



Using the urban metabolism concept to evaluate and valorise urban biowaste

Hans Langeveld (Research4Life)

Foluke Quist-Wessel (Research4Life)

Asher Lazarus (Research4Life)

Miguel Ángel Suárez (CETENMA)

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The HOOP project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°101000836

Evaluating and improving circular bioeconomy in cities
and regions webinar – 21 May 2024

Contents

- Municipal Solid Waste (MSW)
- Inventory and valorisation
- HOOP project activities
 - Identify waste streams
 - Treatment options
 - New production routes
- Relevance and impact
- Conclusion



Municipal Solid Waste

- Urbanisation
 - >50% of the population living in cities
 - Amount of waste increases
 - Share of (non-)degradables
- Policy targets relate to reduction of waste volumes, and enhanced recycling.
- Urban, regional and national strategies are intertwined, linking health and safety issues with economic and environmental targets.



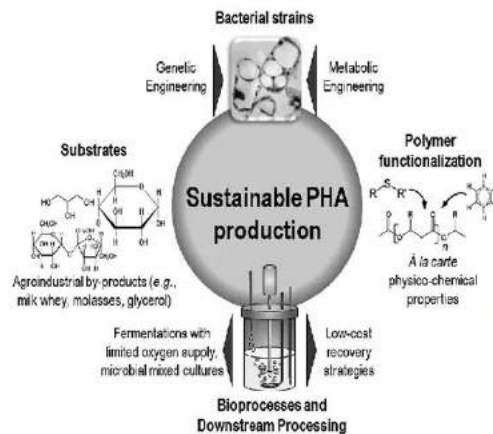
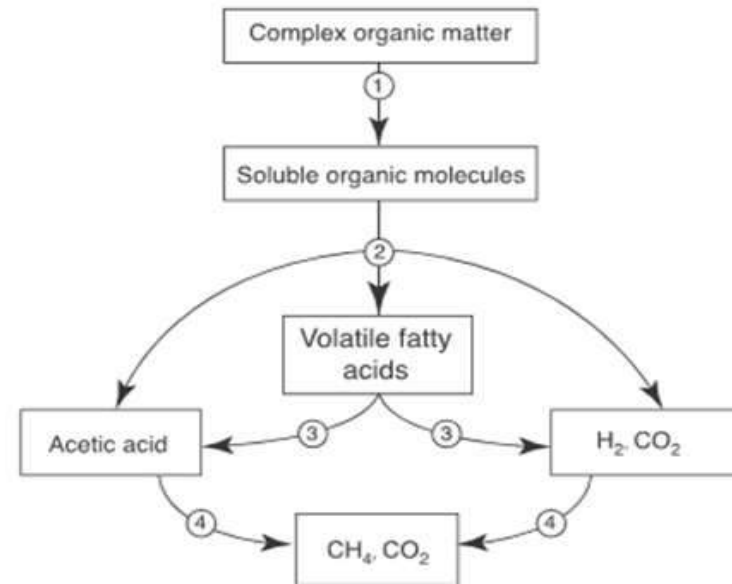
Addressing MSW issues

- Hierarchy in waste management
 - Prevent, Re-use, Recycle, Recover and, Dispose
- Direct and indirect recycling
- Collection system design
 - Separate at source – or not
 - Public and private collection
 - Drop-off points
 - Park and garden waste



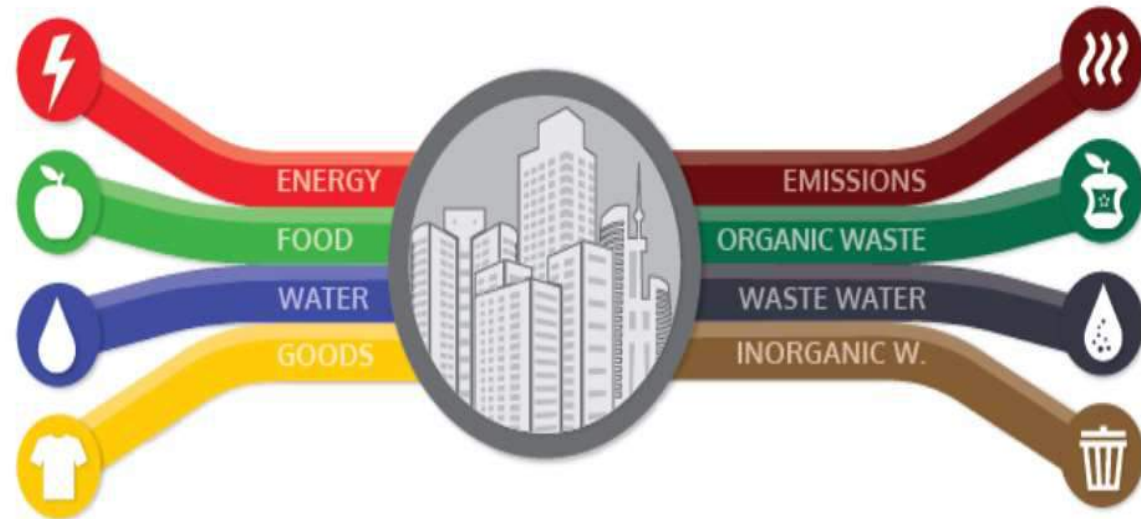
Valorisation

- Mixed waste: OFMSW, non-organic fraction
- Processing and treatment routes
 - Compost and Anaerobic Digestion (AD)
 - Wastewater treatment => Sewage sludge
 - Generation of bioplastics, biomaterials and dedicated outputs
- Interactive process
 - Development of business models
 - Stakeholder mobilisation



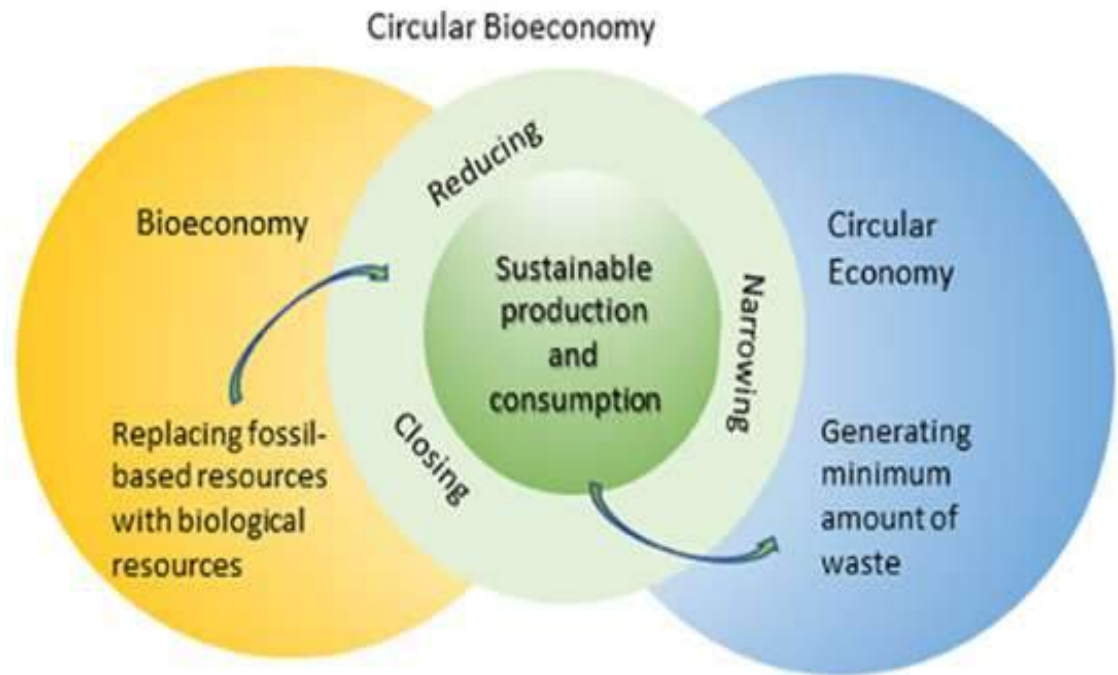
Urban metabolism

- Urban Metabolism, is defined by Kennedy et al. (2007) as: **"the sum total of the technical and socio-economic process that occur in cities, resulting in growth, production of energy and elimination of waste."**
- Urban Metabolism provides insights into the changing metabolism of cities
- Material flows can be evaluated at a generic (consideration all) or partial level, at different scales



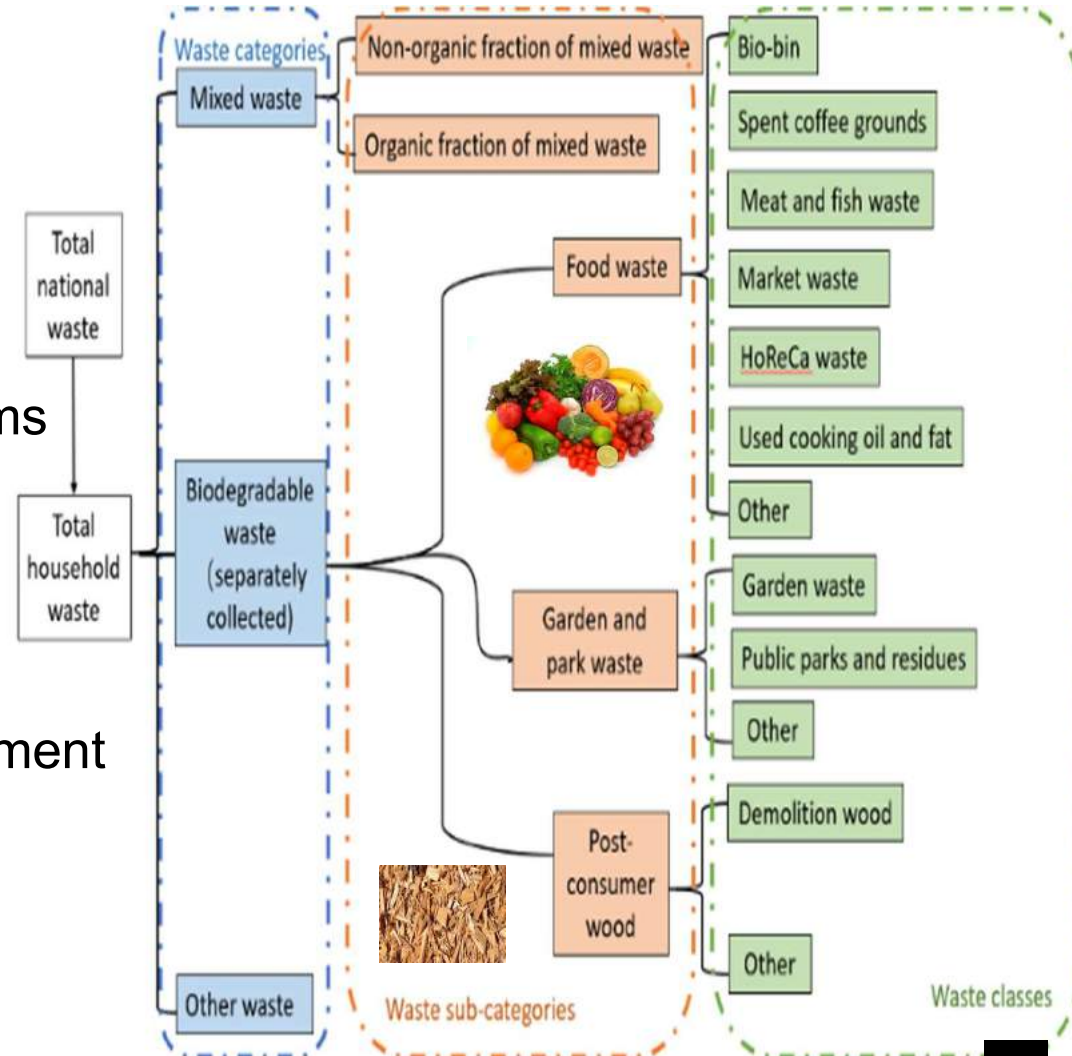
Circular economy

- In the Circular economy bioproducts are returned to the economic loop instead of ending in a landfill.
- Waste streams from renewable bio-resources are used as resources for the technosphere.



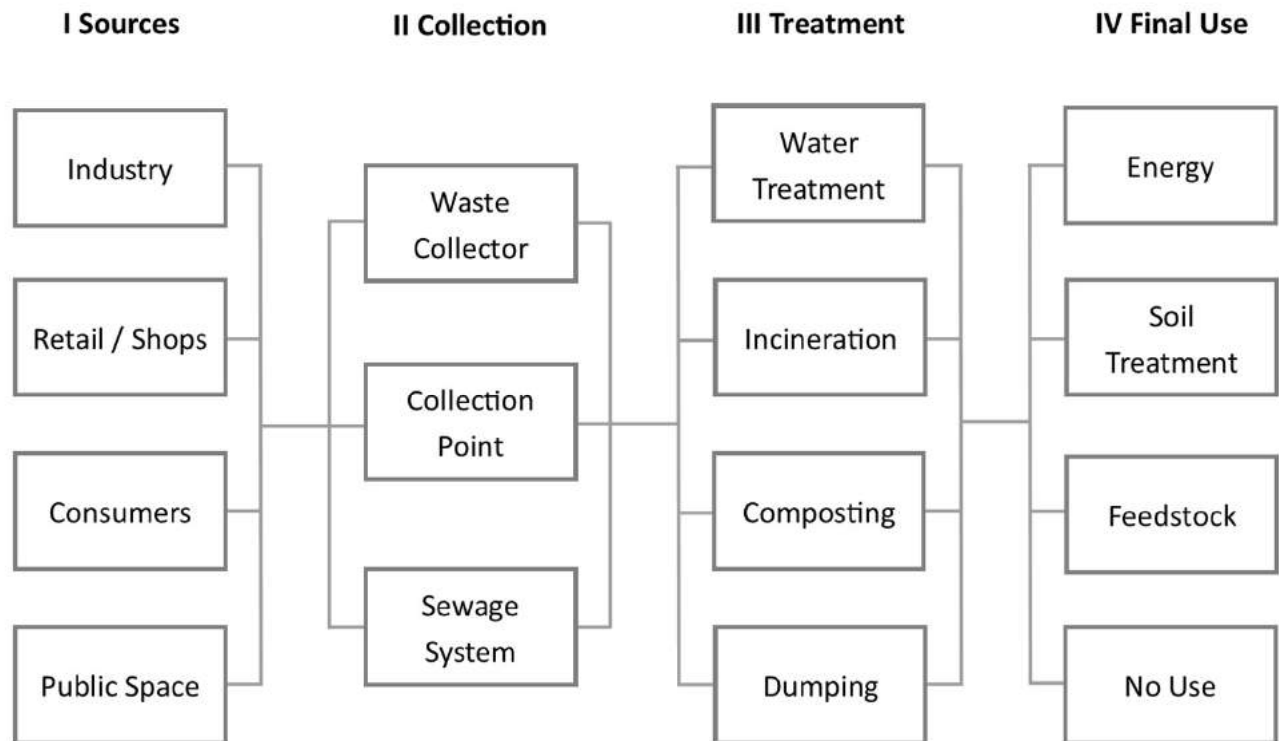
Waste streams

- Mixed waste
 - Organic Fraction (% of MSW)
 - Non-organic fraction
- Dedicated biodegradable waste streams
 - Food waste
 - Garden and park waste
 - Post-consumer wood
- Other municipal waste
- Sewage sludge from wastewater treatment



Structure of waste streams in HOOP project

- **Sources**
- **Collection process**
- **Treatment / conversion**
- **Recycling, use**





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Urban metabolism

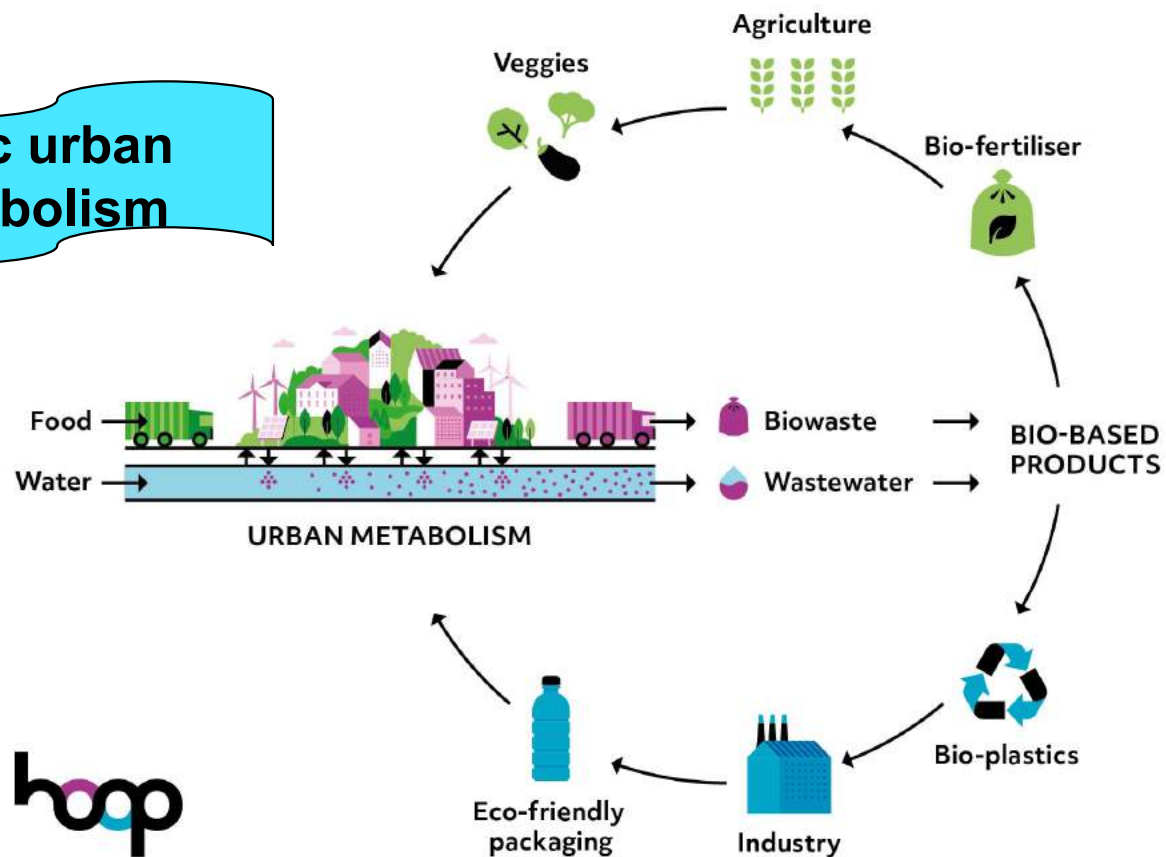


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Urban metabolism

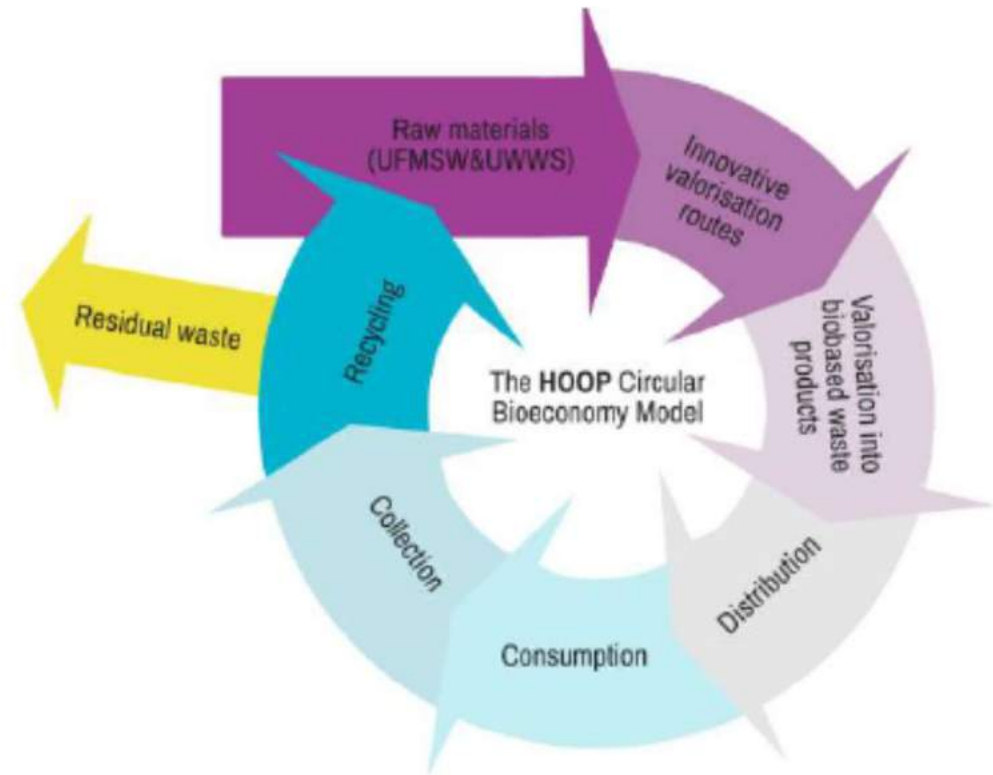
- Concept
 - Analytical instrument
 - Implementation and use
- Streams
 - Food
 - Garden and parks
 - Wood
 - Water
 - (Energy)
- Performance and targets
 - Sankey diagrams
 - Indicators

Basic urban metabolism



Analysis of lighthouse cities and regions

- Type of biowaste / sources
- Legal status
- Quality / composition
- Location and distribution
- Price or cost
- Current use
- Collection process
- Treatment and conversion options
- Final destination



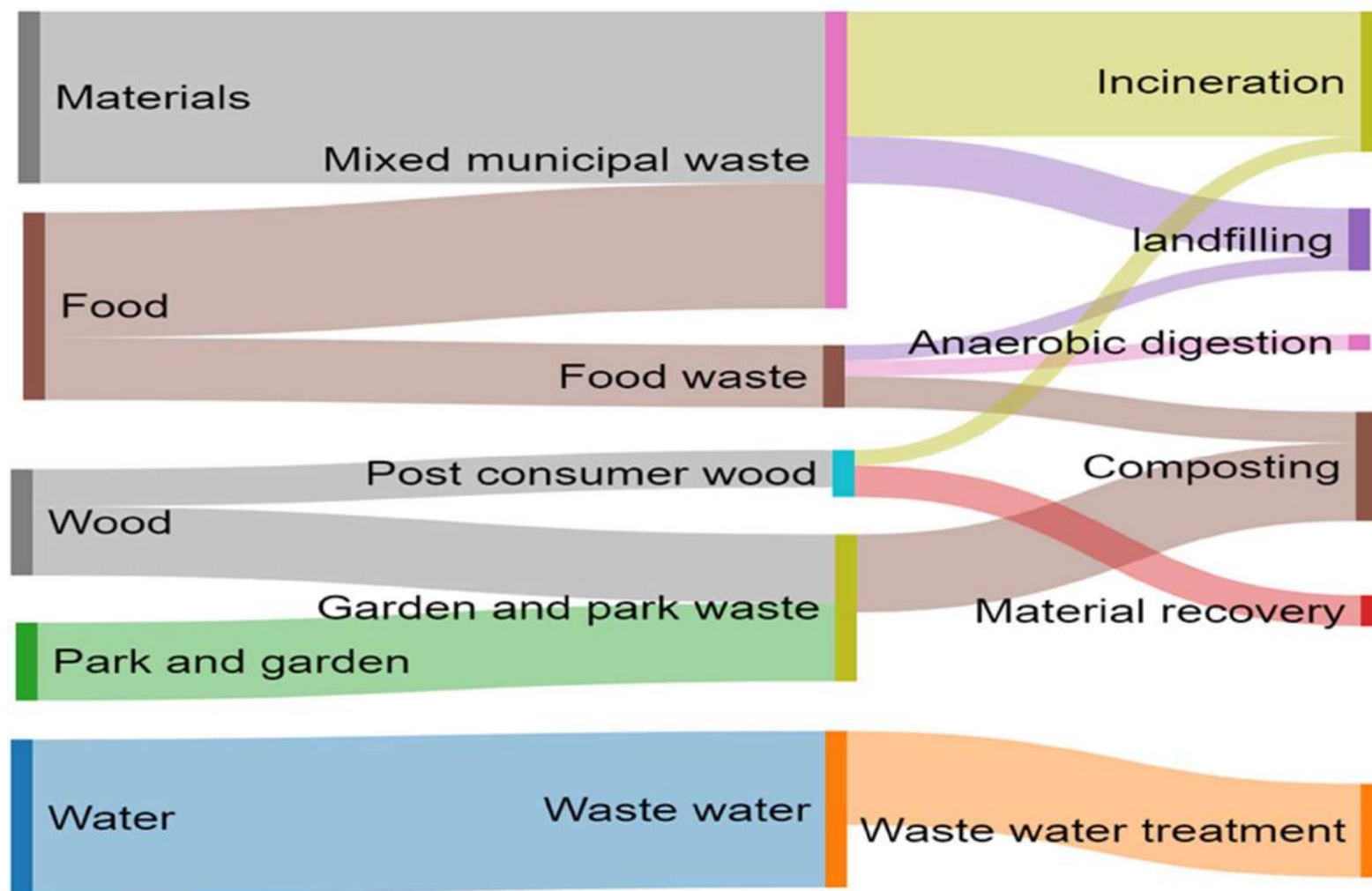
Parameters for a basic urban metabolism

Layer	Description	Source
Layer 1: Context	Examine context of the city: spatial boundaries, constituent cities, population, economy	Maps, national and urban statistics
Layer 2: Biophysical characteristics	Land area, urbanized area, climate, and gross floor area built	Maps, literature, statistics

Parameters for a basic urban metabolism

Layer	Description	Source
Layer 3: Resource metabolism	Consumption of water, food, energy and materials, waste generation during processing and consumption	National and urban statistics
Layer 4: Ownership	Distributors and suppliers of resources (water, energy), stakeholders in collection, consumption and treatment of resources and waste streams	National and urban statistics
Layer 5: Policies	Overview of policies that shape the direction of resource flows	Literature

Sankey-diagram





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Results

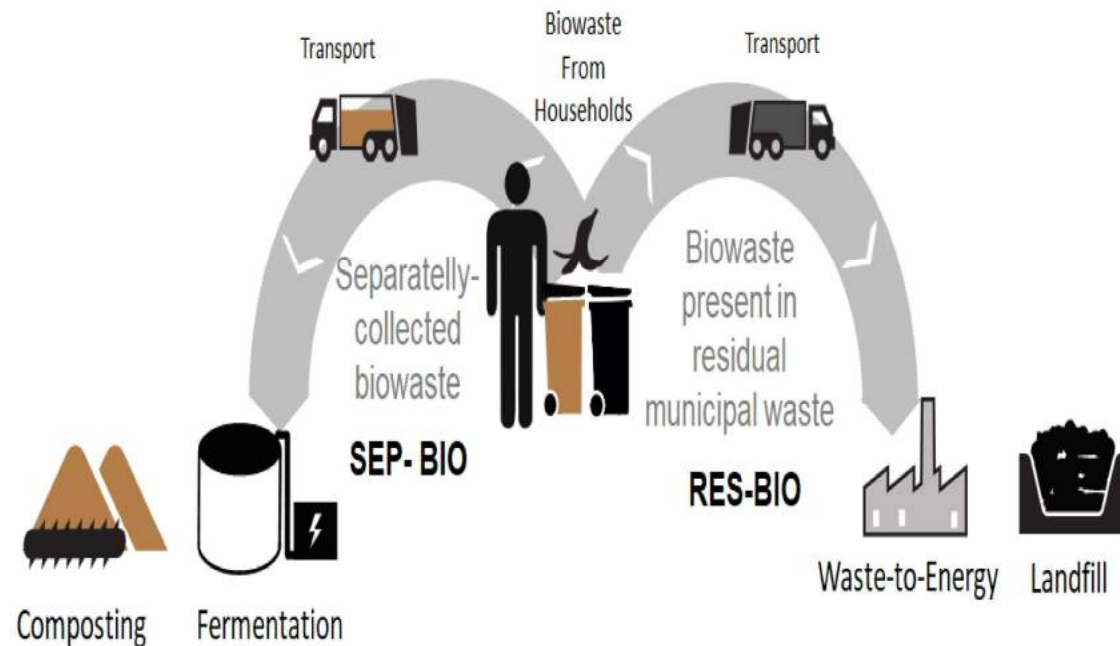


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General outputs

Biowaste treatment in eight HOOP lighthouse cities and regions

- Most biowaste in HOOP lighthouse cities and regions is ending in **mixed municipal waste plus separate biowaste collection**.
- Nearly half of biowaste is **composted**.
- Anaerobic Digestion with or without composting is gaining importance.
- **No landfill** of biowaste.



Anaerobic digestion and compost,

- In eight HOOP lighthouse cities and regions, most of anaerobic digestion and some of composted is generated from mixed municipal waste, food waste, garden and park waste and biowaste.
- Nearly half of selectively collected food waste (SC) is directly composted.



Foodwaste

A quarter of food available to lighthouse cities and regions is food waste.



Woodwaste

Separate collection of post-consumer wood is also remarkable.



Biogas potential (Kenya)

- Primary, secondary, tertiary resources
- High availability
- Industry and urban waste
- High biogas potential

Resource	VS (% of dry matter)	VS (% of fresh)	Methane yield (m ³ per ton of VS)	Methane yield (million m ³ per year)
Primary				
Maize stover	97	90	288	982
Banana stems	4	0,2	13	0.05
Cattle manure	82	9	192	595
Chicken manure	75	19	277	2.184
Pig manure	86	20	355	781
Secondary				
Sisal pulp	82	10	330	20
Coffee pulp	91	50	244	67
Slaughterhouse waste	80	12	560	4
Sugar filter cake	97	24	262	12
Tertiary				
Fruit waste	80	51	516	403
Cereal waste	93	91	265	526
Vegetables, oils	78	10	425	59
MSW (Nairobi)	92	18	260	47
Total				5,700



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Langeveld et al. (2023) EUBCE

Wastewater

- Most biowaste in HOOP lighthouse cities and regions is ending in mixed municipal waste plus separate biowaste collection.
- A significant portion of the wastewater is treated.
- Most sewage sludge (UWWS) is recovered from treatment plants. This is often fed to AD or composting facilities.



Biowaste in mixed municipal waste streams



Dashboard of biowaste in mixed municipal waste as share of total municipal biowaste in three cities.



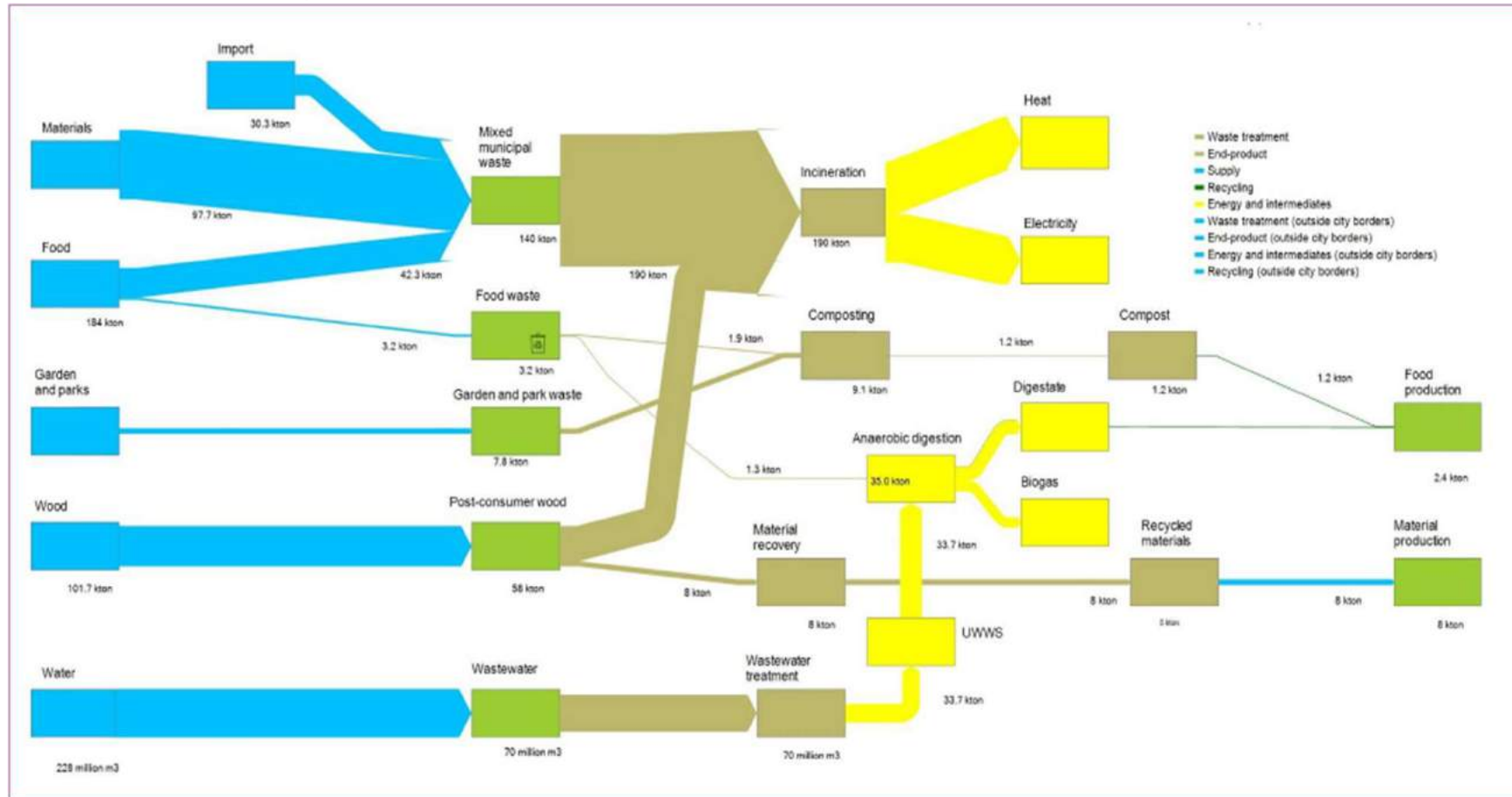
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Relevance and impact



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Example: high treatment rate



Soil Organic Matter – sequestration

- SOM concentrations vary
 - Depend on moisture, temperature and supply
- Depletion is estimated at 2% loss per year
- Increasing organic carbon
 - Carbon sequestration
 - Soil structure and water holding capacity
 - Depending on soil texture
 - Climate adaptation

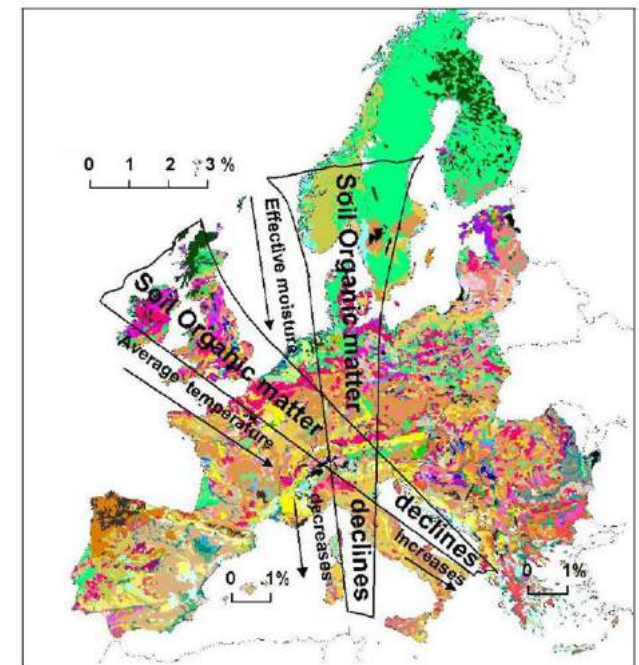


Figure 1 Influence of temperature and moisture on soil organic matter content in Europe

Soil erosion

Erosion is a major problem

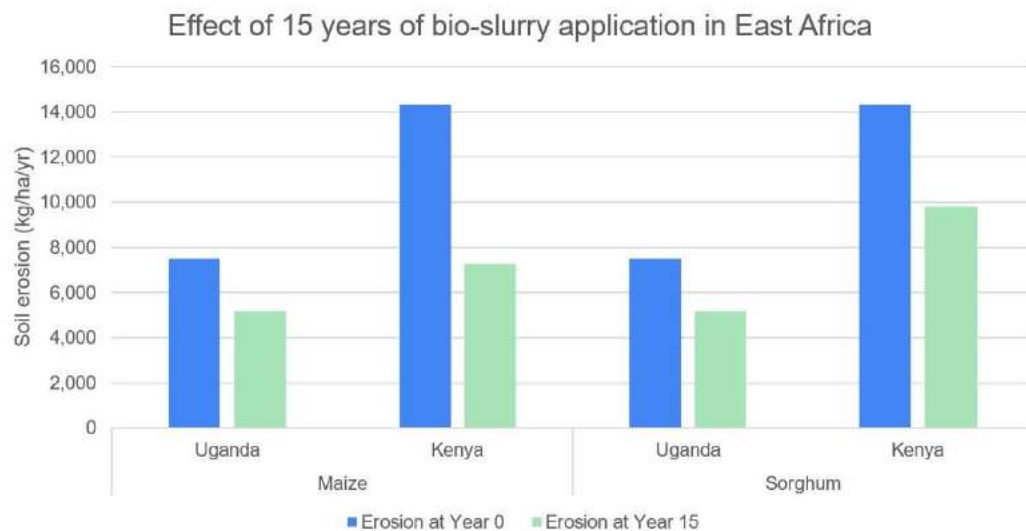
Damage to soil erosion in Italy is estimated to cost **€619 million per year**

Organic matter helps to fight erosion

- Add organic matter to the soil
- Roots hold soil in place



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Effect of digestate application

Langeveld et al. (in prep.) OFVI Imp4 report

Conclusion

- Large amounts of the organic fraction of MSW can serve as feedstocks for advanced biobased production chains.
- The HOOP project identifies available biodegradable waste and **selects promising valorisation routes**.
- **Urban Metabolism** was used as an analytical instrument to depict (waste) streams.
- Each of the lighthouse cities and regions in the HOOP project has a different level of waste management and treated in the EU. **This affects the amount of waste that is recycled, composted, or disposed of in a landfill.**



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Discover more!

Find the factsheet on Urban Metabolism and much more on [HOOP Virtual Academy](#)

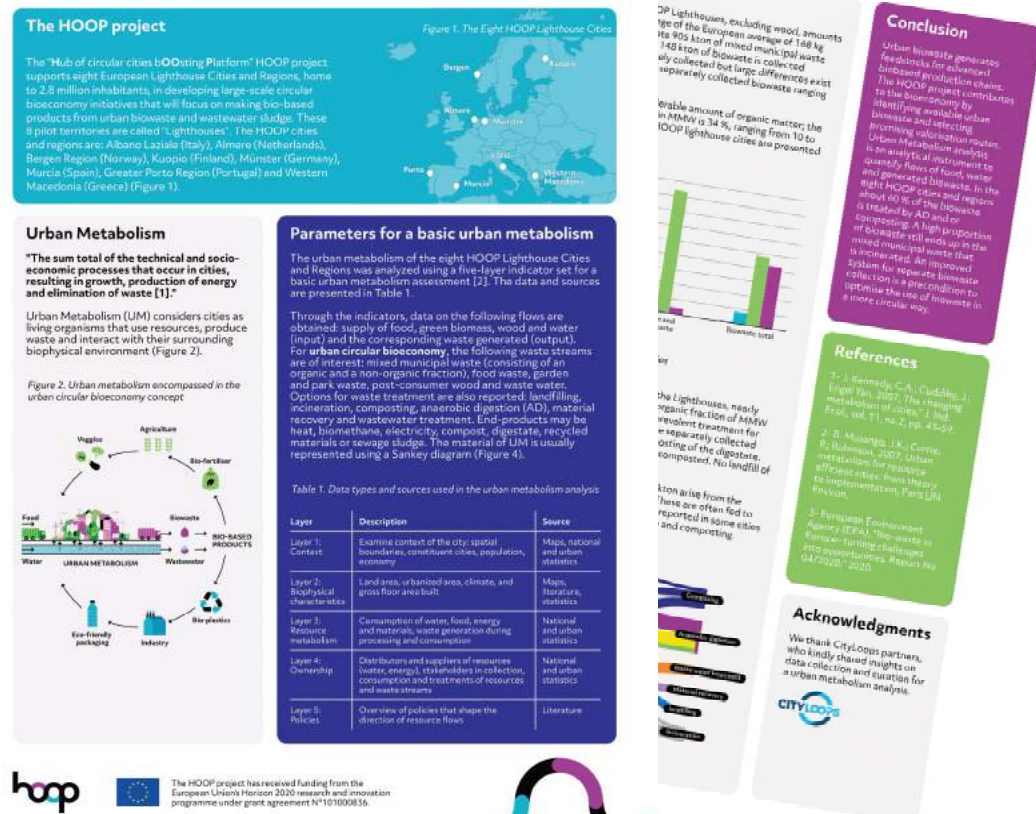
Reports,
Webinar recordings,
Explainer videos,
Factsheets,
Circularity evaluation tools!



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Urban metabolism of HOOP Lighthouses

Author: Research 4 Life



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THANKS FOR YOUR ATTENTION

Hans Langeveld

Foluke Quist-Wessel

Golaleh Ghaffari

Miguel Ángel Suárez (CETENMA)



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Questions?

<https://hoopproject.eu/>

hans@biomassresearch.eu



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Portfolio of technologies

Nr.	Technologies for Organic Fraction MSW
1	Biochemical conversion of the OFMSW
2	Insects reared on HORECA waste
3	Bioprocess involving methanotrophic bacteria using biomethane arising from the anaerobic digestion of the OFMSW
4	Black soldier larvae fed with OFMSW of digestate from anaerobic digestion
5	Nutrients recovered from residual dewatering liquid from anaerobic digestion
6	Fermentation of spent coffee grounds
7	Biochemical production of functional ingredients from animal by-products
8	Bioprocess, production 2,3-butanediol from OFMSW + garden + UWWS
9	Fermentation of used cooking oils
10	Productions of biofertilizers and bioestimulants

Nr	Technologies for Urban Wastewater Sludge
11	Bioconversion of UWWS: CO ₂ fermentation with bioelectrochemical systems
12	Bioconversion of UWWS: PHBV production
13	Slow pyrolysis of UWWS
14	Production and purification of volatile fatty acids
15	Cellulosic rejections WWTP to ethyl lactate biosolvents



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