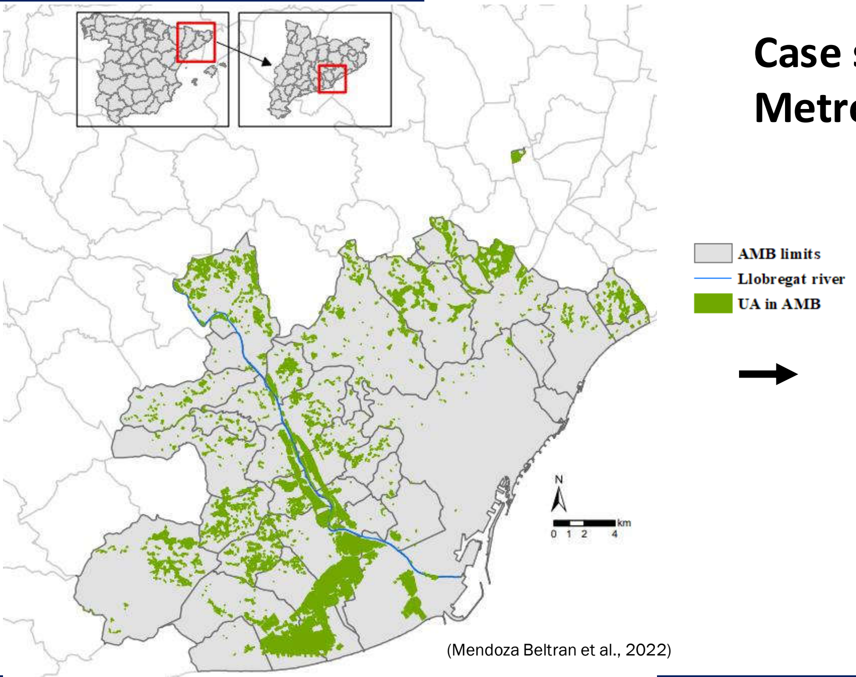
Benefits of (1) OMSW compost as alternative fertilizer and (2) integrating nutrient flows of waste and food systems in cities

(Martínez-Blanco et al., 2009; Tonini et al., 2013; Trimmer and Guest, 2018)

↓

Few have upscale OMSW compost to supply NPK at UA scale and assess it through a circular lens…

1. **What is the of potential of OMSW compost to supply NPK demanded by UA?**
2. **And what are the environmental benefits and trade-offs of replacing mineral fertilizer with OMSW compost while minimizing waste?**



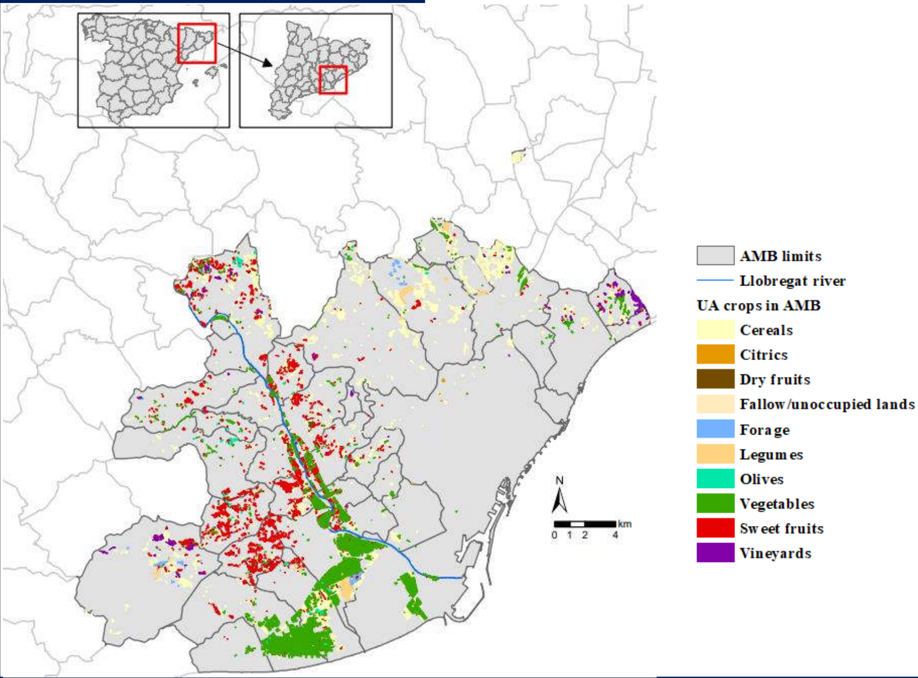
(Mendoza Beltran et al., 2022)

Case study:
Metropolitan Area of Barcelona (AMB)

3.2 million inhabitants (5,093 inhabitants/km^2)

→ **5,568 ha of UA** (2016)

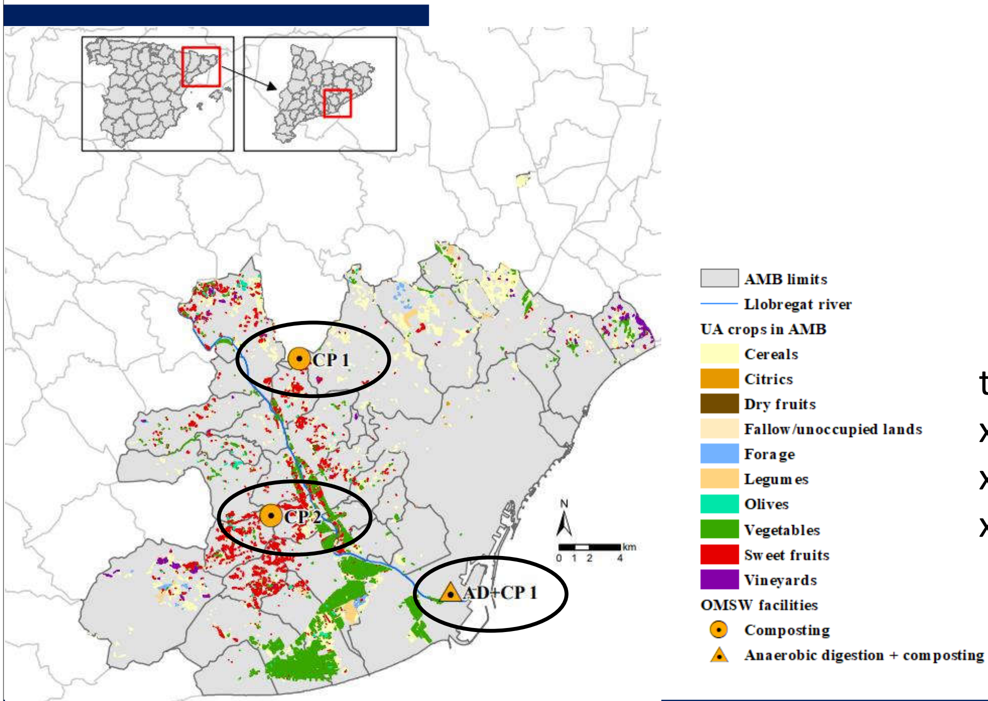
68,800 tonnes of fresh produce a year (2016)



NPK demand in UA? E.g., for N

$$\text{Annual N fertilizer application per crop } (\text{kg N year}^{-1}) = \text{Area of individual crop } (\text{ha year}^{-1}) \times \text{N fertilizer rate per crop } (\text{kg N ha}^{-1})$$

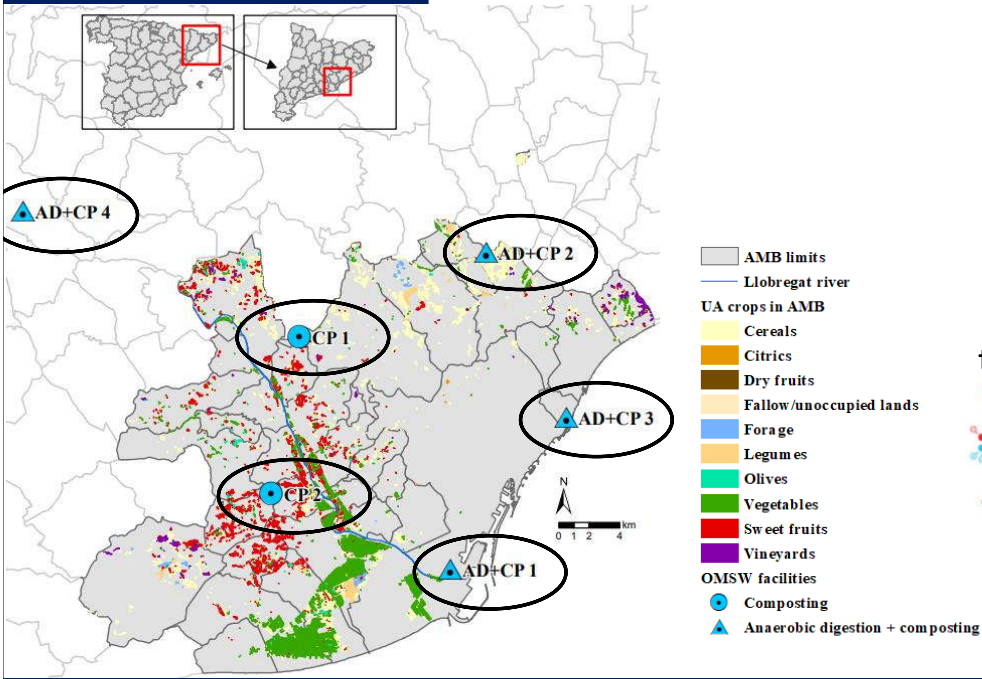
(Adapted from Mendoza Beltran et al., 2022)



NPK supply from OMSW compost?

tonnes of compost produced (2016)
x dry mass content (%)
x NPK content (%)
x assimilation of NPK in soil (%)

CILCA 2023
Viña del Mar, Chile



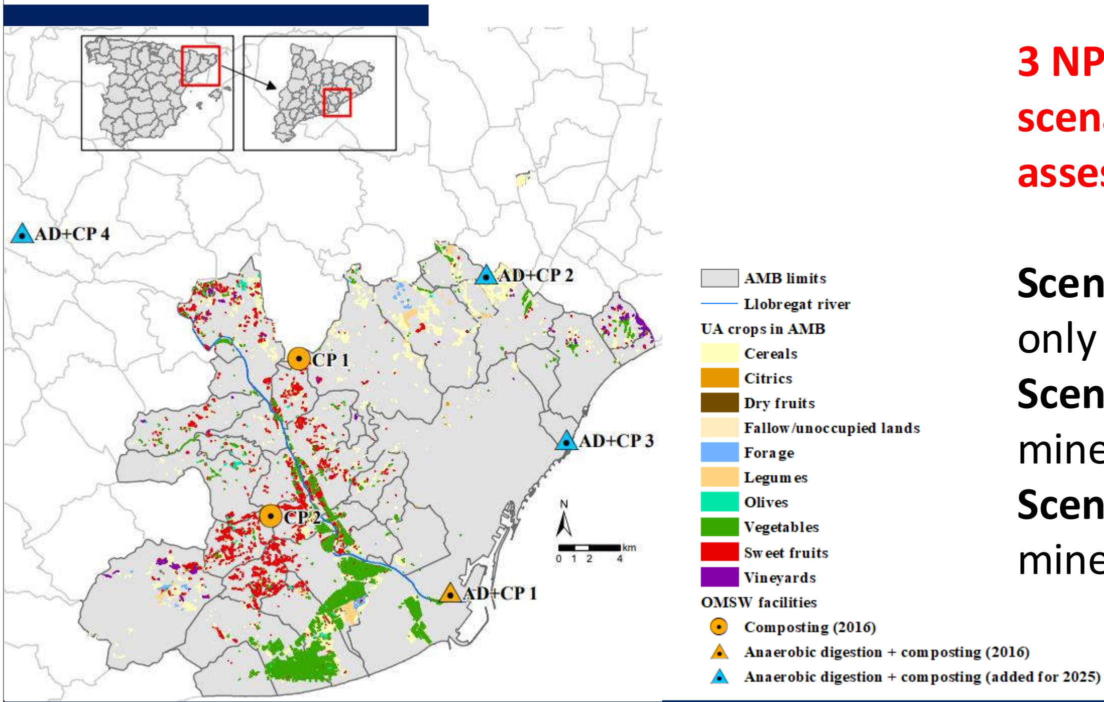
NPK supply from OMSW compost?

tonnes of compost produced (2025)

33 to 55% of selective collection goal

Introduction - Research questions - Methods - Results - Conclusions

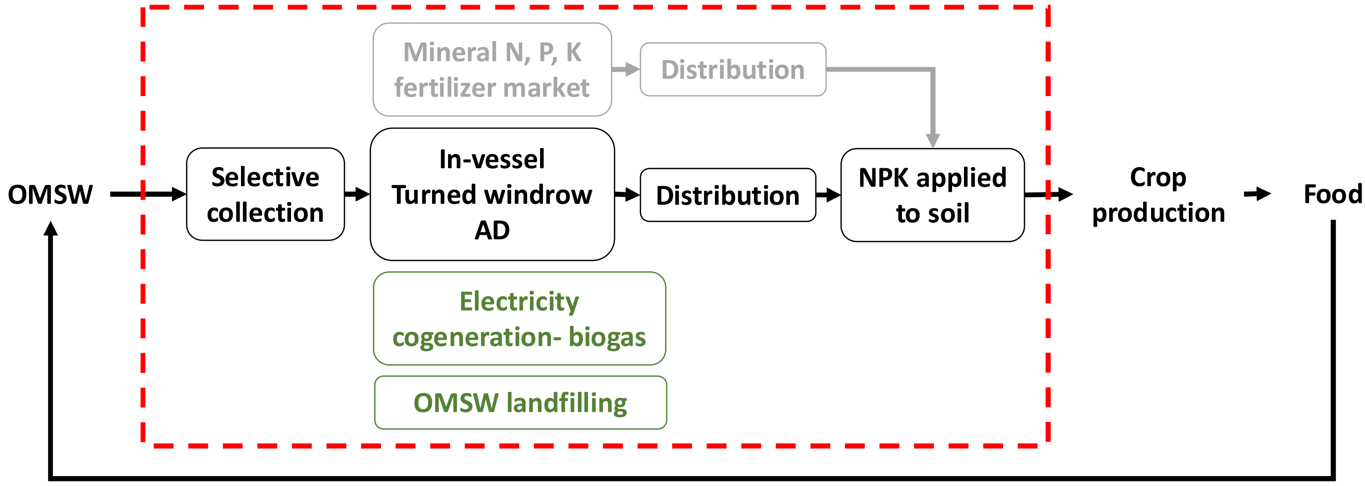
CILCA 2023
Viña del Mar, Chile



3 NPK supply scenarios for UA to assess:

Scenario #1
only mineral NPK
Scenario #2
mineral NPK + 2016
Scenario #3
mineral NPK + 2025

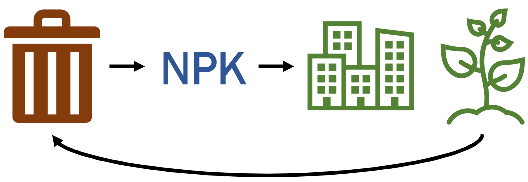
LCA, ISO 14040; **FU: Supply total NPK demand of UA**; SimaPro; Ecoinvent; ReCiPe method (H)



OMSW collection: container, route distance
Composting: water, electricity, direct emissions, refuse
Distribution: distance
Compost NPK to soil: direct emissions

Mineral N, P, K: ES market, distance
Mineral N, P, K to soil: direct emissions (**local N_2O - URBAG**)
Savings: biogas recovery, avoided OMSW treatment

1. **What is the of potential of OMSW compost to supply NPK demanded by UA?**



8% of the total NPK demanded by UA, considering OMSW compost produced in 2016

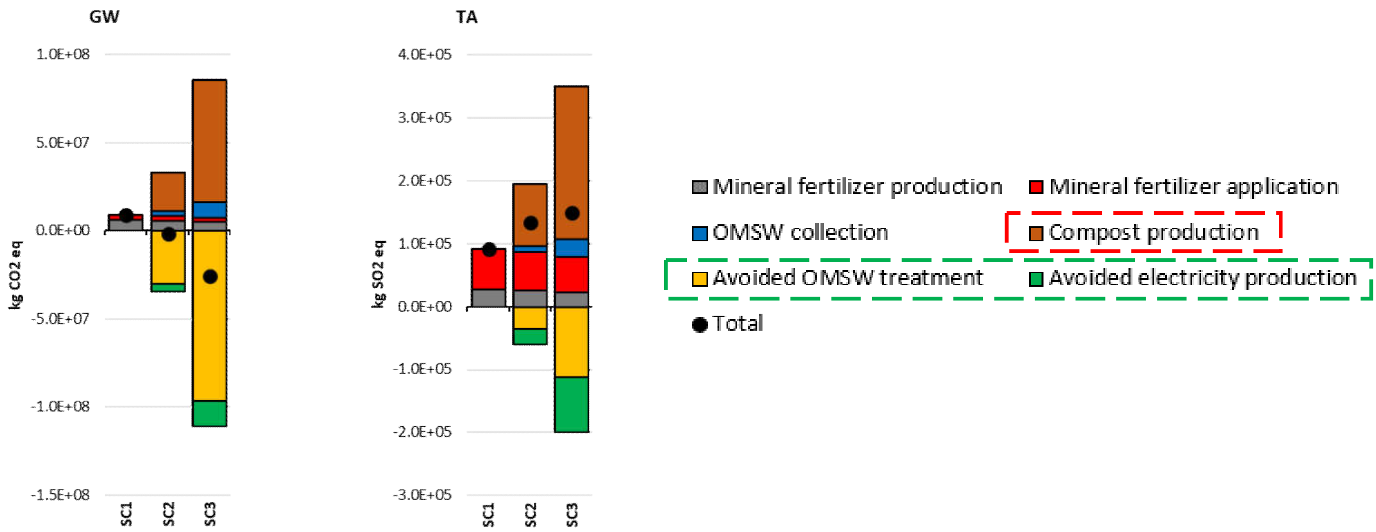
and 21% if compost production increase based on AMB's MSW program goals for 2025

CILCA 2023
Viña del Mar, Chile

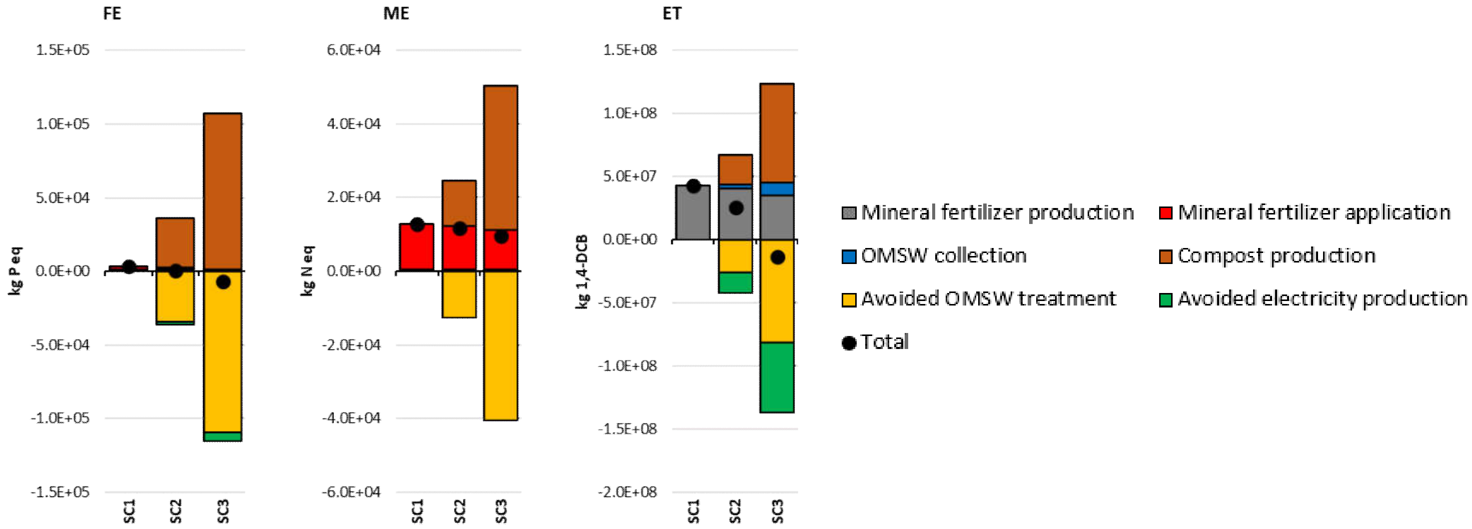
Nutrient supply per scenario					
Scenario	**Nutrient**	**NPK demand (tonnes)**	**Supplied by** OMSW compost (tonnes)	Mineral fertilizer (tonnes)	**NPK supply potential from compost**
Scenario 1	N	769	-	769	-
"only mineral NPK"	P	113	-	113	-
	K	592	-	592	-
	Total NPK	**1,475**	**-**	**1,475**	**-**
Scenario 2	N	769	32	737	4%
"compost NPK 2016 + mineral NPK"	P	113	44	70	38%
	K	592	37	555	6%
	Total NPK	**1,475**	**113**	**1,361**	**8%**
Scenario 3	N	769	95	675	12%
"compost NPK 2025 + mineral NPK"	P	113	113	1	99%
	K	592	99	493	17%
	Total NPK	**1,475**	**306**	**1,168**	**21%**

CILCA 2023
Viña del Mar, Chile

2. What are the environmental benefits and trade-offs of replacing mineral fertilizer with OMSW compost while minimizing waste?



2. What are the environmental benefits and trade-offs of replacing mineral fertilizer with OMSW compost while minimizing waste?



PROS:

1. OMSW compost have (some) potential to supply N, P, and K demanded at UA scale
2. Composting of OMSW provides benefits in GW, FE and ET
3. Useful to inform about benefits of nutrient circularity considering entire life cycle in the city
4. No, we don't need more compost. We need to take advantage of the direct and indirect benefits of closing the loop between 2 systems (MSW + UA)

CONS:

1. OMSW compost is not the best alternative to replace mineral N fertilizer
2. Composting in open facilities and refuse is still impactful. Aside from prevention, gaseous treatment and selective collection is critical
3. Practice is not easy. Barriers exist preventing nutrient circularity in UA, disconnection between systems

Thank you!

JuanDavid.Arosemena@uab.cat
PhD student
URBAG https://urbag.eu/

URBAG Integrated System Analysis of Urban Vegetation and Agriculture
sostenipra Sostenibilitat i Prevenció Ambiental
ICTA Institut de Ciència i Tecnologia Ambientals-UAB
UAB Universitat Autònoma de Barcelona