Spatial configurations of urban waste management systems considering local uses of recovered products

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Spatial implications of a circular economy

Linear economy		Circular economy
Centralization	→	Decentralization
Economies of scale		Short distribution chains
Outsourcing of urban metabolisms		Relocation strategies

→ « eco-cyclic metabolisms » (Coutard, 2010), « fragmented urban services » (Bahers et Durand, 2017)

Spatial implications of a circular economy

→ The spatial implications of this reorganization are not well defined and a wide range of configurations can be considered (case of municipal waste management)

Centralized infrastructure

Micro-networks, local loops

Highly decentralized infrastructure

How to plan for these multiscale systems from an environmental perspective ?

Spatial drivers of MSW management environmental impact

Waste generation rate

- In kg/m2.yr or kg/cap.yr
- Depends on a myriad of socio-economic factors
- Can be source of environmental benefits or pressure

[D'Alisa et al. 2012 ; Tanguy et al., 2017]

Transportation distances during collection

- In km
- The most studied in environmental studies (LCAs)
- Usually adressed via comparative analyses (centralized vs decentralized scenarios)

[Bernstad and la Cour Jansen, 2011, Zeller et al., 2020]

Another important driver…

Uses and materials / energy substituted

- Usually not analyzed through a spatial perspective

[Laurent et al., 2014]

Research objectives

Influence of local uses on spatial configurations

For a given treatment technology and territory, the objectives are:

- To spatialize local uses of recovered products
- To assess their influence on the spatialized environmental performance of MSW management systems
- Ultimately, to identify territorial units (districts) where a technology should be implemented, at a certain scale (multi-districts, within a district or other finer scales).

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Spatialized environmental performance

For each territorial unit A, calculation of a **recovery potential P_A** associated to one recovery scenario *(collection, treatment, upgrading (if needed), substitution, transport)*

$$P_A = 1 - \frac{Net\ avoided\ impact_{tot-A}}{Net\ avoided\ impact_{tot}}$$

Based on the work of Tanguy et al., 2017

$P_A > 0$ Territorial unit A is favorable to the scenario

$P_A < 0$ Territorial unit A should be managed differently (other collection scheme, decentralization, other treatment etc.)

Indicators from ReCiPe 2016 Midpoint (H)

- *Climate change (GWP100)*
- *Human toxicity*
- *Terrestrial acidification*
- *Freshwater eutrophication*

Methodology

Integration of local uses

For each territorial unit A, calculation of a **recovery potential P_A** associated to one recovery scenario *(collection, treatment, upgrading (if needed), substitution, transport)*

$$P_A = 1 - \frac{Net\ avoided\ impact_{tot-A}}{Net\ avoided\ impact_{tot}}$$

Proportional to the amount of waste sent to the treatment site

OR

Proportional to the amount of recovered products that can be used within the district

Case 1

Case 2

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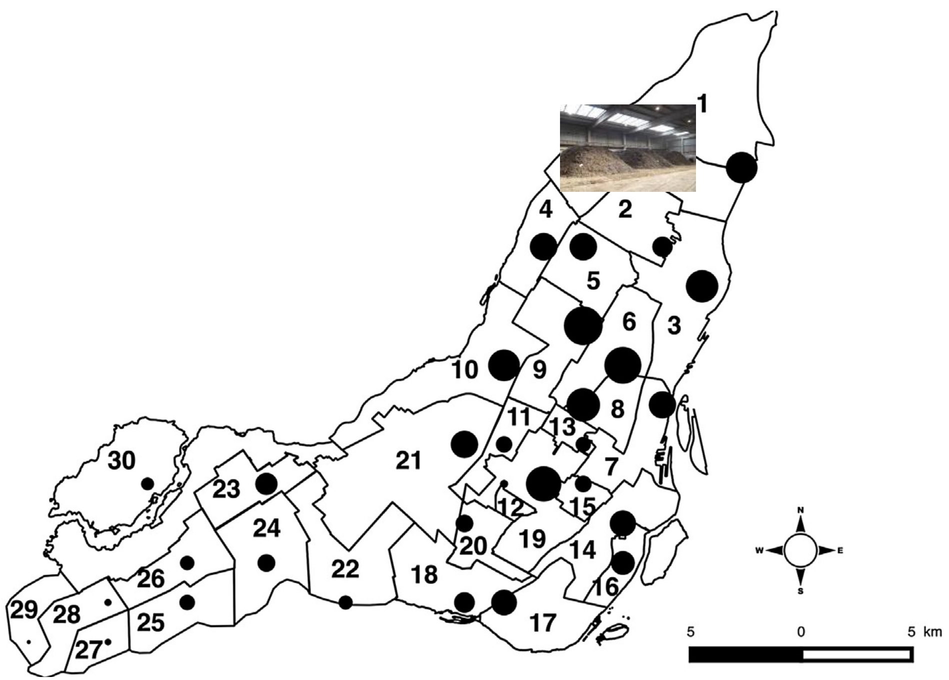
Methodology

Case study: food and green waste management



Montreal's island

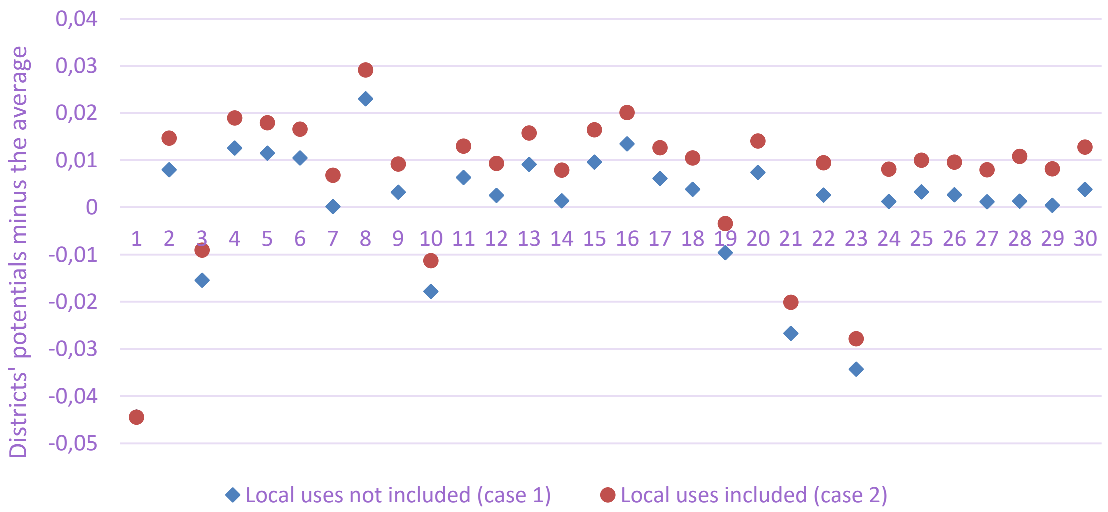
- 30 districts
- About 135 kt/yr of organic waste generated
- 56% food waste and 44% green waste

Scenario studied

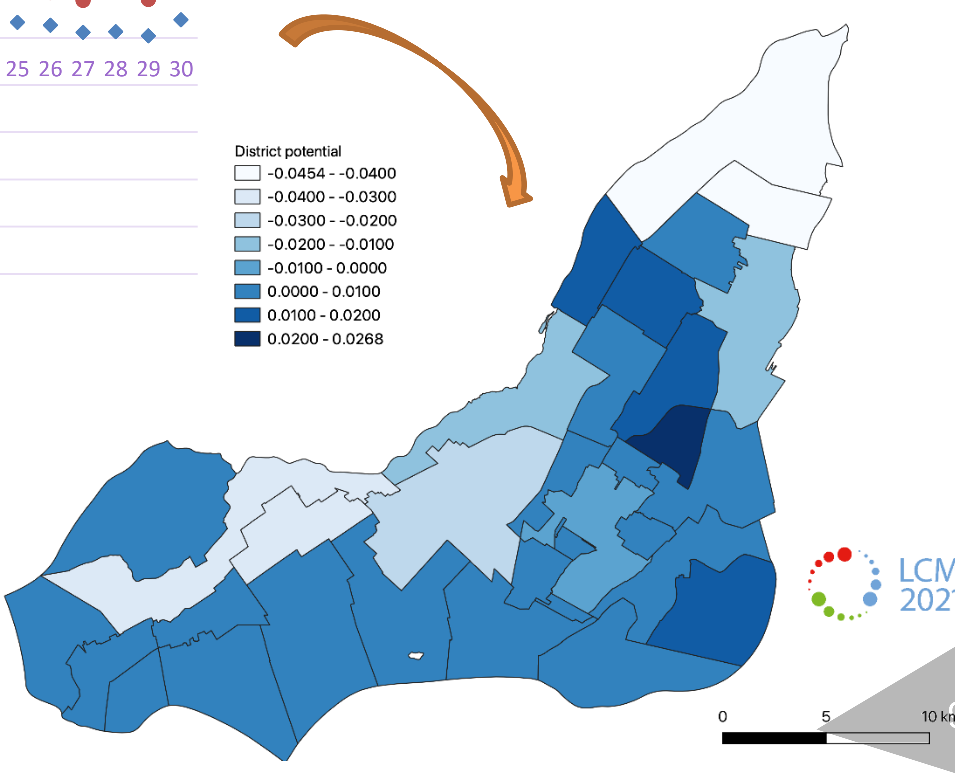
- 1 centralized industrial composting (closed building tunnel facility)
- Separate collection (FW+GW combined)
- 6778 km travelled at each round
- Potential local uses estimated based on areas of public gardens and parks, agricultural zones, community gardens and residential lawns
- 44% of compost is exported, 40% used in municipal activities, 8% for agriculture and 8% go to residents

Results

Recovery potentials (climate change) for cases 1 & 2



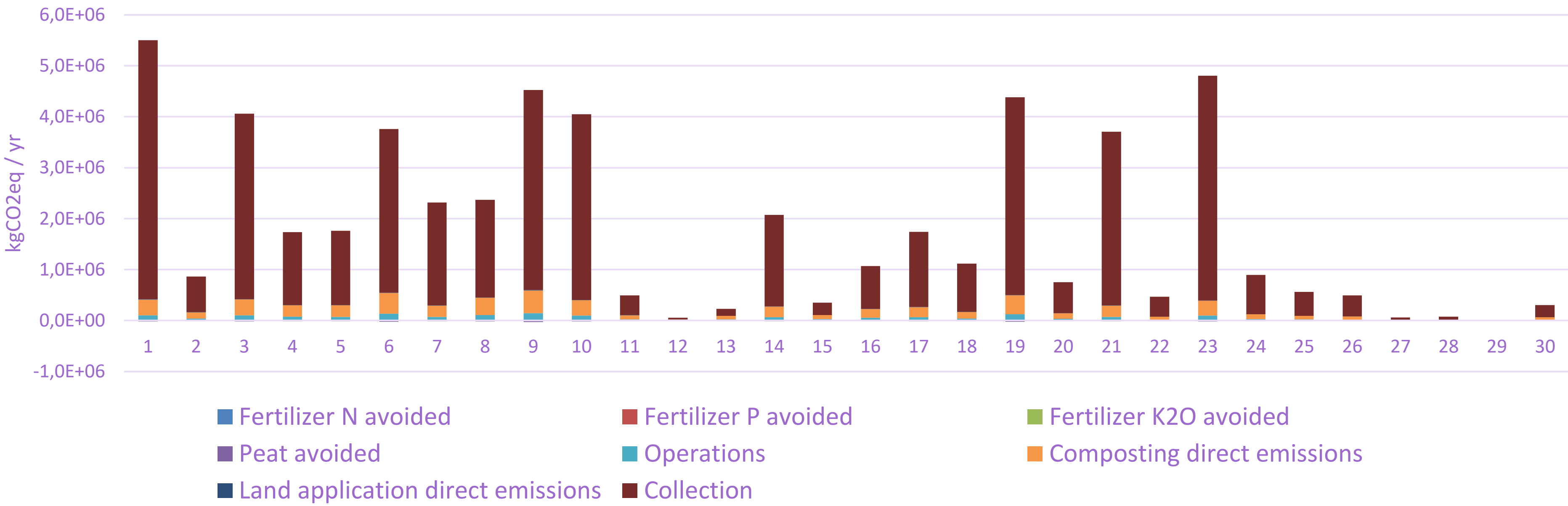
The relative order of potentials does not differ between cases 1 & 2



- Integrating local uses do not influence the environmental significance of a district to the centralized composting scenario
- Same trends for human toxicity and terrestrial acidification

Results

Impact contribution of each phase (climate change) for case 1 (without local uses)



- Impact is dominated by the collection phase (for most districts but not all)
- For low-potential districts, actions related to collection should be prioritized to increase their potential : scheduling optimization, decarbonation, highly decentralized systems etc.

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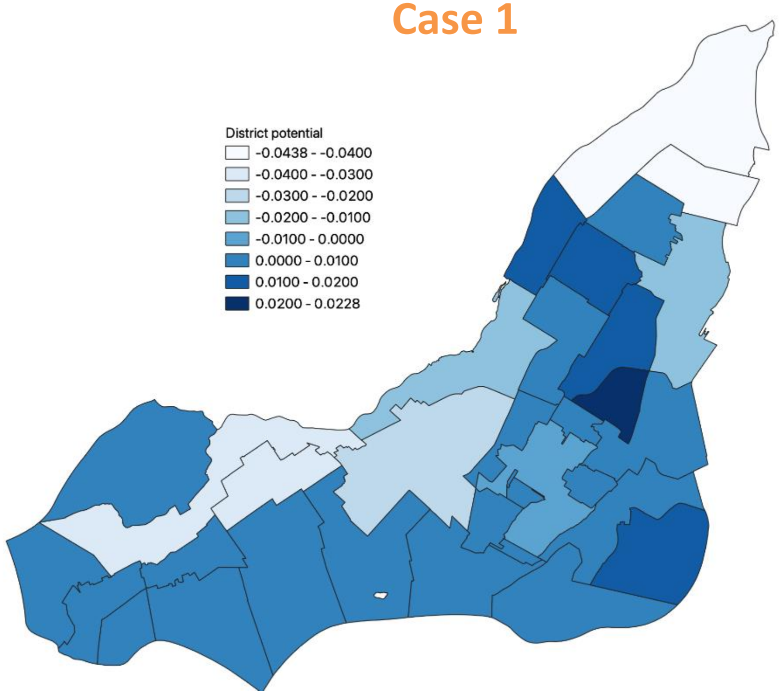
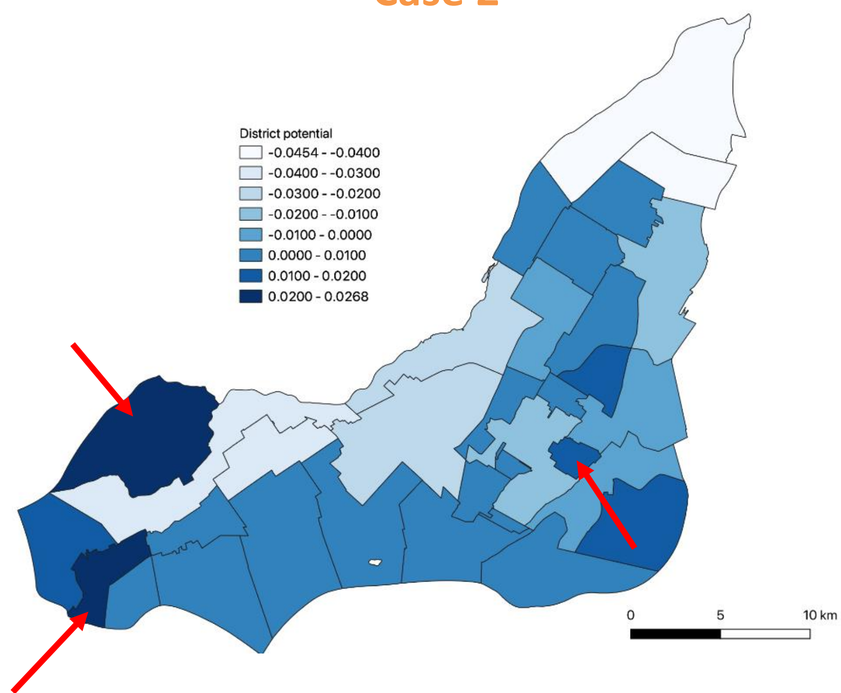
Recovery potentials (FW eutrophication) for cases 1 & 2

Case 1



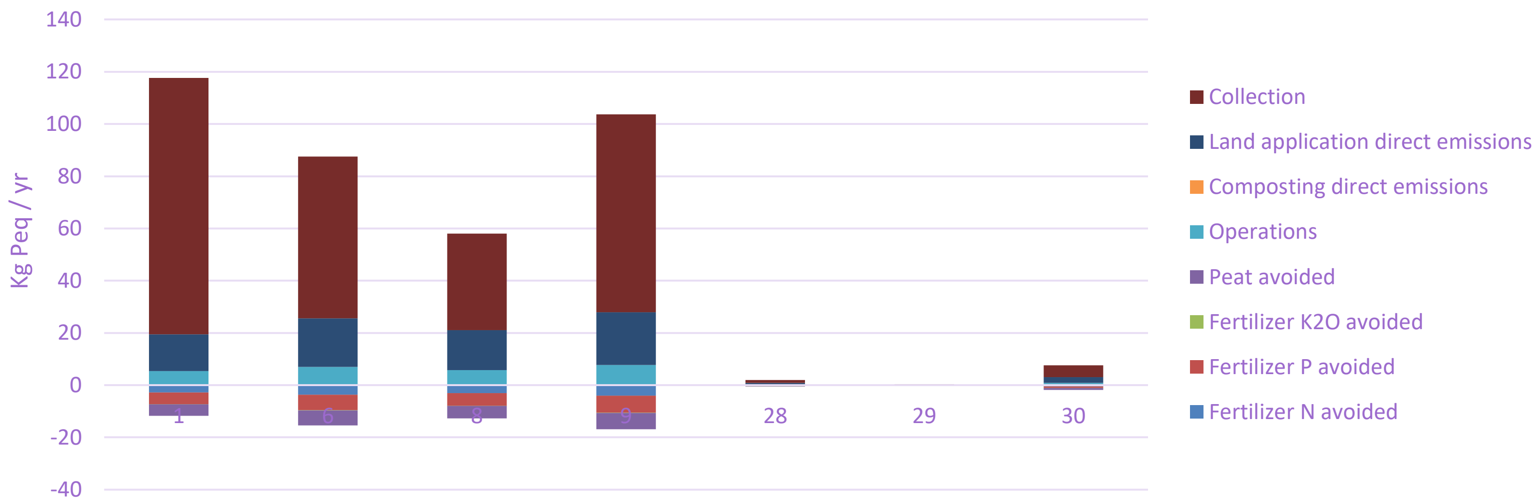
Case 2



- Integrating local uses increases the recovery potential of 3 districts
- Promoting and organizing compost uses in these districts seem to be a promising lever for the composting recovery scenario

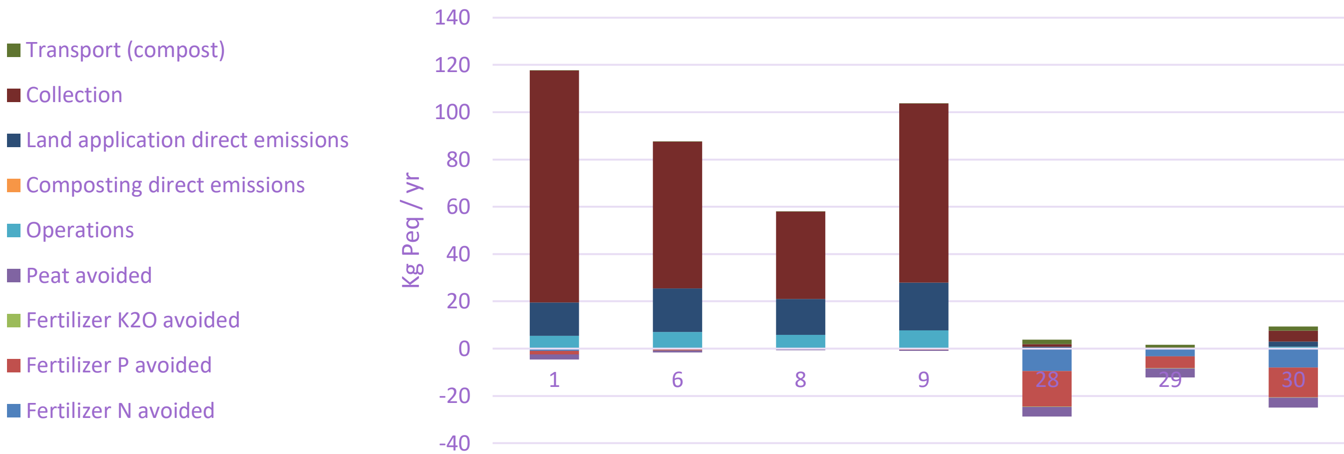
Results

Impact contribution of each phase (FW eutrophication)



Case 1

Case 2



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Conclusions

Do we need spatialized local uses of recovered products?

- Do specific local uses influence the environmental performance, and ultimately, the spatial planning of MSW management systems ? … it depends !
  - On the indicator
  - On the district
  - On the treatment technology (not assessed here)

- Proposed an approach to plan multiscale systems in a systemic manner and design a diversity of strategies relevant for each territorial unit:
  - Collection optimization and/or decentralization
  - Fostering uses of recovered products

- Other factors influence the spatial planning of MSW management systems:
  - Political agenda and organization
  - Reluctance towards uses of recovered products (quantitative and qualitative data are lacking)

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Thanks

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