SECTOR-WIDE CIRCULARITY ASSESSMENT

BIOMASS SECTOR

CITYLOOPS

METABOLISM OF CITIES

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WP	3
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Abstract	This current Sector-Wide Circularity Assessment report provides contextual information on the four different CityLoops cities and their biomass sectors under study. It then illustrates how circular these sectors are through circularity indicators and a Sankey diagram. Finally, it analyses and interprets the results, presents the limitations of the data used and offers recommendations on how to make this sector more circular. The assessment was carried out by the cities themselves after receiving extensive training on data collection and data processing. Numerous additional insights can be found in the individual Data Hubs of each city.
Keywords	Material flow analysis; sector-wide circularity assessment; circular sector; Urban metabolism;
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Executive Summary

This document contains four separate reports of the Sector-Wide Circularity Assessments (SCA) of the biomass sector that were carried out by four different cities of the CityLoops project: Apeldoorn (the Netherlands), Mikkeli (Finland), Porto (Portugal) and Seville (Spain). The SCA was carried out by the cities themselves, based on the SCA method that was developed by Metabolism of Cities and after receiving extensive training on data collection and data processing.

Carrying out the SCA

Through a first course, cities were trained to properly undertake the data collection process necessary to conduct a SCA. Each session explained what type of data is important in contributing to a comprehensive understanding of circularity at a sector level. By the end of the course, cities had developed skills in gathering and uploading data for their own city data portal. Numerous insights can be found in the individual Data Hubs of each city. Metabolism of Cities (MoC) ran this moderated version of this course for the CityLoops cities, in which there was live support and weekly online class sessions with a group of participants. (The course ran for 8 weeks from Feb-March 2021.)

In a second moderated course, which Metabolism of Cities ran for 10 weeks from April-June 2021, the cities learned how to take the documents and datasets collected during the first course, which were in different formats such as excel sheets, pdf, shapefiles and csv among others, and convert them into a standardised, machine-readable format. That enabled for the interactive visualisation of data into the centralised and accessible CityLoops Data Hub. Through this process, the cities learned how to create interactive maps and graphs that helped visualise their data in any way they chose.

Lessons learned

The development of a method, its translation in online courses and its application by city officials and practitioners brought forward numerous insights that are essential to be shared in the context of circularity assessment of cities, but also in terms of capacity building in this complex topic of circular economy. These insights can be relevant for researchers (in terms of developing a scientifically rigorous yet easy-to-use method), for city officials (to get familiar with the necessary steps to measure circularity), and for policy makers (to determine means to increase capacity building and streamline circularity assessments).

Overall, it was observed by the cities, as well as the SCA method developers that this entire process proved to be fairly challenging for several reasons:

- **End result:** While a very clear idea of the outcome was formulated by MoC before its implementation by cities, it was hard to showcase it beforehand, as the method was tailor made for the CityLoops project. As such, it was sometimes unclear for cities what they would achieve at the end of the analysis.
- **Data:** The availability of and accessibility to data quickly became an issue for all the cities. For some it was an "unpleasant surprise" that they did not have good local data and that

national data for downscaling made up a considerable share of the data. The possibility for the picture not to be representative or misleading because of that made some cities a bit uncomfortable. This meant that they were not so keen on the use of national data, which was often the only way to arrive at some results. This element also showcases the need for a data infrastructure and knowledge by cities, as cities do not have any data on the very system that they want to change.

- **Importance of the assessor:** Connected to the data gathering as well, it also turned out that it mattered who was in charge of conducting the method. In some cities, it was an administrator from the city itself, in others it was a consulting company or even a university. Some city governments did not want to ask companies for their data, whereas this was not a problem for a university, for example. Different assessors also have different "circular economy" and "data analysis" fluency levels, which radically altered the level of in-depth analysis.
- **Capacity building:** The objective of WP4 was and is to support cities in their efforts of measuring circularity by developing accounting methods and helping cities to apply them. As such, capacity building was one crucial component of WP4. Nevertheless, most city officials/administrations are under permanent time scarcity. For that reason, most analytical or new types of work are generally outsourced. In practice, a number of cities were reluctant to apply the method themselves and even build capacity internally. Tied to this, there was misalignment of tasks in the sense that some cities had understood that the analysis was to be carried out by MoC in WP4, rather than by themselves in WP2 and 3, respectively.
- **Purpose:** Linked to the first point of end results and to the previous one on capacity building, one of the most challenging points within the SCA development and application was for cities to understand its utility in their everyday tasks. Indeed, most cities (within the CityLoops consortium, but also more widely in the EU context) are preoccupied with implementing a circular economy through specific demonstration actions. Knowing their status quo (in terms of circularity) as well as knowing how to propose systemic actions and policies come at a second order of priority. As such, while the utility of the SCA was increasingly understood by the cities over the course of the project, it was difficult for them to place it at the same level of importance as the demonstration actions.

Aside from these reasons, there were possibly others at play that made carrying out the SCA for the first time challenging (both from the development and the application sides). However, it also needs to be stressed that many cities committed to the work, put in a lot of effort and produced in-depth analysis that can enable them to draft policies and actions to make their sector(s) more circular.

Meta-analysis

The sector-wide circularity assessment provided a framework to develop a solid data and knowledge foundation for cities to kickstart or solidify their circularity journey. As mentioned in the previous part, different cities included different levels of engagement in this process and had different levels of data quality. Therefore, different levels of insights can be extracted from each of the sector-wide circularity assessment reports. In addition, the entire method was not developed with benchmarking or comparison in mind. On the contrary, it was focusing on providing contextual information and insights. Nevertheless, some general insights can be summarised when looking at the work from all cities side-by-side. For instance, different circularity pathways exist depending on the local resources, local actors and infrastructures. Indeed, in most cases local extractive, productive and waste treatment activities are situated just outside the city boundaries.

Scope and use of reports

Each Sector-Wide Circularity Assessment report provides contextual information on the four different CityLoops cities and their biomass sectors under study. It then illustrates how circular these sectors are through circularity indicators and a Sankey diagram. Finally, it analyses and interprets the results, presents the limitations of the data used and offers recommendations on how to make this sector more circular.

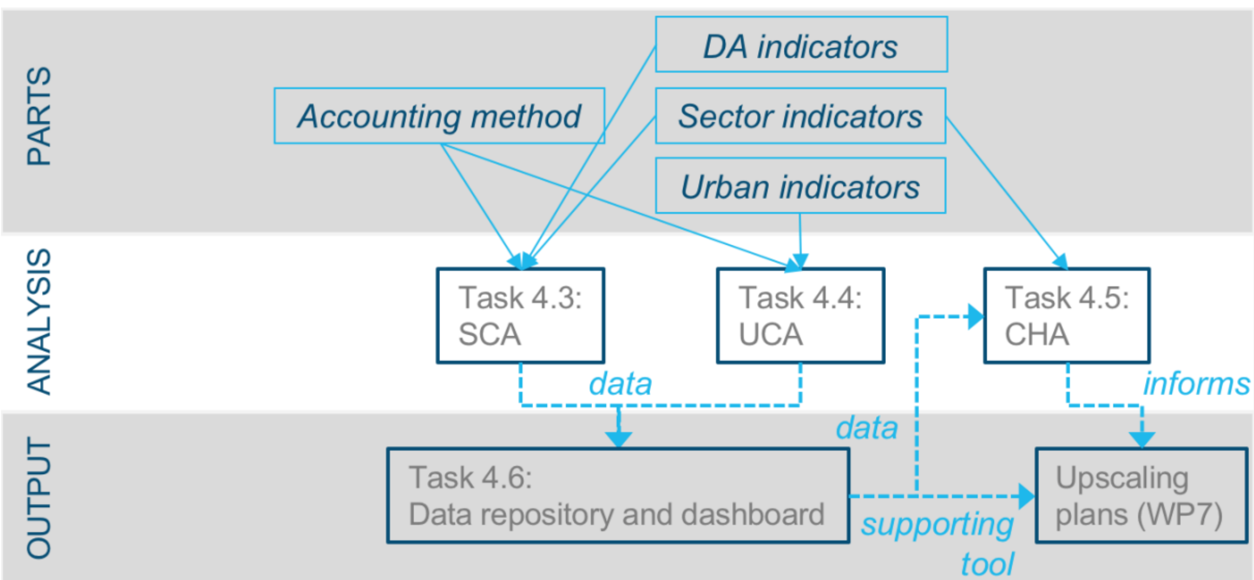
The reasons and benefits of carrying out the SCA method (taken from "Sector-Wide Circularity Assessment Method", Deliverable 4.3, page -A-):

- ***"Make data visible:*** *At its most basic level, the SCA makes data that cities have or have access to visible, by digging them out of drawers and locally stored files on computers and putting them in a centralised place.*
- ***Break silos:*** *Looking for and making data visible also opens up silos that city departments often operate in due to their organisational nature and working structures. Breaking silos (of information) can uncover data that other departments were not aware of, can benefit from and potentially allow for better communication around data needs. It can also highlight areas where it is possible to start collaborating on, ideally creating synergies, but that is its own point.*
- ***Put material into context:*** *The materials that the cities deal with in the Demonstration Actions are, on their own, not representative of the whole sector that they are in. By analysing a number of other material (flows) that in this group embody the sector better and gaining information on the sizes of those, the material of interest to a single city or DA can be seen in context and its significance understood.*
- ***Understand the big picture:*** *By studying a number of materials, along various elements of the value chain, throughout a sector, and ideally over more than a year, cities will, possibly for the first time, see the big picture of a sector in their city. They will also gain insights about the sectors' complexities, main challenges and efforts that are needed to be carried out in order to achieve their objectives and goals.*
- ***Establish a status quo:*** *If they do create this big picture for the first time, they will simultaneously establish a first status quo. This baseline will give them a starting or reference point for their analysis, efforts and policy making in the future and also for the evaluation framework in CityLoops that the assessment is primarily designed for.*
- ***Inform policy making:*** *With the status quo and the big picture, a city is given a basis from which they can optimise planning and develop policies that are holistic, context-specific,*

and informed and supported by hard values. In an iterative process, they could even carry out the assessments over and over to track the efficacy of their implemented policies.

- ***Put DAs into context:*** *Aside from having the materials in a larger context, the DAs themselves also need to be understood as part of a larger "ecosystem". This ecosystem is made up of stakeholders and supply chains that are uncovered through the SCA, by spatialising and disaggregating as much as possible the metabolic flows and stocks and economic activities, infrastructures, and actors associated with them.*
- ***Upscale DAs:*** *By obtaining insights on both the material and waste flow sizes and the economic landscape in the city, cities will be able to develop informed circularity upscaling plans (WP7). They will be able to determine where the DAs can be further expanded and how much capacity there is. It may also help to directly support the implementation of the demonstration actions themselves through indicating relationships and pressure points.*
- ***Unlock circular hotspot analysis:*** *Determining the circularity of a single sector lays the groundwork and unlocks the ability to do a "circular hotspot analysis" (later in WP4). The hotspot analysis will uncover the sectors to be prioritised, since one of their material flows or part of the value chain is significant, either in terms of size or economic importance, and very linear."*

Connection to other CityLoops work



"The SCA is not an analysis that stands on its own in the CityLoops project nor within WP4 which focuses on Circularity Assessment of Cities as a whole. In addition to the SCA, there will be the development of an Urban Circularity Assessment (UCA) and a Circularity Hotspot Analysis (CHA) method, later in the CityLoops project. The SCA, UCA and CHA are in fact connected and complementary analyses which help to further advance cities towards their circular economy journey until they can develop their own circularity roadmap. These steps have to be carried out in that very order, since the information output of one method will become input for the next analysis. That implies that these three types of analyses do and have to build on each other in a

logical and complementary way, and are integrated with each other to make the overall approach coherent and easiest for the cities to work with" (taken from "Sector-Wide Circularity Assessment Method", Deliverable 4.3, page 5).

Indicator glossary

The indicators used for the SCA were the following nine. The methodology of indicator assessment is described in the linked metadata of each indicator. These indicators are all related to the biomass sector specifically and do not account for the urban economy as a whole.

Indicator	Description
Domestic material consumption (DMC)	The total amount of materials directly used by an economy and is defined as the annual quantity of raw materials extracted from the domestic territory, plus all physical imports minus all physical exports. See Eurostat
Share of secondary materials in DMC	This indicator assesses the significance of secondary materials in the economy.
EU self-sufficiency for raw materials	The indicator measures how much the city is independent from the rest of the world for several raw materials.
Quantity of material for anaerobic digestion	Estimates mass of materials going to anaerobic digestion.
Quantity of material for composting	Estimates mass of materials going to composting at demo, sector and city scale.
Amount of sector specific waste that is produced	Total mass of waste for sector.
End of Life Processing Rate	The End-of-Life Processing Rate (EoL PR) measures the efficiency of the end-of-life processing process.
Incineration rate	Mass percentage of waste which is incinerated.
Landfilling rate	Mass percentage of waste which is landfilled.

Online resources

These reports can also be found online: Apeldoorn; Mikkeli; Porto; Seville;

(The italic texts in this report were written by Metabolism of Cities' Aristide Athanassiadis and Carolin Bellstedt. They provide relevant general information and serve as connecting elements of the single report parts. They are the same texts in every single city report and marked italic to avoid duplicated reading.)*

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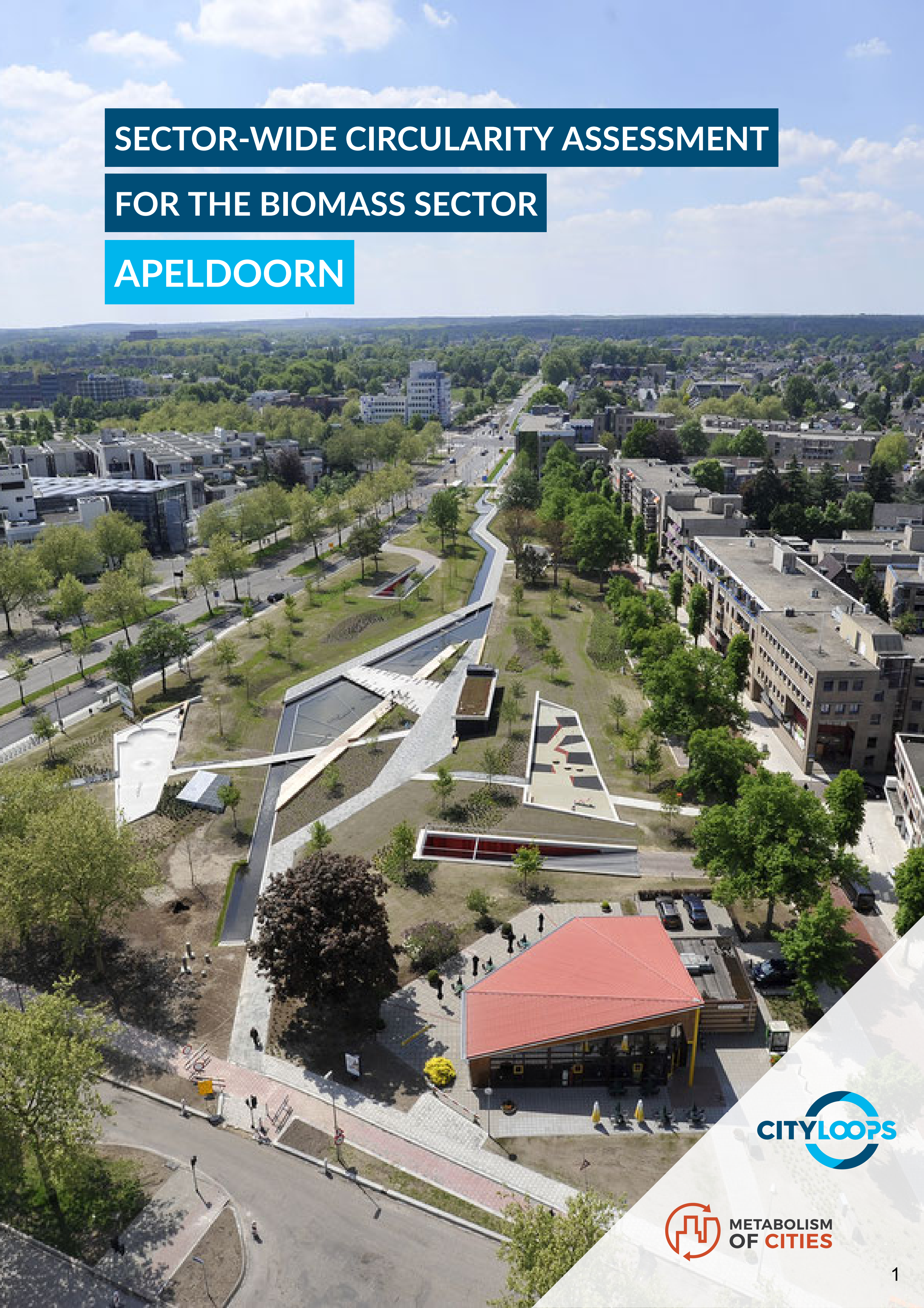
APELDOORN



CITYLOOPS

METABOLISM OF CITIES

Introduction

The EU Horizon 2020 funded CityLoops project focuses on closing the material loops of two central sectors of any city in terms of material flows, societal needs and employment, namely the construction and biomass sectors. Due to their sizes, they represent a considerable opportunity for cities to transform their metabolism and economy towards a more circular state.

Within this project, seven European cities, amongst those also the City of Apeldoorn are planning to implement demonstration actions to kickstart their circularity journey. To better understand what the current circularity status quo is, as well as the impact of these actions, and the efforts needed to transform their sector, a Sector-Wide Circularity Assessment method was developed. This method combines a circular city and circular sector definition, a material flow and stock accounting method, as well as circularity indicators. The sector itself was defined in terms of a number of representative materials that make up a large share of the sector and associated economic activities. The biomass sector is made up of 12 materials, depicted as icons here, which were studied along the entirety of their supply chains. Altogether, these elements help to set a solid knowledge and analytical foundation to develop future circularity roadmaps and action plans.

Cereals

Dairy products

Fish

Fodder crops

Fruits

Garden and park materials

Live animals

Oil-bearing crops

Roots, tubers

Sugar crops

Timber

Vegetables

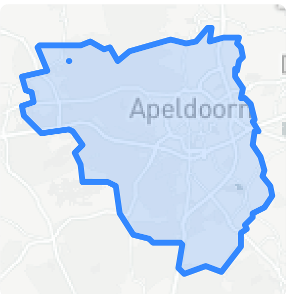
The assessment was carried out by the cities themselves after receiving extensive training in the form of courses on data collection (construction and biomass) and data processing. Numerous additional insights can be found in the individual Data Hubs of each city.

This current Sector-Wide Circularity Assessment report provides contextual information on the city and the economic sector under study. It then illustrates how circular these sectors are through circularity indicators and a Sankey diagram. Finally, it analyses and interprets the results, presents the limitations from the data used and offers recommendations about how to make this sector more circular.

(The italic texts in this report were written by Metabolism of Cities' Aristide Athanassiadis and Carolin Bellstedt. They provide relevant general information and serve as connecting elements of the single report parts.)*

Urban context

To contextualise the results of the sector-wide circularity assessment, this section provides population and land use information data of the city. In addition, population and area of the city under study, as well as its corresponding NUTS3, NUTS2 and country were included. Data for these scales were added to better understand how relevant and important the approximations are when downscaling data from these scales to a city level.



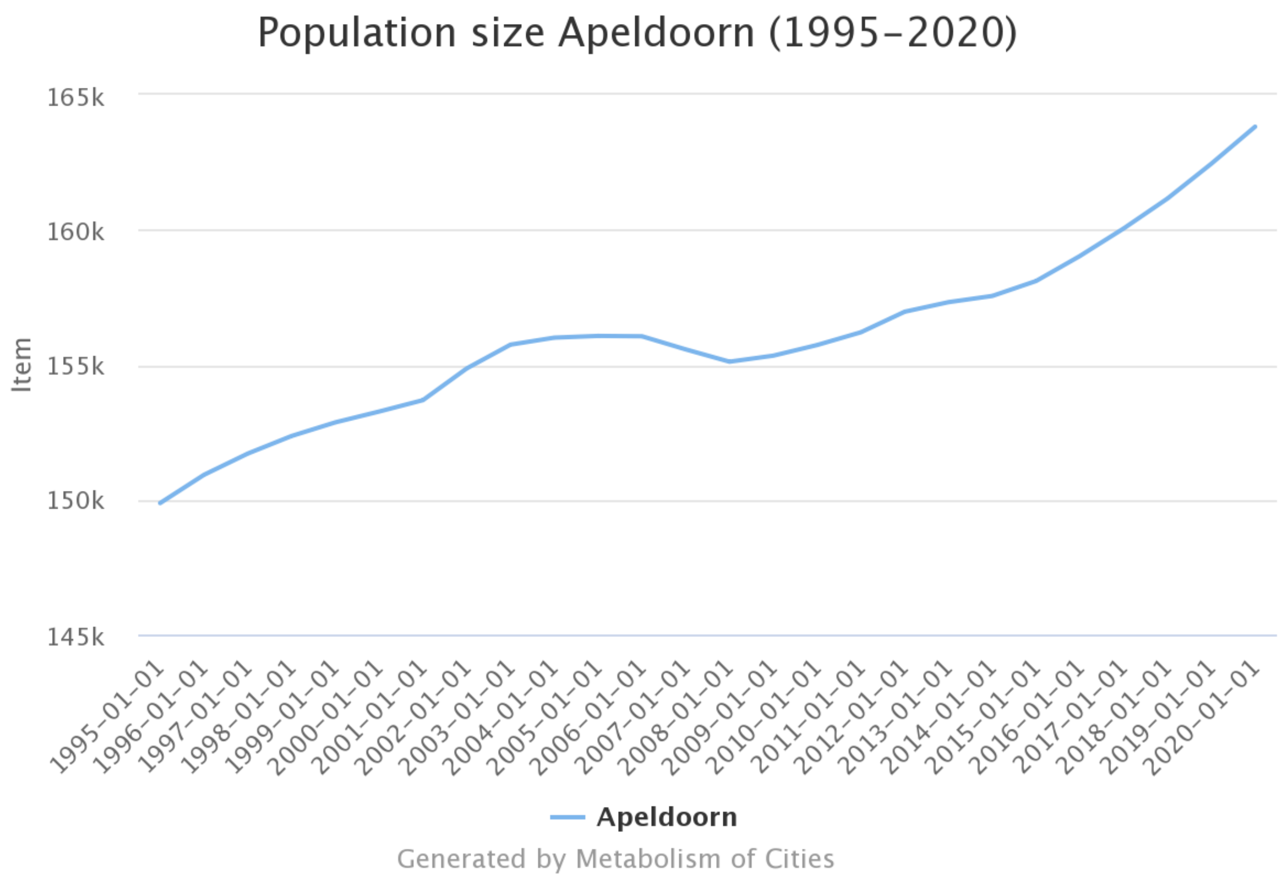
Apeldoorn
164,781
341 km^2

Veluwe
700,975
1,860 km^2

Gelderland
2,096,603
5,136 km^2

Netherlands
17,475,415
41,543 km^2

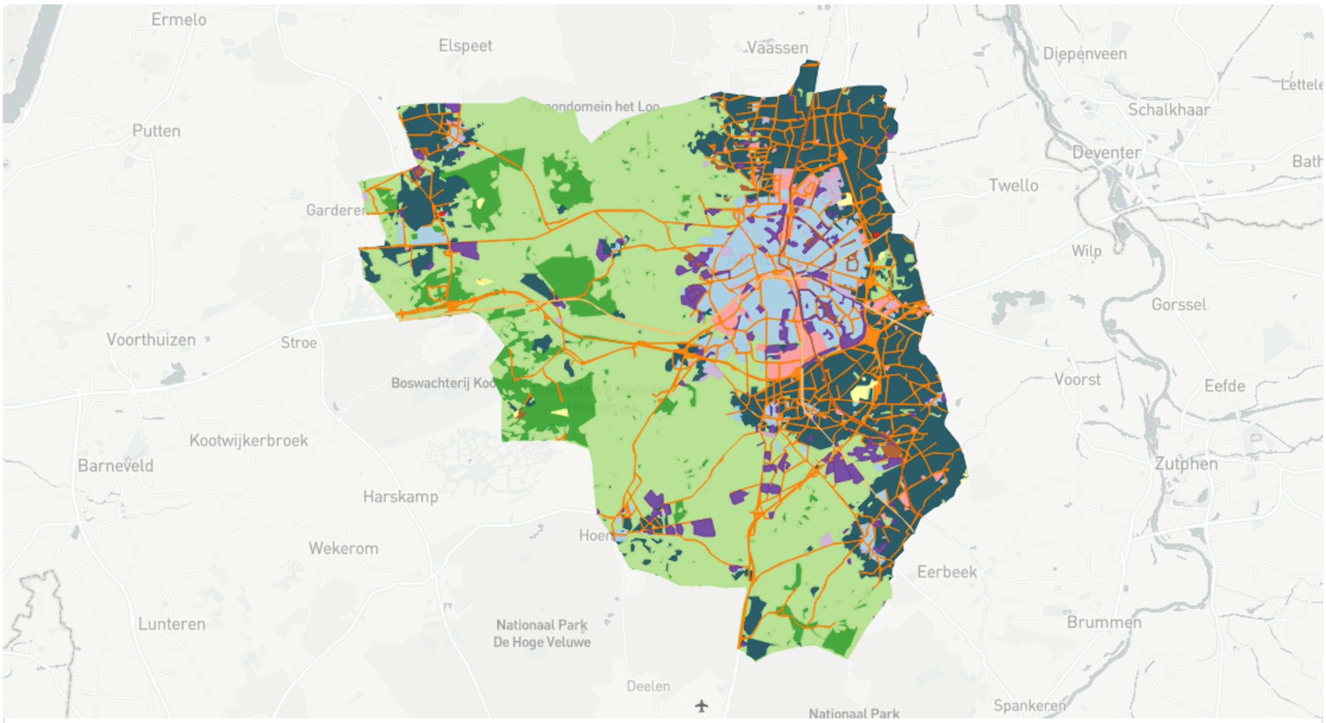
Population of Apeldoorn



Data source

The population of Apeldoorn has been increasing significantly over the past decades. The population grew from 149,869 inhabitants in 1990 to well over 163,818 in 2020, a growth of 9.3%.

Land use



- Agriculture
- Built area
- Dry natural terrain
- Forest
- Greenhouse horticulture
- Industrial area
- Main road
- Railway
- Recreation
- Semi-built area
- Water
- Wet natural terrain

The land use of the municipality of Apeldoorn's is dominated by forests, agricultural use and built-up area. About half of Apeldoorn's area is covered by forests, and even becomes well over half of the area, when including other natural terrains. The city itself has a strong urban character, which mainly consists of residential areas and business parks. The rural area of the municipality combines forested and agricultural lands with various smaller towns that are all part of the municipality.

Economic context of biomass sector

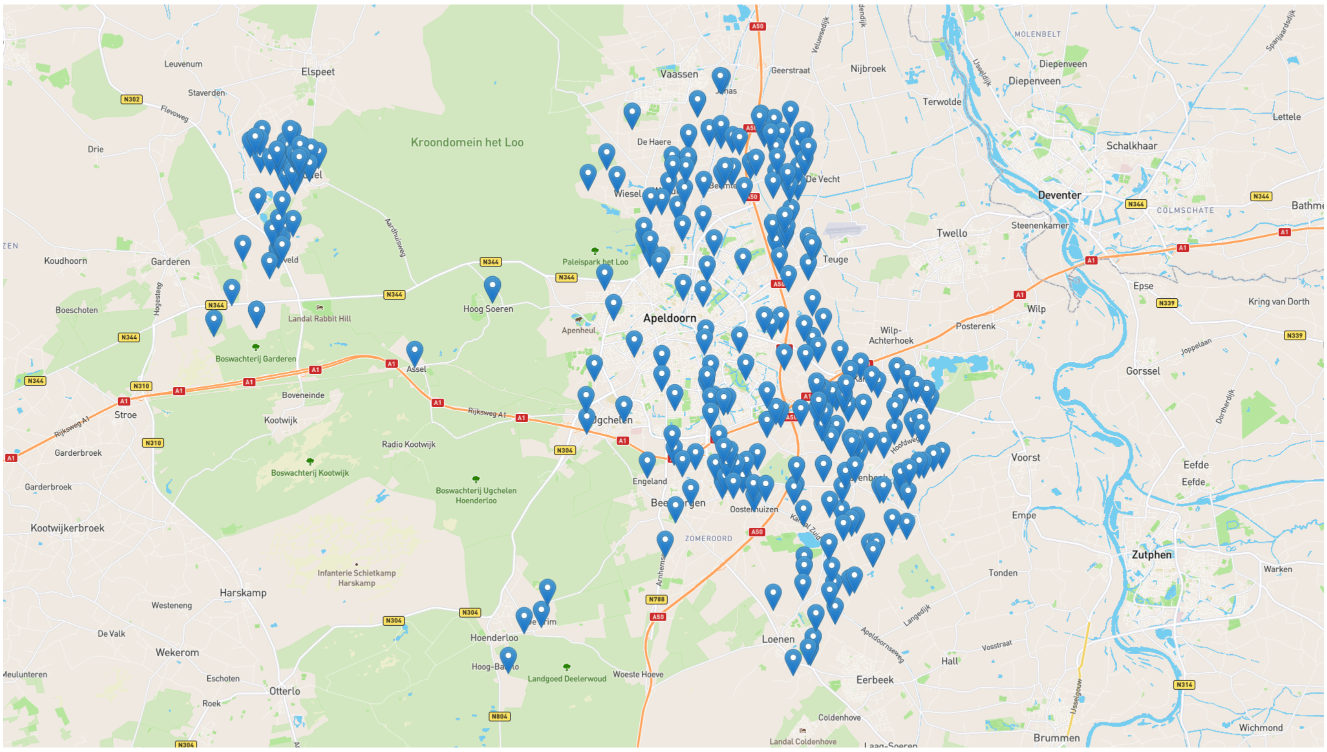
This section puts into perspective the economic context of the sector under study. It describes how many people are employed in this sector, as well as who the main actors involved (from all lifecycle stages for the sector's materials) are.

	GDP (monetary value, in €)	Employees
Apeldoorn	56,000,000	200
Veluwe	980,000,000	3,500
Gelderland	3,700,000,000	13,400
Netherlands	29,000,000,000	103,100

The biomass sector in Apeldoorn

Although forested and agricultural land dominate Apeldoorn's land use, the agro-food sector is not a dominating sector in the city itself. The province of Gelderland has a strong agricultural character, resulting in many surrounding municipalities having even higher numbers and rates of employment in the biomass sector than Apeldoorn. Apeldoorn's biggest sectors in terms of employment are healthcare, wholesale and retail and administrative and support services. Nevertheless, for the whole of Gelderland the food industry is a dominant industry type, containing multiple clusters within the entire province, also in Apeldoorn. However, these numbers are not represented in the number of employees shown above, those are solely based on actors active in agriculture, forestry and fishery.

The actors of the biomass sector



[Data source]

Most of Apeldoorn's biomass harvesting actors are, as expected, located outside of the city and its built-up area. Livestock farmers and in particular those raising dairy cattle and other cattle and buffaloes comprise over half of the biomass harvesting actors. 63 actors are active in non-animal farming (mixed farming, vegetables, cereals etc.) and 23 are active in the forestry business.

There are two local waste collection sites: Circulus-Berkel and SITA Recycling. Circulus-Berkel is the company that collects all household waste in the municipality of Apeldoorn. From that location, the materials are redistributed to other companies where they are treated (recycling, incineration, landfilling etc.). A few companies treat non-hazardous waste and most companies are active in the recovery of sorted materials. It is important to note, that these are all companies categorised under the NACE-codes 37, 38 and 39. These NACE-codes are non-material specific and therefore some companies might not be active in the collecting or treating waste from biomass or construction sector.

Indicators

To monitor the progress of this economic sector towards circularity, a number of indicators were proposed and measured. Altogether, these indicators depict several facets of circularity of the sector. As such, they need to be considered in combination rather than in isolation when assessing circularity. In addition, these indicators can be compared to other cities or spatial scales (such as the country level). However, this has to be done with great care and use of the contextual elements in the previous sections of the report. Finally, the value measured from these indicators can be traced over time to track the sector's progress towards circularity.

Indicator number	Indicator	Value	Unit
34	Domestic material consumption (DMC)	771,610.06	Tonnes/year
41	Share of secondary materials in DMC	0.00	%
48	EU self-sufficiency for raw materials	97.13	%
53	Quantity of material for anaerobic digestion	2,407.63	Tonnes/year
56	Quantity of material for composting	5,617.80	Tonnes/year
57	Amount of sector specific waste that is produced	146,287.56	Tonnes/year
58	End of Life Processing Rate	0.00	%
59	Incineration rate	7.46	%
61	Landfilling rate	4.31	%

The indicator table above describes calculated values for the mandatory indicators of the Sector-wide Circularity Assessment. There is no information on the indicator values over time, as there was only data collected, processed, and analysed for one year: 2018. However, these indicator values can be compared to values from other geographical scales. It is especially relevant to compare per capita or percentage values from the Netherlands level to those of Apeldoorn. In comparing these values, multiple issues arose. In many cases the data from Apeldoorn was significantly different from those values of Netherlands as a whole. It is difficult to pinpoint whether Apeldoorn is truly performing on these indicators as the presented values or that the calculated values of the material flows are just not representative for Apeldoorn.

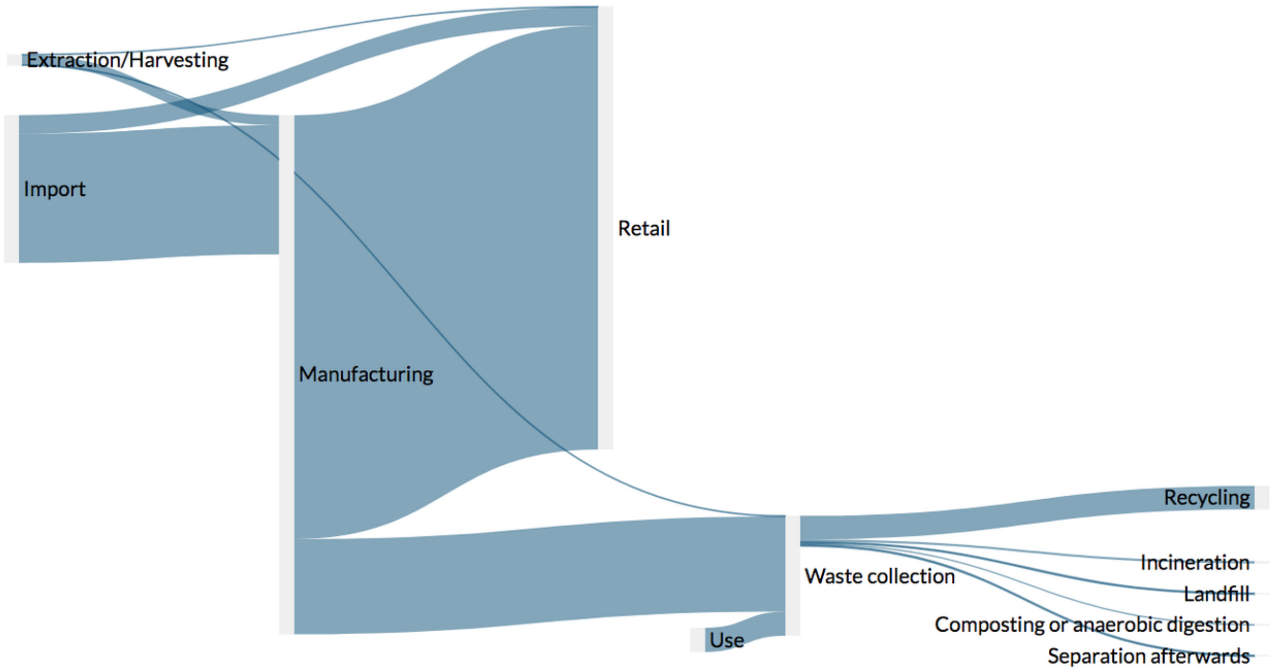
For example, DMC is based on the total material extraction plus total imports and minus the total exports. In Apeldoorn this is 771,610 tonnes and per capita this is around 4.7 tonnes of domestic (construction) material consumption. For the Netherlands, this value (biomass DMC) is around 2.821 tonnes per capita. However, all information is downscaled and there was no information on the imports of waste as well as no information on the distribution of extraction values to each of the lifecycle stages. In addition, the share of secondary materials in DMC is zero, because there was no information on the quantities of recycling of biomass materials to other lifecycle stages whereas in the Netherlands, it is very common to compost or anaerobically digest biomass, which produces products that are used locally. This also caused the value of 0 percent for indicator 58, End-of-Life processing rate. Lastly, the quantities of sector specific waste are also uncertain, as it comprises the total amount of company waste and not biowaste per economic activity.

Visualisations

Measuring circularity is a data heavy exercise. Numerous datasets were collected and visualised throughout the sector-wide circularity assessment process. To synthesise these findings, a Sankey diagram illustrates how material flows from the studied economic sector are circulating from one lifecycle stage to another. The height of each line is proportional to the weight of the flow. This diagram therefore helps to quickly have an overview of all the materials flows that compose the sector and their respective shares. The flows that are coloured in light blue in the Sankey diagram, are return flows. This means that they flow in the opposite direction of the lifecycle stages and are subjected to reuse, redistribution, or remanufacturing. Their size relative to the others is a good indication for the materials' circularity.

The Sankey diagram clearly shows that the biomaterials in Apeldoorn are mainly flowing in through import. Extraction/Harvesting makes up approximately seven percent of the total incoming flow of biomaterials. Other than that, it should be noted that Manufacturing uses about four times more resources than are accounted for in the incoming biomaterials. This discrepancy is most likely due to missing data on a municipal level.

A significant portion of the data that is visualized here is based on statistics for the Netherlands, using the population or employment numbers as proxies to create estimates. This is the case for Use , Imports, Exports and Waste Processing. Also note that there is no outflow from Retail, as there is no data available at the moment.



[Data source]

Data quality assessment

Numerous datasets were collected and considered in the sector-wide circularity assessment. In some cases, datasets were not available for some materials or for some lifecycle stages for the studied sector. Therefore, estimations need to be done by looking at data at higher spatial scales (region or country). This section qualitatively assesses how reliable the data used is.

Data quality

Before describing data gaps and assumptions, the overall data quality is considered. It is expressed through four data quality dimensions that are depicted in the data quality matrix: reliability, completeness, temporal correlation, and spatial correlation. Each dimension has its own criteria for the ranking of high (green), medium (yellow) and low (red), which is based on this Pedigree report and shown in the table below. There can be additional explanations in some cells, as supporting information.

Rating	*Reliability*	*Completeness*	*Temporal correlation*	*Spatial correlation*
high	*Reviewed or measured data*	*Data exists for all of the single materials and their respective economic activites*	*Data less than 3 years difference to the time period of the data set*	*City-level data*
medium	*Estimated data*	*Data exists for most single materials and most economic activities*	*Data less than 6 years difference to the time period of the data set*	*Regional-level data (NUTS 3)*
low	*Provisional data*	*Data exists for the sector only for the Life Cycle Stages*	*Data less than 10 years difference to the time period of the data set*	*NUTS 2 and country-level data*

Data quality matrix

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
Extraction/Harvesting			All data from 2018	Only country level data
Manufacturing			All data from 2018	Only country level data
Retail	No data	No data	No data	No data
Use			All data from 2018	Only country level data
Stock			All data from 2018	
Waste collection			All data from 2018	Only country level data

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
Landfill			All data from 2018	Only country level data
Incineration			All data from 2018	Only country level data
Recycling			All data from 2018	Only country level data
Anaerobic digestion	No data		No data	Only country level data
Composting	No data		No data	Only country level data
Imports			All data from 2018	Only country level data
Exports			All data from 2018	Only country level data

The data collection process was difficult due to various reasons. First of all, there is almost no information on material flows collected locally. Therefore, Netherlands Statistics (CBS) was the primary source for gathering data (also the source that delivers Dutch data on Eurostat statistics). However, the scale of information was therefore almost always national which means that the **spatial correlation** was often low and in almost all cases downscaling needed to be performed.

Secondly, information on companies e.g. manufacturing or waste produced is often estimated through surveys with companies as well as information derived from annual environmental reports, this data is therefore often estimated rather than measured this data is therefore often estimated rather than measured resulting in medium **reliability**.

Thirdly, the **completeness** of the data is also very limited. Information was very often only be found on sector level, and sometimes it was also difficult to pinpoint at which lifecycle stage the datasets were providing information about. The material categories used in the collected datasets or for the proxies were not the same as for this course (e.g. Eurostat's MFA uses raw material categories, and for this MFA also products were used, making it difficult to find information on materials per lifecycle stage). Additionally, the municipality of Apeldoorn also did not want ask companies for data on material use. In the Netherlands a strict division between governmental organisations and companies is desired and it is unlikely that individual companies will provide much information on their material use on a public website. Then, for waste collection and processing there is some information for governmental organisations available (LMA, nation-wide waste reporting) as it is mandatory for companies to register waste collection and treatment. However, the information is highly confidential and it is not allowed to publish this information unless it is aggregated so that no individual companies can be extracted from the information.

Unfortunately, all these reasons have resulted in a rather red and orange coloured data quality matrix. Only the **temporal correlation** was high, as most data was present from the year 2018. Partly because CBS acquires much of their data on a yearly basis and for half of the lifecycle stages the same dataset was used; Eurostat's Material Flow Accounts.

Data gaps and assumptions

As described above there were quite some data gaps in terms of the completeness of the data (level of detail in which information was obtained) as well as on which spatial scale information could be collected.

Material and lifecycle stage information

- There is **no difference made between use and retail** in the material flow accounts of Eurostat and therefore data on retail is lacking. It was decided that, due to the uncertainty in choosing which material category of Eurostat would have to be linked to the MoC material categories, the information would be summed to the sector level.
- In terms of **stock** information there is a local dataset called GBI which collects information on all locations in Apeldoorn that are subjected to maintenance performed by (contracted companies of) the municipality of Apeldoorn. However, the information is mainly collected in the unit of 'number of items' (trees) or area size of green areas. This could not be recalculated to a number of tonnes, and therefore it was decided to leave this information out and only deal with the animal stock in Apeldoorn.

Proxy information

- **Agricultural area:** the information on agricultural area in Apeldoorn and the Netherlands was based on different material categories than the material extraction data from Eurostat. Therefore, some assumptions were made in terms of classifying the area size of certain crops for agricultural land.
- **Employees**: local employee data was obtained from the Provincial Employment Survey (in Dutch, Provinciale Werkgelegenheid Enquete, PWE). It was required to round up/off the number of employees to tens (10, 20, 30 etc.), so there might be some results that are not fully representative for Apeldoorn. Then, in using the employees as a proxy for the sector as

a whole also resulted in using some employees multiple times which in reality is of course not the case. NACE-codes only specify on the economic activity that it entails, and not per se on the type of materials that are being dealt with. Especially for wholesale and retail and imports and exports this was problematic.

- **Downscaling:** In all cases, except for household waste and material stock (which is incomplete), national data was used which required downscaling to estimate the size of material flows for Apeldoorn. The problem was however that for the Eurostat MFA only uses raw materials and only a couple of materials in product forms, making it especially difficult for construction materials to select the appropriate material categories.

Data analysis

This section analyses the Sankey diagram developed in the previous section. It discusses and interprets the results for the sector-wide circularity assessment. It also reflects on how the current demonstration actions fit within the bigger picture of the sector, as well as how they could be upscaled to accelerate the transition towards a more circular sector.

Insights on status quo of the biomass sector

The bio-waste collection from households in Apeldoorn is focused on fruit, vegetable and garden waste (organic waste). Apeldoorn estimated to collect approximately 120 kg of bio-waste per resident per year as of 2020. Bio-waste of leaves, branches and wood are approximately 300 m^3 of trees/logs, 350 tonnes of grass and 8,000 tonnes of leaves. These numbers are estimates. There is a large opportunity to make some flows more circular. These numbers indicate that there is willingness for circularity in the city. With the project CityLoops, Apeldoorn hopes to get more control of these bio-waste flows. Apeldoorn needs to invest more time into collecting the different flows of biomaterials in order to get better insights for reuse and recycling.

Connection to and upscaling of demonstration actions

The demonstration actions in Apeldoorn target an important flow of bio-waste from public outdoor spaces. The municipality of Apeldoorn does not have an estimate of how much of this bio-waste can be reused or recycled. However some numbers are available to give an insight in the reusability of bio-waste flows from public outdoor spaces. The largest cause of this bio-waste flow comes from maintenance that is carried out in these public areas.

Some examples (yearly) are: 75m^3 is reused as firewood, 21m^3 is made available as lumber, 176m^3 is repurposed as pulpwood and 5 tree trunks are made available for art projects. If we have better insights in the composition of these bio-waste flows and how they are distributed in the city, we could improve on the circularity of these bio-waste flows from public outdoor spaces.

Furthermore there are still some open questions: How can this bio-waste be optimally collected and who should be responsible for the implementation? Should the municipality be responsible from start to end, or should the collection of bio-waste be outsourced to contractors?

Recommendations for making the biomass sector more circular

1. *Start measuring material flows locally*, in categories and units that are relevant for the municipality. Perhaps begin at the level of the demonstration actions and scale up based on those results. Simultaneously, *set specific and measurable goals* for circularity which in the initiation phase can be based on national values. Over time, these goals need to re-evaluated and specified to the local situation.
2. Investigate the *role of import and export* of materials in Apeldoorn's sectors. Many materials produced in Apeldoorn are not consumed locally which can partly be caused by the fact that the economic character of the Netherlands is based on throughflow and export of materials as well as the fact that companies are not per se city oriented but often operate at larger scales in the region or country.
3. Choose on what scale(s) the municipality has and wants to have *influence* on obtaining circularity. Is it possible and realistic to create industrial metabolisms and connect companies or even sectoral flows to one another or should the municipality focus more on what kind of materials go in and out of and are consumed in the municipality. Then, the municipality can decide on setting more circular demands on the materials that they use in biomass (e.g. greening) or construction projects.
4. *Evaluate the circularity of sustainability initiatives and the sustainability of setting demands for circularity*. Potential trade-offs exists if issues of material flow monitoring and actions linked to them are not viewed holistically. Who and what benefits of certain decisions, and who or what bears the losses? In the transition towards circular and sustainable societies, quick win-wins might overshadow relevant questions and processes that demand more time.

References

- Netherlands
- Gelderland
- Veluwe
- Apeldoorn population (1995-2020) line graph
- Land use Apeldoorn 2015
- Apeldoorn biomass sector actors map

SECTOR-WIDE CIRCULARITY ASSESSMENT FOR THE BIOMASS SECTOR

MIKKELI

CITYLOOPS

METABOLISM OF CITIES

Introduction

The EU Horizon 2020 funded CityLoops project focuses on closing the material loops of two central sectors of any city in terms of material flows, societal needs and employment, namely the construction and biomass sectors. Due to their sizes, they represent a considerable opportunity for cities to transform their metabolism and economy towards a more circular state.

Within this project, seven European cities, amongst those also the City of Mikkeli are planning to implement demonstration actions to kickstart their circularity journey. To better understand what the current circularity status quo is, as well as the impact of these actions, and the efforts needed to transform their sector, a [Sector-Wide Circularity Assessment] method was developed. This method combines a circular city and circular sector definition, a material flow and stock accounting method, as well as circularity indicators. The sector itself was defined in terms of a number of representative materials that make up a large share of the sector and associated economic activities. The biomass sector is made up of 12 materials, depicted as icons here, which were studied along the entirety of their supply chains. Altogether, these elements help to set a solid knowledge and analytical foundation to develop future circularity roadmaps and action plans.

Cereals	Dairy products	Fish
Fodder crops	Fruits	Garden and park materials
Live animals	Oil-bearing crops	Roots, tubers
Sugar crops	Timber	Vegetables

The assessment was carried out by the cities themselves after receiving extensive training in the form of courses on data collection (construction and biomass) and data processing. Numerous additional insights can be found in the individual Data Hubs of each city.

This current Sector-Wide Circularity Assessment report provides contextual information on the city and the economic sector under study. It then illustrates how circular these sectors are through circularity indicators and a Sankey diagram. Finally, it analyses and interprets the results, presents the limitations from the data used and offers recommendations about how to make this sector more circular.

(The italic texts in this report were written by Metabolism of Cities' Aristide Athanassiadis and Carolin Bellstedt. They provide relevant general information and serve as connecting elements of the single report parts.)*

Urban context

To contextualise the results of the sector-wide circularity assessment, this section provides population and land use information data of the city. In addition, population and area of the city under study, as well as its corresponding NUTS3, NUTS2 and country were included. Data for these scales were added to better understand how relevant and important the approximations are when downscaling data from these scales to a city level.

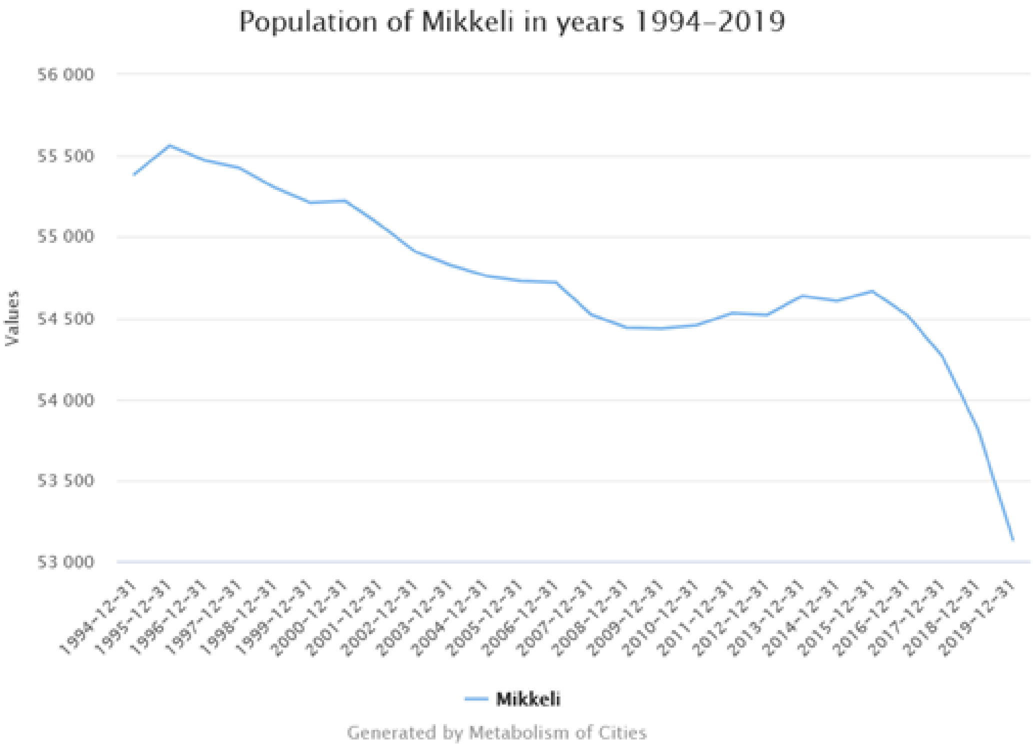
Mikkeli
53,134
3,229 km^2

Etelä-Savo
144,615
19,130 km^2

Pohjois- ja Itä-Suomi
1,278,237
236,450 km^2

Finland
5,525,292
390,908 km^2

Population of Mikkeli



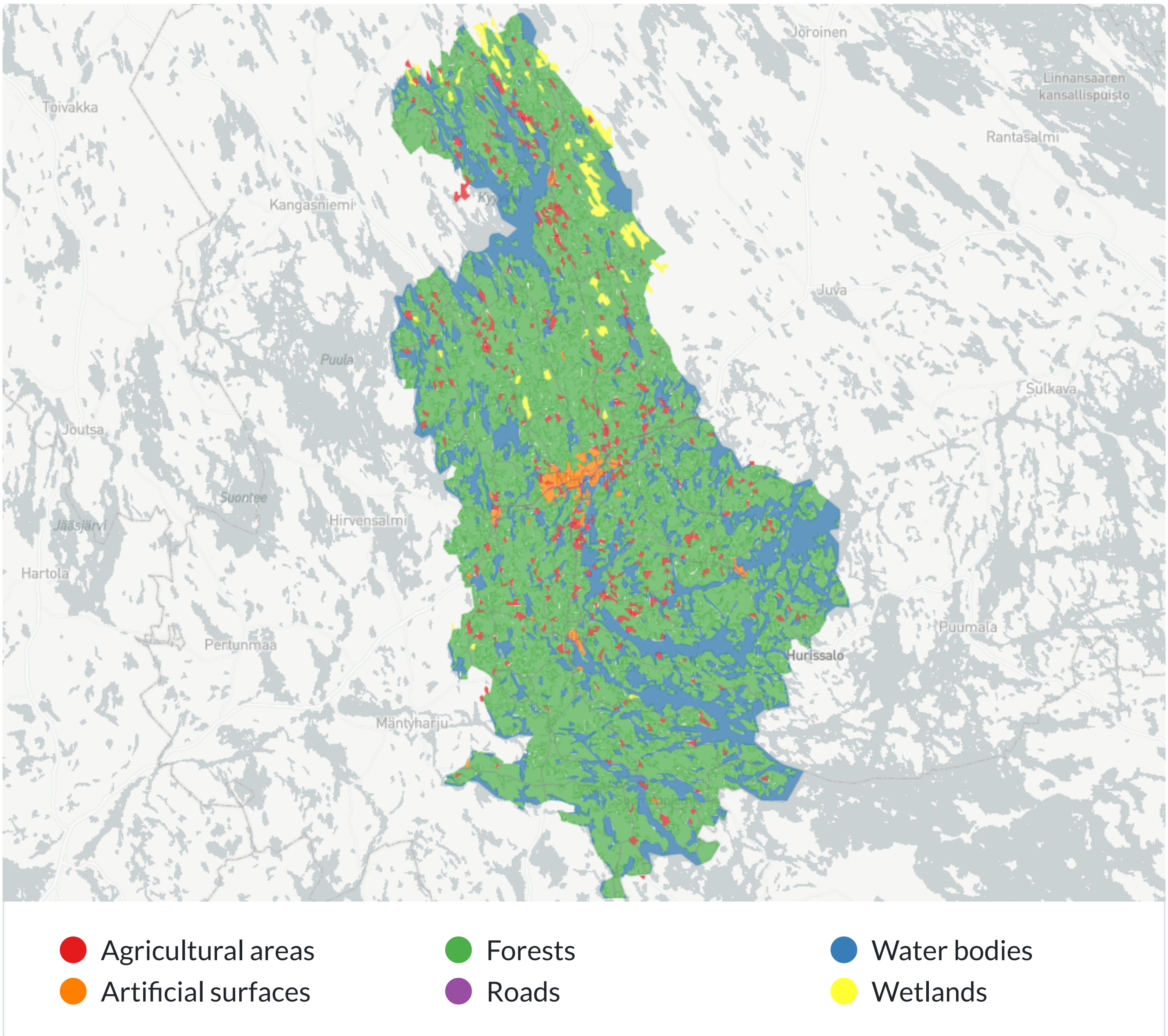
Data source

The population development in Mikkeli

In 2019, there were 53 130 inhabitants in the city of Mikkeli, of which 13.9% were aged 0-14, 60.2% were aged 15-64 and 25.7% were over 65 years old. The population of the city of Mikkeli has been slightly declining in the 21st century, but since 2016 the population change has clearly accelerated and the city lost almost 1 400 people between 2016 and 2019. The negative demographic development of the city of Mikkeli is largely the result of two components: natural demographic change has accelerated slightly, but especially outward migration (particularly emigration of young adults) has increased considerable in 2016-2019. In 2019, Statistics Finland published a new population forecast for the city of Mikkeli. The city's population is predicted to decline by 11 % by 2040. (Kumpusalo 2020, Mikkeli Development Miksei Ltd)

In 2018, Mikkeli was the 18th largest city in Finland by population. (City of Mikkeli website)

Land use



Living in Mikkeli

There are various living environments in Mikkeli. These include a growing downtown area, developing agglomerations and the quiet of the rural area. Living in Mikkeli is divided in two main area types: city/agglomerations and dispersed habitat/rural areas. There are 10558 summer cottages by the lake shores of the rural areas of Mikkeli. This makes the city the second most popular summer cottage areas in Finland. In Mikkeli, there are around 700 lakes and ponds and water covers 424.7 km2 of the city. In 2019 there was 12,747 ha of agricultural land in Mikkeli and 479 farms in total. (Riihelä et al. 2015)

Economic context of biomass sector

This section puts into perspective the economic context of the sector under study. It describes how many people are employed in this sector, as well as who the main actors involved (from all lifecycle stages for the sector's materials) are.

	GVA (monetary value, in €)	Employees
Mikkeli	353,200,000	653
Etelä-Savo	784,800,000	3,724
Pohjois- ja Itä-Suomi	9A	9B
Finland	13,750,000,000	65,159

The biomass sector in Mikkeli

Mikkeli is rich in forest resources and water bodies, but its industrial production relies heavily on the forest cluster surrounding the city. The major industries in Mikkeli are in mechanical wood processing and engineering. According to Kumpusalo, important future trades in Mikkeli might be with the production of various bioproducts, expertise in bioenergy and environmental technology. (Kumpusalo 2020, Mikkeli Development Miksei Ltd)

The biomass sector is smaller in Mikkeli compared to the surrounding areas in South-Savo region. In South-Savo, forestry-, farming- and fishing industries are the fourth largest in employment (Etelä Savo Ennakoi 2021). In Mikkeli, these are only the twelfth largest industry sectors in employment. The most significant employment sectors in Mikkeli are in health- and social services, manufacturing and in wholesale- and retail trade. (Data of Statistics Finland on industries and employees in Mikkeli)

The actors of the biomass sector

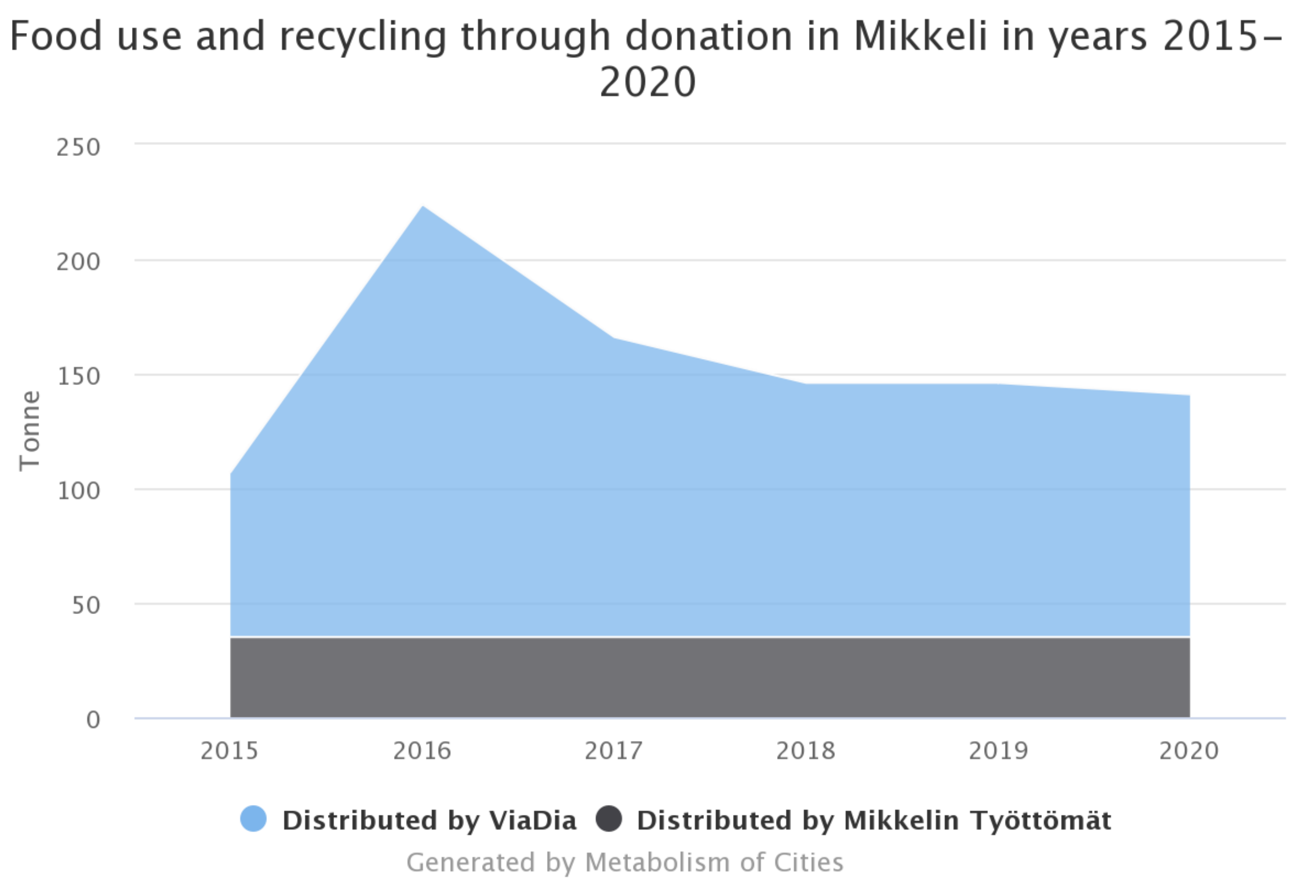
[Data source](#)

Actors in waste collection and treatment

The main actors in waste collection and treatment in Mikkeli are seen in the map of actors. Metsäsairila Ltd. is the municipal waste company of Mikkeli. Metsäsairila has one main waste collection- and treatment area and three smaller waste stations in conurbations in Mikkeli. There are several other companies in the waste business such as RL Huolinta Ltd. which concentrates in the collection of waste. Mikkelin Romu Ltd. mainly recycles metal, wood, cars and CDW material. Lassila & Tikanoja Ltd. collects and recycles paper, glass, cardboard, metal and plastic. In addition to waste stations there are around 60 recycling points in Mikkeli where one can recycle paper, glass, cardboard, metal and plastic.

Actors in recycling

Mikkelin Toimintakeskus assoc. focuses on reuse by fixing and upcycling goods and materials. They collaborate with the waste companies and sell products in several stores in Mikkeli. ViaDia Mikkeli assoc. and Mikkelin Työttömät assoc. both collect food waste (expiring food) from grocery stores in order to distribute it as food aid.



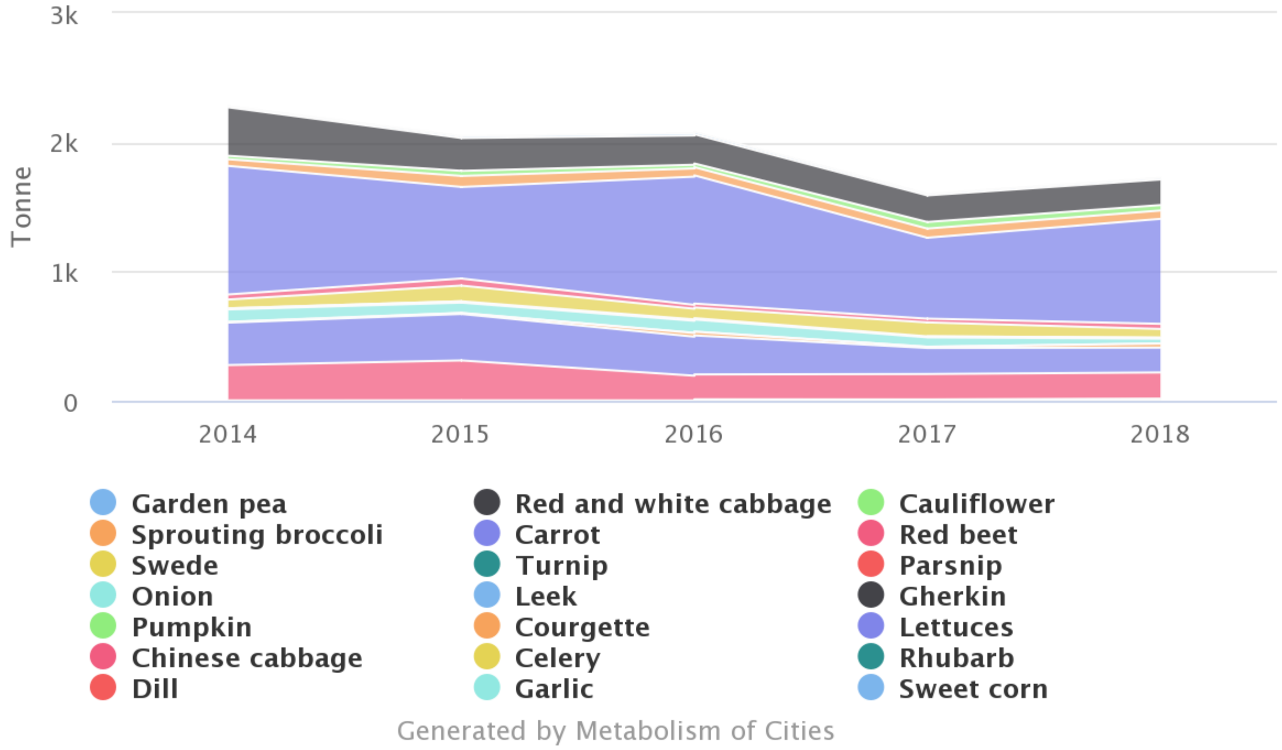
Data source

Actors in production of food

In Mikkeli area, there is some primary production of food, but only a little of further processing it. Cultivation of vegetables, berries, cereals and production of milk have had an important role both in South-Savo region and in Mikkeli. As it can be seen in the charts below, carrots, cabbages and lettuces are the main vegetables produced in Mikkeli. Strawberries, currants and raspberries are the main berry products cultivated in the area. For cereal products, farming oats is clearly favoured.

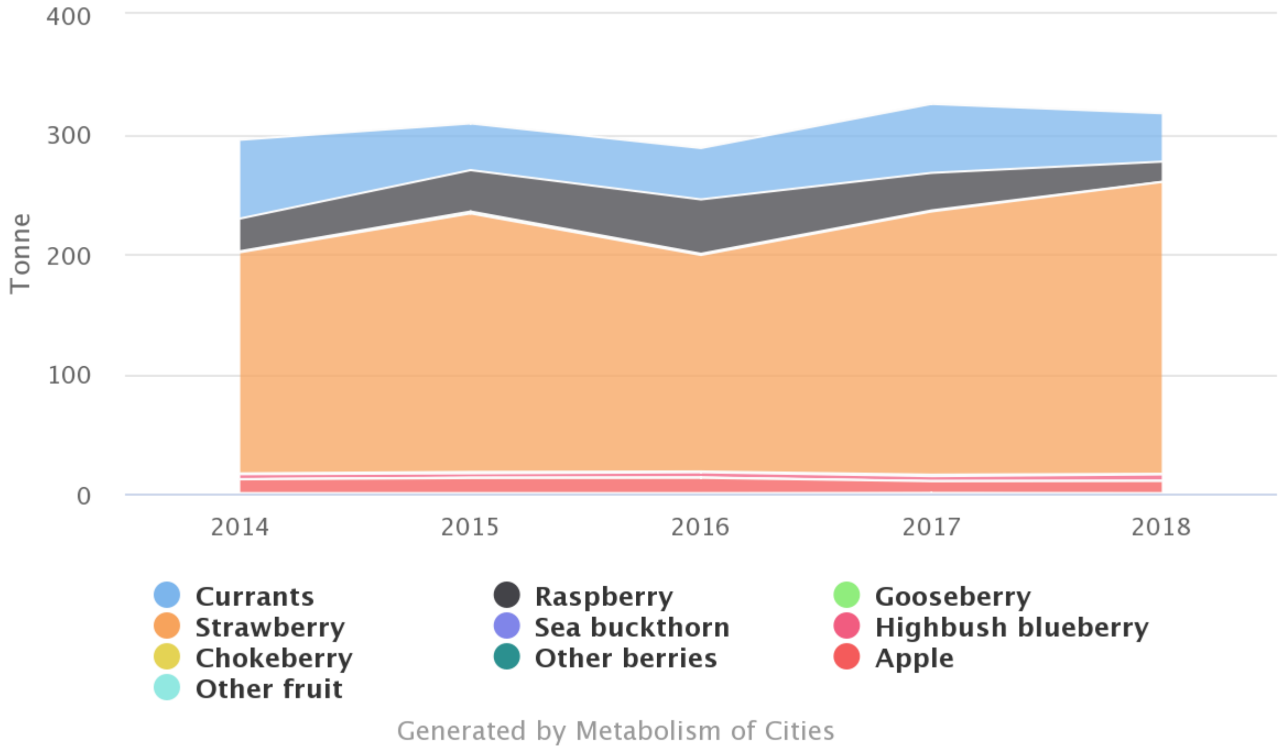
Milk production has been important in the South-Savo area, but for several years has been steadily declining. In Mikkeli there is less milk production than in the surrounding areas of the city, and farming is shifting towards the municipalities surrounding it. This is well expected, since to enhance production, the size of the farms and fields need to grow and there is simply more farming land available in the rural areas. The number of farms are also declining, since small farms either need to invest and grow in size or find other means to support their livelihood in the countryside.

Cultivation of vegetables in Mikkeli (from Etelä-Savo data) in years 2014-2018



[Data source]

Cultivated amount of berries and fruits in Mikkeli (from South-Savo data) in 2014-2018



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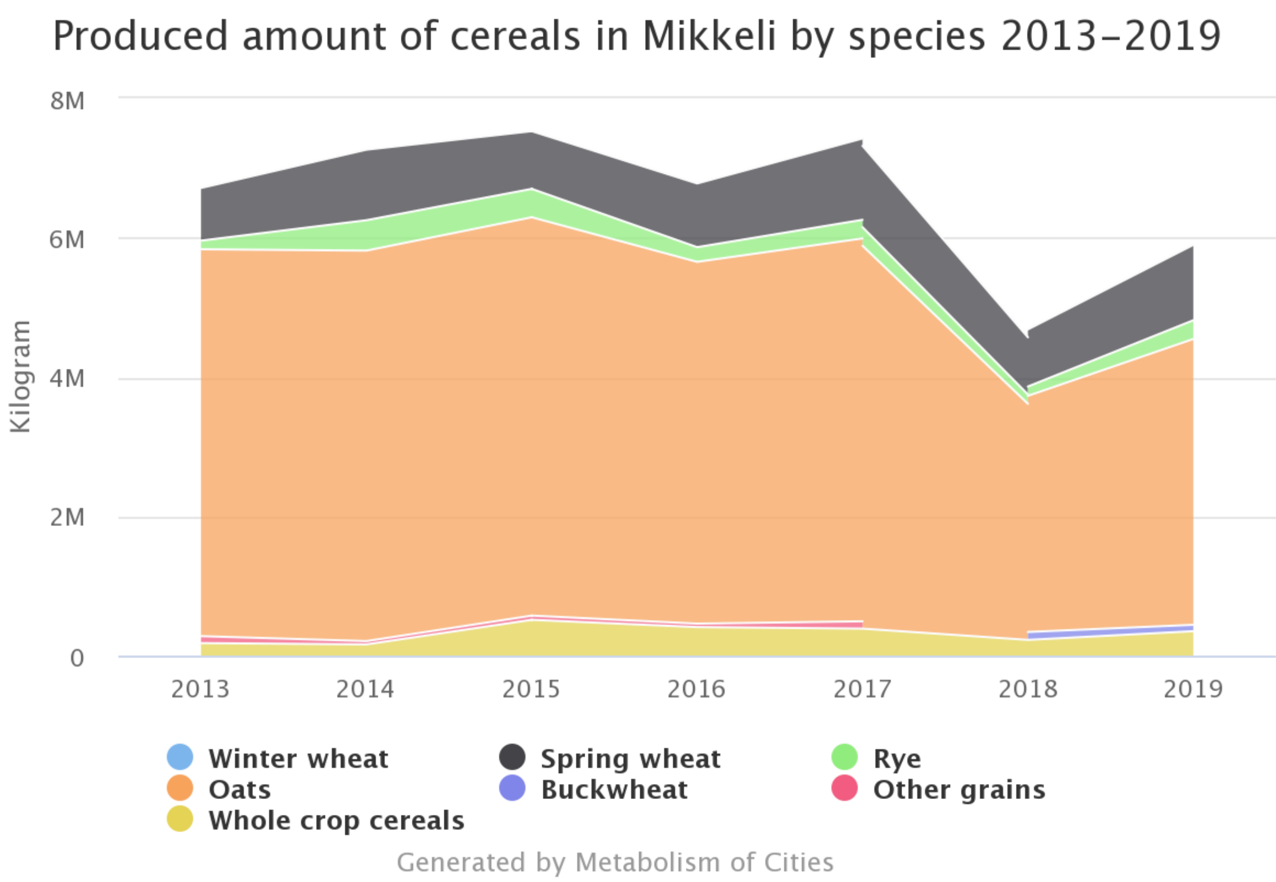

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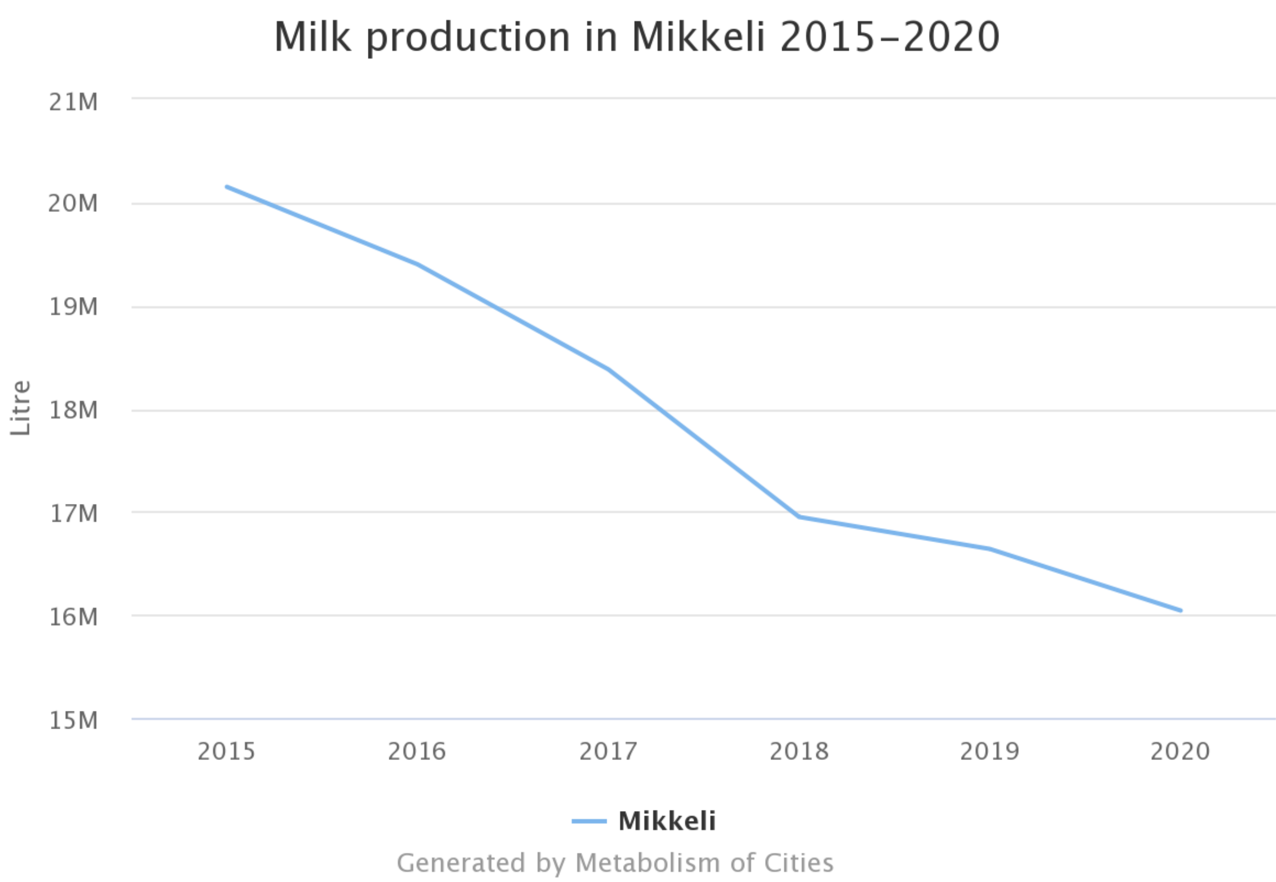


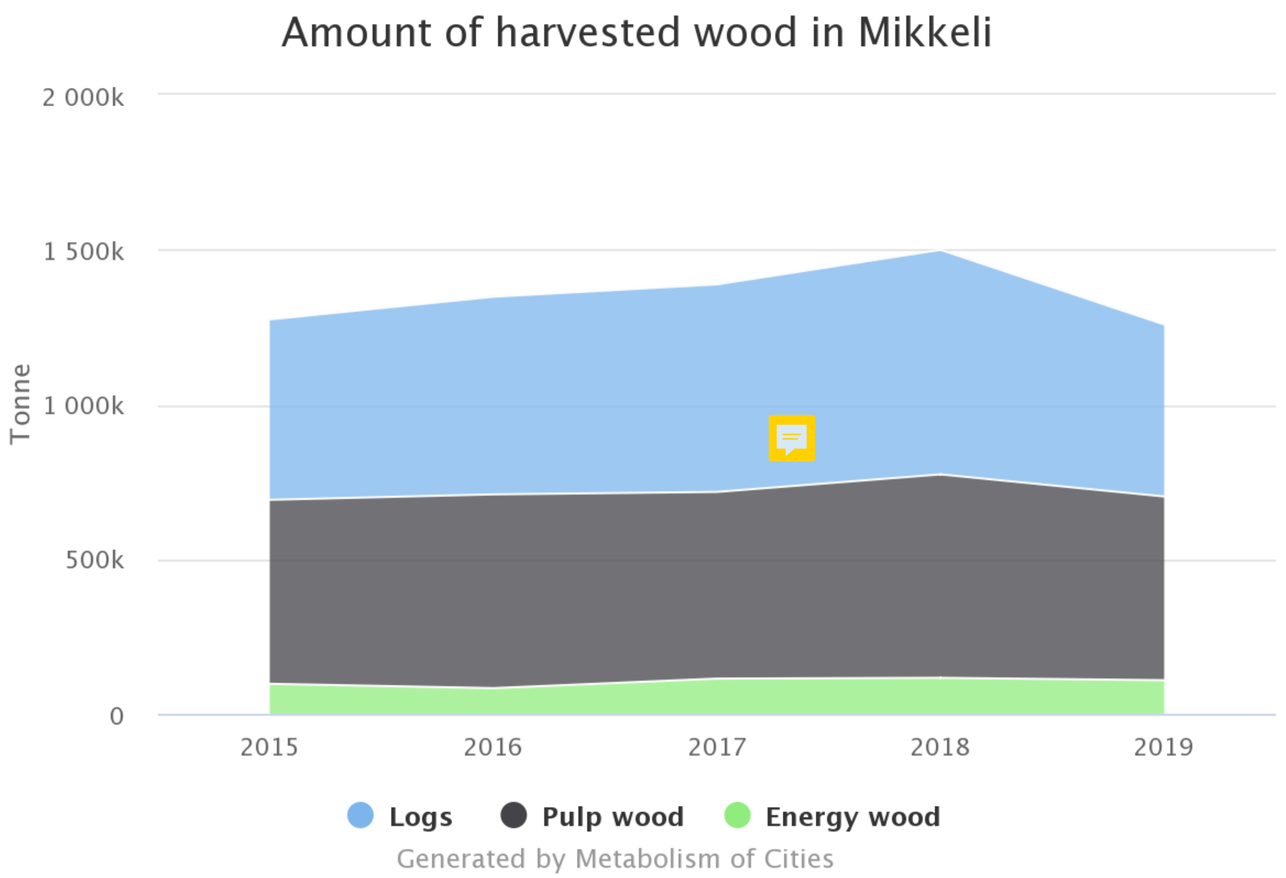
Data source

Actors in manufacturing of food

In further processing these farmed goods, the main actors in Mikkeli are Suur-Savon Leipomo Ltd. for bread and other baking products, HK Scan Mikkeli Ltd. which produces meat products, sausages and ready-meals. There are plenty of smaller producers in Mikkeli, which some can be found in this link.

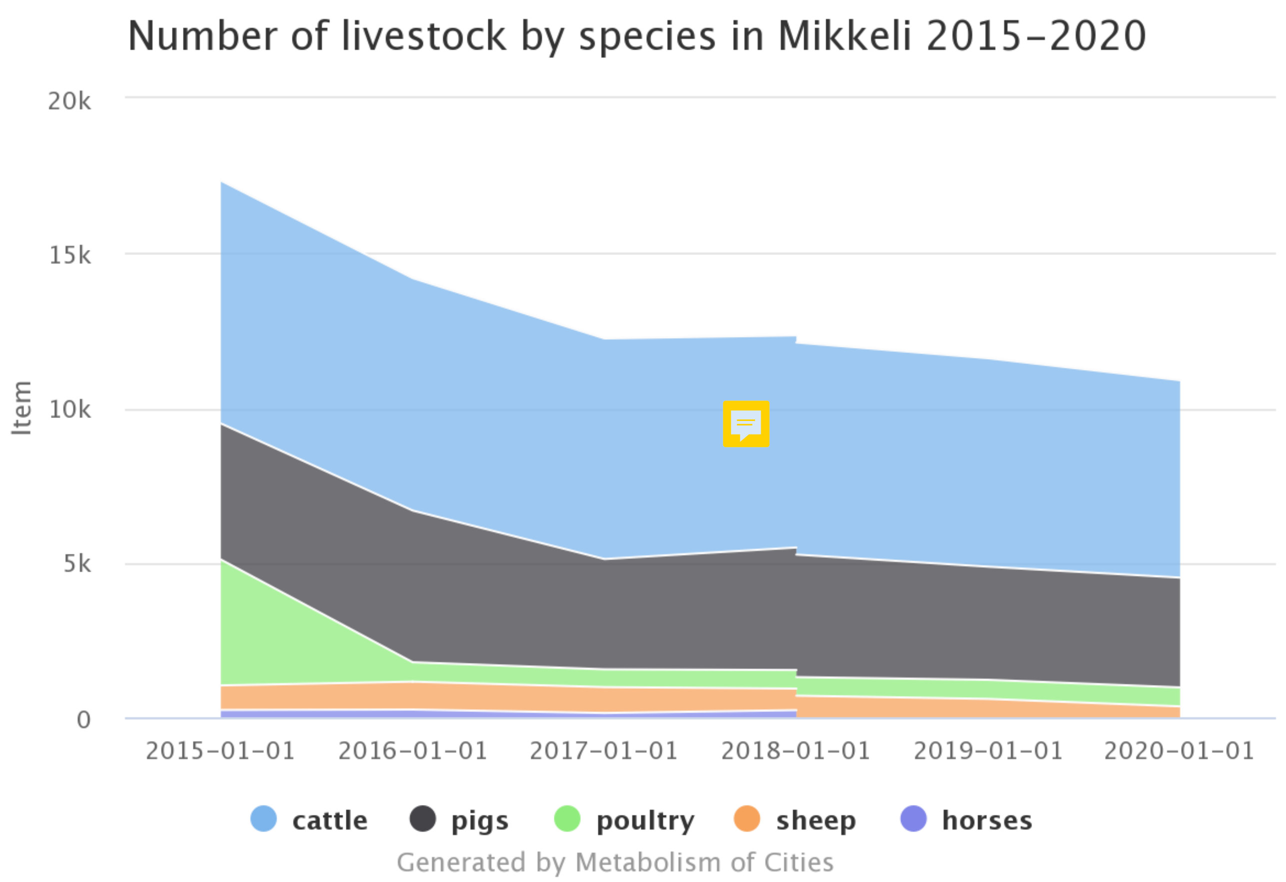
Actors of biogas refineries and the production and distribution of heat, energy and gas

Etelä-Savon Energia Ltd. is a local energy company in Mikkeli that produces energy, heat and biogas. At the Pursiala power plant, Etelä-Savon Energia Ltd. (ESE) produces about 100 GWh of electricity, 400 GWh of district heat and 20 GWh of industrial steam annually. The plant is fueled by wood 80% and peat 20%. ESE owns part of the biorefinery Biohauki Ltd and distributes transport biogas through 4 of its biogas stations in Mikkeli and Kuortti. ESE also distributes the biogas produced from the new biogas refinery BioSairila Ltd.



Data source

Biohauki Ltd. is a small biogas refinery in the rural area of Haukivuori, designed to produce methane from the manure of livestock and hay from the surrounding areas. The by-products of this refinery is then transported back to the farms inorder to use as soil improvers for the cultivation of crops.



Data source

BioSairila Ltd. began its biogas production in year 2021. Biosairila is owned by the municipal waste company Metsäsairila Ltd. (70%) and the energy company Etelä-Savon Energia Ltd. (30%). The biorefinery treats sewage sludge, biowaste and agricultural and industrial by-product streams generated in Mikkeli and the surrounding areas. The end products of biorefining is biomethane processed into transport fuel and fertilizer and soil improvement products. At full capacity, the plant will produce approximately 1.5 Mm3 (1,000 tons, 15 GWh) of transport biomethane, which corresponds to the annual consumption of approximately 2,000 passenger cars.

Indicators

To monitor the progress of this economic sector towards circularity, a number of indicators were proposed and measured. Altogether, these indicators depict several facets of circularity of the sector. As such, they need to be considered in combination rather than in isolation when assessing circularity. In addition, these indicators can be compared to other cities or spatial scales (such as the country level). However, this has to be done with great care and use of the contextual elements in the previous sections of the report. Finally, the value measured from these indicators can be traced over time to track the sector's progress towards circularity.

Indicator number	Indicator	Value	Unit
34	Domestic material consumption (DMC)	906,983.00	Tonnes/year
41	Share of secondary materials in DMC	0.33	%
48	EU self-sufficiency for raw materials	1.04	%
53	Quantity of material for anaerobic digestion	0.00	Tonnes/year
56	Quantity of material for composting	7,469.00	Tonnes/year
57	Amount of sector specific waste that is produced	22,733.00	Tonnes/year
58	End of Life Processing Rate	40.17	%
59	Incineration rate	0.00	%
61	Landfilling rate	0.00	%

Indicators 34, 41, 48

- Domestic material consumption (DMC)
- Share of secondary materials in domestic material consumption
- EU self-sufficiency for raw materials

In the strategy of the city of Mikkeli (strategy 2018-2021): Establishing new opportunities from the use of material flows in Mikkeli, the idea is to increase the utilisation of reused and recycled materials. This saves in extraction and use of virgin materials. In Mikkeli, biowaste has been recycled for years into soil products, but now the intention is to upcycle the biowaste material into biogas. From the by-products of the biogas process, the nutrients are developed into soil improvers and fertilisers. By producing and using biogas from biowaste, the city is able to reduce the usage of fossil fuels. The extraction of nutrients from the reject water of the biogas process, reduces the need to extract and use virgin fertiliser chemicals.

Materials such as wood and peat have been a stable source of energy and heating in Mikkeli. Now peat is being slowly abandoned because of the negative environmental effects. Locally produced peat for energy use, is coming to an end. New sustainable and local energy sources need to be developed.

Wood is still an abundant resource in Finland and Mikkeli, but cold winters set a challenge in self-sufficiency. It is not sustainable nor economical to use logs that can be further manufactured, for energy- and heating purposes. This is well respected throughout Finland, so instead wood chips and other by-products from the forest industry are used at district heating plants such as Etelä-Savon Energia´s Pursiala plant. During cold peaks in winter, there is occasionally shortage of local wood chips and by-product wood for heating purposes. This is then imported from other parts of the country or Russia. Mikkeli keeps on pursuing to be more sustainable in its energy- and heat production.

Concerning the indicator 41, the expected outcome of these actions in Mikkeli is 5% reduced consumption of virgin materials at city level, compared to the start of the CityLoops project.

The results of the Sector-Wide Circularity Assessment research for domestic material consumption in Mikkeli is 17 tonnes per capita. This is a slightly higher value when compared to the average in Europe of 13.4 tonnes per capita. The corresponding value in Finland is at 31.6, making the difference to Mikkeli at 14 tonnes per capita. This result is very interesting and seems that in this comparison the city of Mikkeli is doing quite well with using less resources in material consumption.

Indicators 53, 56, 57, 58, 59, 61

- Quantity of material for anaerobic digestion
- Quantity of material for composting
- Amount of sector specific waste that is produced
- End of Life Processing Rate
- Incineration rate
- Landfilling rate

In the city strategy of Mikkeli, the aim is to reduce traffic emissions and increase the use of biofuels for city transportations. In this aim, it is vital to be able to provide the city with enough biofuel made of local biowaste. Further promoting and adding the coverage of the biofuel distribution network, as well as growing the number of biofuel vehicles used in the city is needed. This would then set a good base for a more sustainable and self-sufficient production and use of fuels.

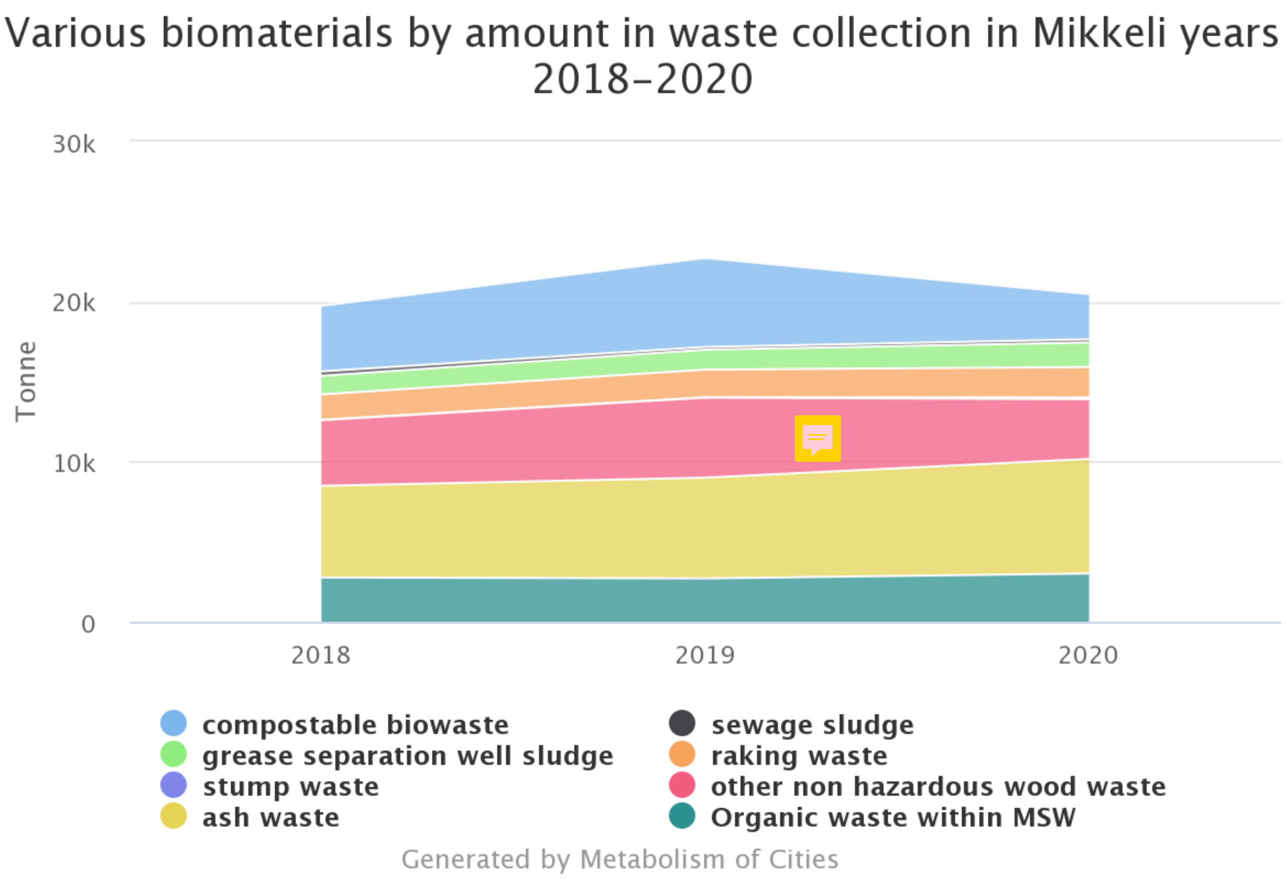
Previously, there has only been one biogas refinery in Mikkeli, Biohauki Ltd. This plant was designed to start its production in the year 2017, but because of having problems with its construction, began its production in the year 2020. Now even larger biogas refinery, BioSairila Ltd., has been recently taken to use in year 2021.

To be able to produce and distribute more biofuels in Mikkeli, more biowaste is needed to be collected in the city. The city strategy (2018-2021) has the aim of increasing the recycling of biowaste by improving sorting and collection (residential waste, waste recycling: Baseline 98.6% / Target 99%).

The study in Mikkeli (South-Eastern Finland University of Applied Sciences´ study of waste composition in Peitsari area) show that there is still much biowaste to be salvaged from the municipal solid waste going to incineration. This biowaste could be recycled if it were collected separately and placed in the proper biowaste collection bins by the citizens. The study showed that about 35% of the municipal solid waste is of recyclable biomaterial. This raw material could be used in upcycled products such as biofuel and soil products. Landfilling is not an issue in Finland or Mikkeli, since non-hazardous bio-waste has not been landfilled, but has mostly been composted into soil products.

The CityLoops project in Mikkeli has several expected outcomes for the collection, treatment and use of biomaterials. These are:

- Increasing upcycled amount of CDW/soil and organic waste 50% by the end of project.
- Increasing recycling/reuse rate of CDW/soil and organic matter: Increased recycling rate of bio-waste in the demonstration area (Peitsari) within the demo action.
- Increasing recycling/reuse rate of organic matter within the city boundaries: increase of soil products made from bio-waste.
- 10% reduction in the amount of organic waste landfilled or incinerated.



Data source

In the results of the Sector-Wide Circularity Assessment research, it should be noted, that some waste is exported to incineration. This waste includes the municipal solid waste (MSW) and the biowaste within MSW (not recycled by the citizens). Stump waste and other non hazardous wood waste are used mostly as raw material for the Pursiala power plant. These organic matters are substantial in weight when compared to the total amount of biowaste accompanied for. Also ash (from the Pursiala plant) and grease separation well sludge cannot all be recycled into upscaled products, so they are recycled in building the grounds of the landfill.

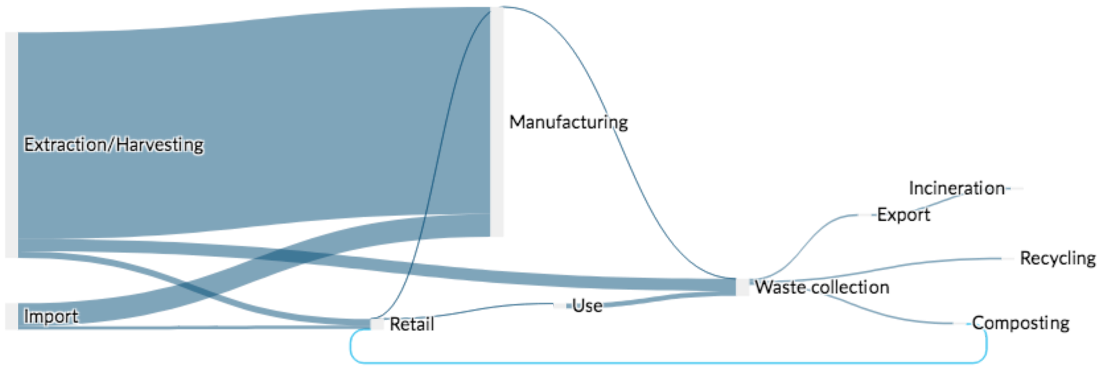
Benchmarking the different indicators need more insight in the particular matters that are studied for the comparison, in order to be just, and to be taken into account properly. It is possible, that wood materials, ash and grease are not accounted for in the compared numbers of the studied EU countries. Exporting some materials to incineration, might not give the right picture in the calculated indicators. Perhaps there should be developed a standard for various biowaste materials accounted for in waste management, in order to compare information between other EU countries. For more information about the different biowaste materials that are included in the study of biowaste in Mikkeli, please see the collected data in the graphic above.

Visualisations

Measuring circularity is a data heavy exercise. Numerous datasets were collected and visualised throughout the sector-wide circularity assessment process. To synthesise these findings, a Sankey diagram illustrates how material flows from the studied economic sector are circulating from one lifecycle stage to another. The height of each line is proportional to the weight of the flow. This diagram therefore helps to quickly have an overview of all the materials flows that compose the sector and their respective shares. The flows that are coloured in light blue in the Sankey diagram, are return flows. This means that they flow in the opposite direction of the lifecycle stages and are subjected to reuse, redistribution, or remanufacturing. Their size relative to the others is a good indication for the materials' circularity.

The Sankey diagram describes well the large extraction volume of biomaterials in Mikkeli. These flows come from the forestry and farming sectors of the city. Since the city is small and there is a lot of rural area surrounding it, the citizens have the opportunity of favouring and consuming local produce. However there is little further manufacturing of food in Mikkeli, so the locality consists mainly from items such as vegetables, roots and tubers, berries that do not need processing. Other materials consumed in the city are manufactured and processed outside the city, and are therefore imported.

There is very little amount of export in the biomaterial sector, but perhaps some of this is explained in the difficulty of getting import and export information in city-scale. There are many small producers in the city, that mainly sell their produce for local use and there is no information on the material being further exported. As mentioned before, there are only a few bigger manufacturers of bakery and meat products but these companies did not give out information of their produced or exported volumes.



Data source

Data quality assessment

Numerous datasets were collected and considered in the sector-wide circularity assessment. In some cases, datasets were not available for some materials or for some lifecycle stages for the studied sector. Therefore, estimations need to be done by looking at data at higher spatial scales (region or country). This section qualitatively assesses how reliable the data used is.

Data quality

Before describing data gaps and assumptions, the overall data quality is considered. It is expressed through four data quality dimensions that are depicted in the data quality matrix: reliability, completeness, temporal correlation, and spatial correlation. Each dimension has its own criteria for the ranking of high (green), medium (yellow) and low (red), which is based on this Pedigree report and shown in the table below. There can be additional explanations in some cells, as supporting information.

Rating	*Reliability*	*Completeness*	*Temporal correlation*	*Spatial correlation*
high	*Reviewed or measured data*	*Data exists for all of the single materials and their respective economic activites*	*Data less than 3 years difference to the time period of the data set*	*City-level data*
medium	*Estimated data*	*Data exists for most single materials and most economic activities*	*Data less than 6 years difference to the time period of the data set*	*Regional-level data (NUTS 3)*
low	*Provisional data*	*Data exists for the sector only for the Life Cycle Stages*	*Data less than 10 years difference to the time period of the data set*	*NUTS 2 and country-level data*

Data quality matrix

Lifecycle stage	**Reliability**	**Completeness**	**Temporal correlation**	**Spatial correlation**
Extraction/Harvesting				
Manufacturing				
Retail				
Use				
Stock				
Waste collection				
Landfill				
Incineration				
Recycling				

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
Anaerobic digestion				
Composting				
Imports				
Exports				

Information of extraction and harvesting was mostly obtained from LUKE, the Natural Recources institute of Finland. This data was mainly from the city scope, and only a little data was from the regional area. Information from this source is highly reliable.

Data was not available from manufacturing and retail. Information was asked from several main manufacturers in Mikkeli, but the companies either did not answer or did not want to give out the inquired information. Prodcom information was available on the national level, but was not used in Mikkeli, because it was thought to distort the picture, since there is less manufacturing of food goods in the city than in other areas in Finland.

For retail, information of selling food goods were asked from four main grocery chain stores in Mikkeli, but only got an answer from one chain. Other chains either did not want to give out the asked information or they did not answer. Because of this, information from the one chain was not used at all, since it was not possible to estimate the rest of needed information.

Here are some links to more information on these issues :

- Finlands Agriculture and food economy by LUKE. A report on growing, producing and use of different foods in Finland, also information of South-Savo Region (not city-level).
- 11b7 -- Industrial output by PRODCOM heading, 2013-2020

The data for use, was obtained from Statistics Finland and was highly reliable, however the data was in national scale, so it needed to be downscaled using a secondary proxy: earned income on average in year 2017 (information in year 2019 not available) of the country and the city of Mikkeli.

Information of waste collecting, treatment and mostly of recycling was obtained from the municipal waste company Metsäsairila Ltd. This information was highly reliable but there was some information given, that was not simple to interpret so there might be a quality gap in the interpretation of the data. Of course there are still unkown flows of biomaterials, for which were not counted for.

Data gaps and assumptions

The data gaps in import and export were closed through obtaining national level data, and downscaling the data into city level by using a primary proxy of employment in the wholesale and retail trade. This proxy information for downscaling was from the year 2018 for both national and city level.

The data for use was downscaled using a secondary proxy, which was earned income on average in the year 2017. From the year 2019, information was not available for both country and the city of Mikkeli.

Only a few data for extraction and harvesting needed downscaling, these were: berries and fruits, vegetables and wood. These were downscaled from regional level to city level using the amount of hectars used for cultivation in the areas. Also some items in extraction and harvesting needed to be converted from land use into yield to get the mass (kg or tonnes) of the material. For this conversion information of the yield of different produce was used from the FAOSTAT (Food and Agriculture Organisation of the United Nations).

Data analysis

This section analyses the Sankey diagram developed in the previous section. It discusses and interprets the results for the sector-wide circularity assessment. It also reflects on how the current demonstration actions fit within the bigger picture of the sector, as well as how they could be upscaled to accelerate the transition towards a more circular sector.

Insights on status quo of the biomass sector

There are many circular flows in the city but some of the flows are quite small in mass. This indicates that there is willingness for circularity in the city but perhaps this is still quite new and in progress. All the different flows of biomaterial need to be better collected for reuse and recycling.

Connection to and upscaling of demonstration actions

The demonstration actions in Mikkeli target a very important flow of biowaste within the municipal solid waste. About 35% of the municipal solid waste consists of bio-waste that could be salvaged to recycling and upscaling. Motivating and guiding the citizens of Mikkeli to better recycle their waste is a good way to salvage some of that waste. The aim is to achieve 10% reduction in the amount of organic waste being incinerated by the end of the CityLoops project.

Different ways of biowaste collection need to be resolved especially in the scarcely populated areas of the city. How this should be done, is still left for discussion: Should multi-compartment waste bins be available for the detached houses or should there be shared biowaste bins for the neighbourhoods? How should collecting biowaste be billed as a service by the companies that collect waste? These questions are tackled in the busines case report as well as in a workshop.

Recommendations for making the biomass sector more circular
Some materials such as ash is used in the building of landfill areas. Some ash material may be used as fertiliser in the forests or may be added to soil improvers or soil products. However this depends on the composition of the ash waste, and how much it contains harmful substances, and therefore dictates on the possibilities of being recycled. It is not only a question of willingness to recycle, but also the safety of recycling different substances must be taken in account. There should be further study of how to recycle ash better, since there is an abundance of this material available for reuse and recycling.

Non-hazardous wood waste is a large fraction of the biowaste sector. This is mostly incinerated for heat and energy production, but more insight should be obtained in how this material could be better upscaled and reused so less virgin material would be needed through extraction. The problem in this is in the various levels of quality in the material which contributes to the need of assessing the materials, dividing in different fractions for different kinds of use. This work is difficult to implement cost effectively. Some insight to this can be obtained from various studies and projects. Here is a report on from 2017 on the Recovery and potential of biodegradable waste from the forest industry.

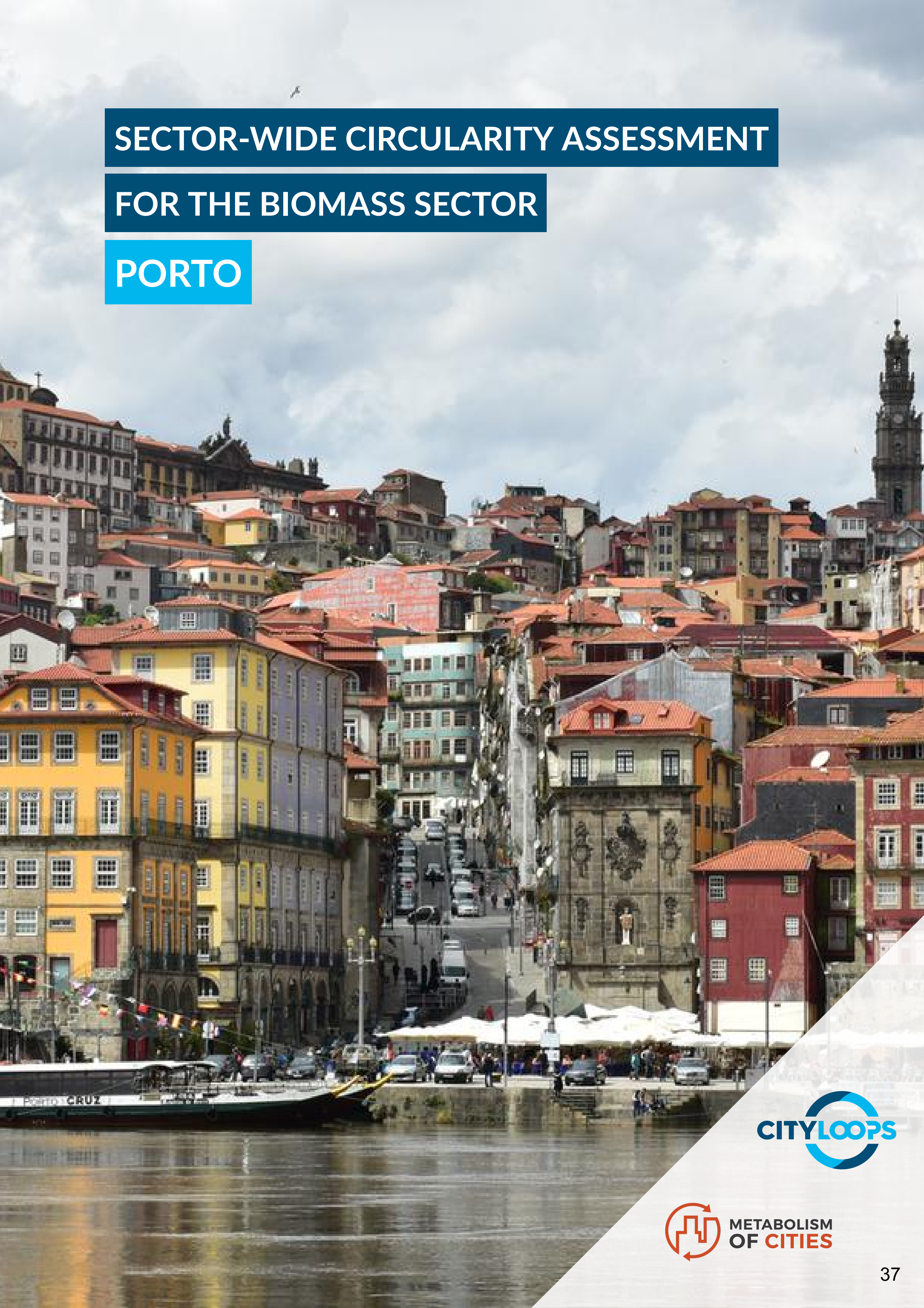
The new biogas plant in Mikkeli will be able to process and upscale sludge, garden- and park material, food waste and other biowaste materials into biogas. This is a very good way to upgrade the material into useful products that reduce the usage of fossil fuels. The traditional use for biomaterial as compost, soil products and fertilisers is still followed through by using the by-products of the biogas plant. For the sector of biowaste in Mikkeli, the recycling rate will continue to grow through the subjection of materials to the various reuse streams.

References

- Finland
- Pohjois- ja Itä-Suomi
- Etelä-Savo
- Population of Mikkeli in years 1994-2019 line diagram
- CORINE Land Cover 2018, 25 ha, Mikkeli
- Waste collection and treatment facilities in Mikkeli map

SECTOR-WIDE CIRCULARITY ASSESSMENT FOR THE BIOMASS SECTOR

PORTO



CITYLOOPS

METABOLISM OF CITIES

Introduction

The EU Horizon 2020 funded CityLoops project focuses on closing the material loops of two central sectors of any city in terms of material flows, societal needs and employment, namely the construction and biomass sectors. Due to their sizes, they represent a considerable opportunity for cities to transform their metabolism and economy towards a more circular state.

Within this project, seven European cities, amongst those also the City of Porto are planning to implement demonstration actions to kickstart their circularity journey. To better understand what the current circularity status quo is, as well as the impact of these actions, and the efforts needed to transform their sector, a Sector-Wide Circularity Assessment method was developed. This method combines a circular city and circular sector definition, a material flow and stock accounting method, as well as circularity indicators. The sector itself was defined in terms of a number of representative materials that make up a large share of the sector and associated economic activities. The biomass sector is made up of 12 materials, depicted as icons here, which were studied along the entirety of their supply chains. Altogether, these elements help to set a solid knowledge and analytical foundation to develop future circularity roadmaps and action plans.

Cereals	Dairy products	Fish
Fodder crops	Fruits	Garden and park materials
Live animals	Oil-bearing crops	Roots, tubers
Sugar crops	Timber	Vegetables

The assessment was carried out by the cities themselves after receiving extensive training in the form of courses on data collection (construction and biomass) and data processing. Numerous additional insights can be found in the individual Data Hubs of each city.

This current Sector-Wide Circularity Assessment report provides contextual information on the city and the economic sector under study. It then illustrates how circular these sectors are through circularity indicators and a Sankey diagram. Finally, it analyses and interprets the results, presents the limitations from the data used and offers recommendations about how to make this sector more circular.

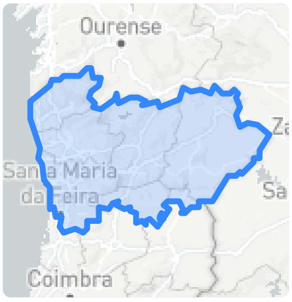
(The italic texts in this report were written by Metabolism of Cities' Aristide Athanassiadis and Carolin Bellstedt. They provide relevant general information and serve as connecting elements of the single report parts.)*

Urban context

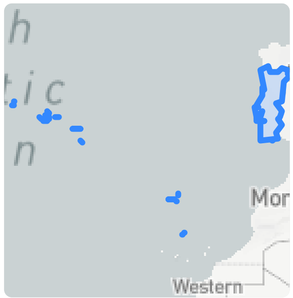
To contextualise the results of the sector-wide circularity assessment, this section provides population and land use information data of the city. In addition, population and area of the city under study, as well as its corresponding NUTS3, NUTS2 and country were included. Data for these scales were added to better understand how relevant and important the approximations are when downscaling data from these scales to a city level.

Porto
216,606
41 km^2

Área Metropolitana do Porto
1,728,226
2,041 km^2

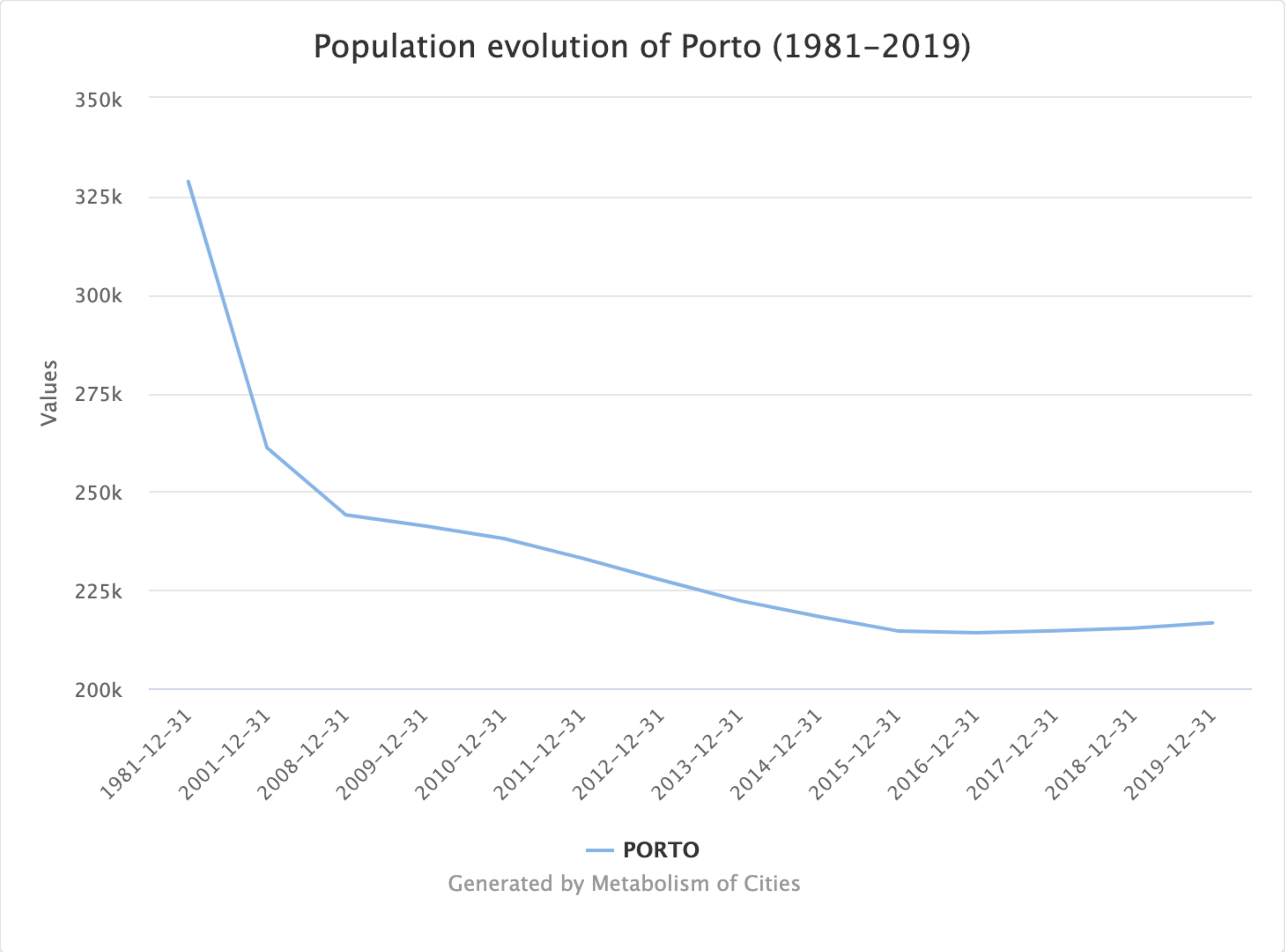


Norte
3,575,338
21,286 km^2



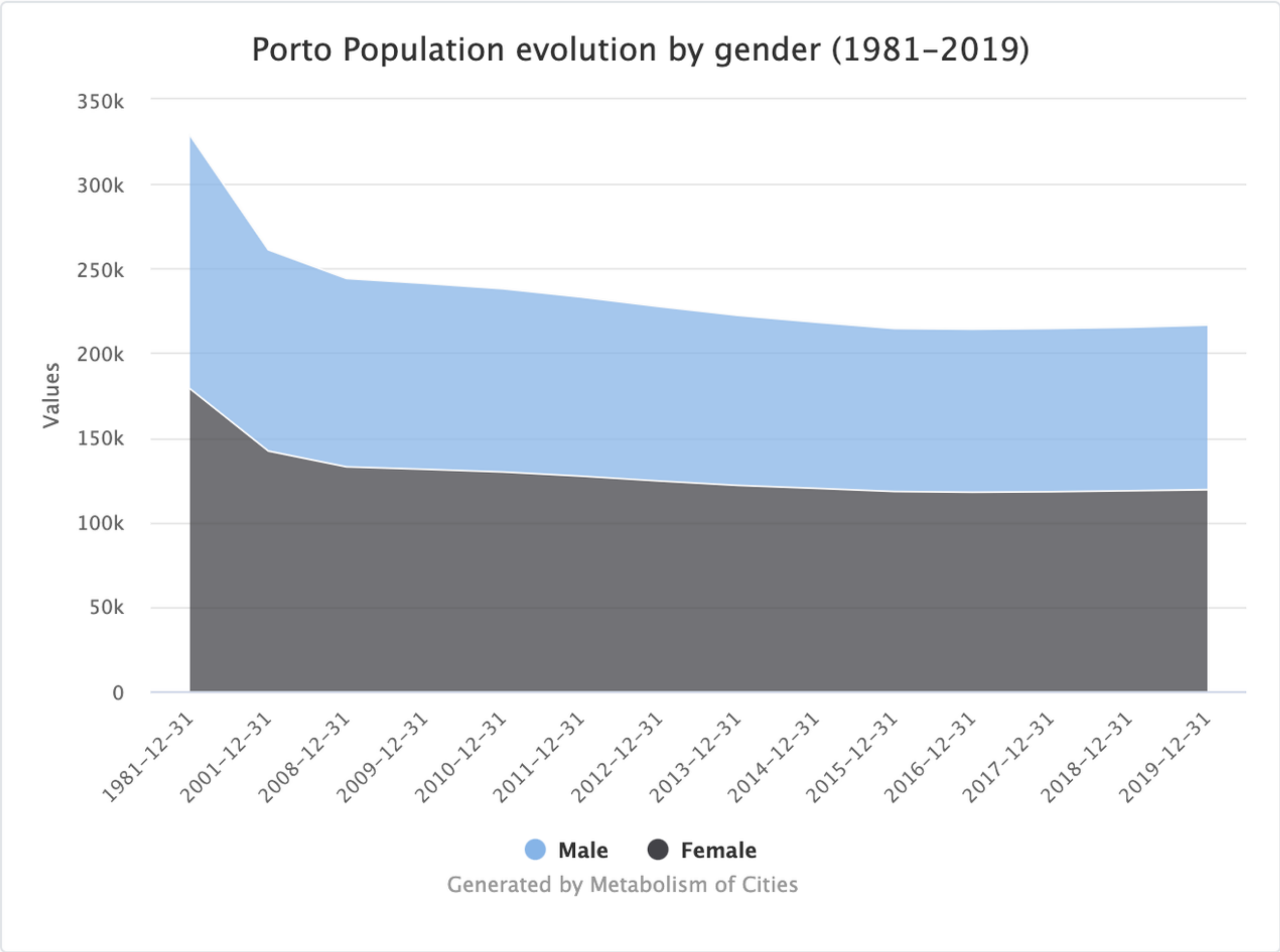
Portugal
10,295,909
92,226 km^2

Population of Porto



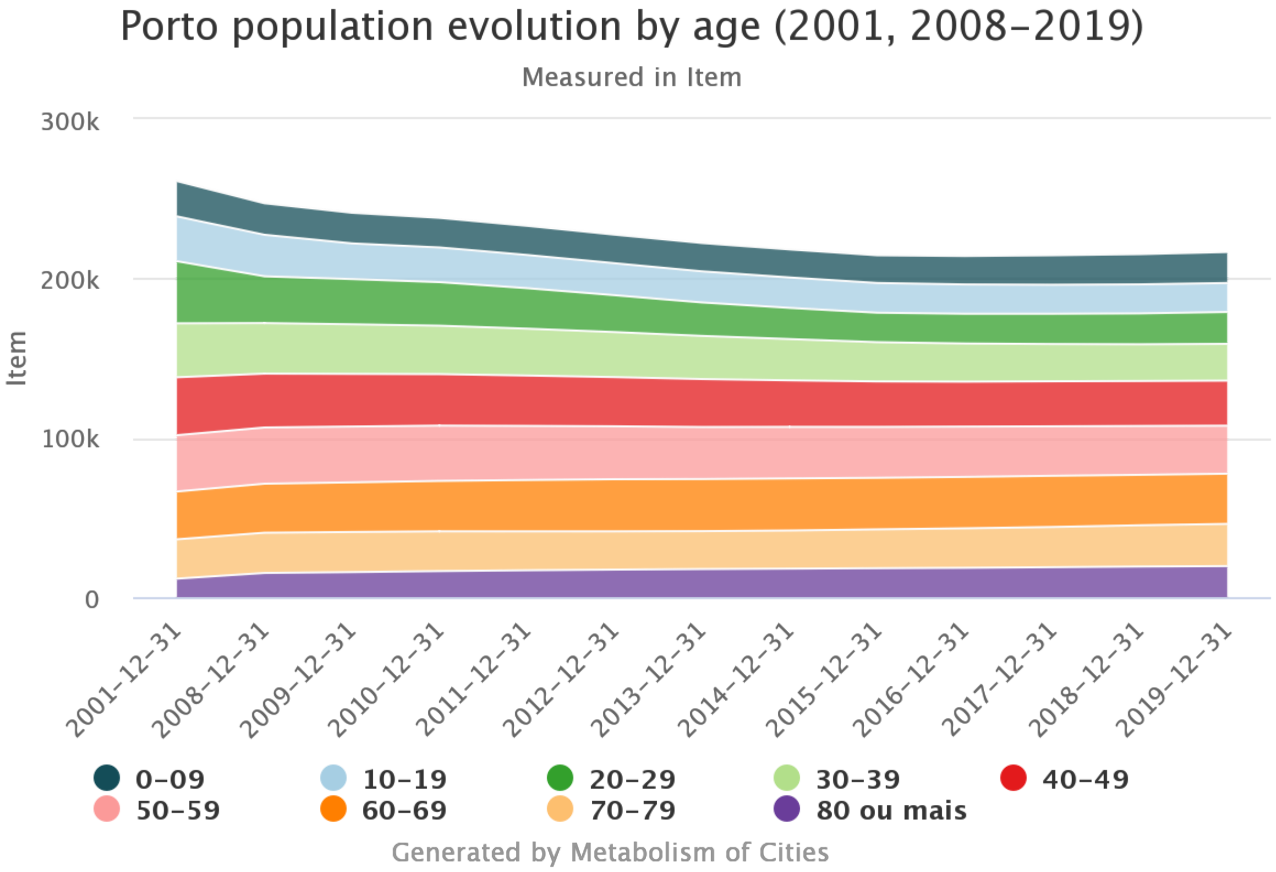
Data source

Despite the fact that Porto has suffered high population decline in recent decades, it looks like it has seen a small population growth since 2017, in part as a result of the city's rising reputation as a place to live. Nowadays, around 216,606 persons (2019) live in the city. The city is in majority female with 55% of the population and 45% being male, following the trend of the regions where it is located and of the country itself.



[Data source](#)

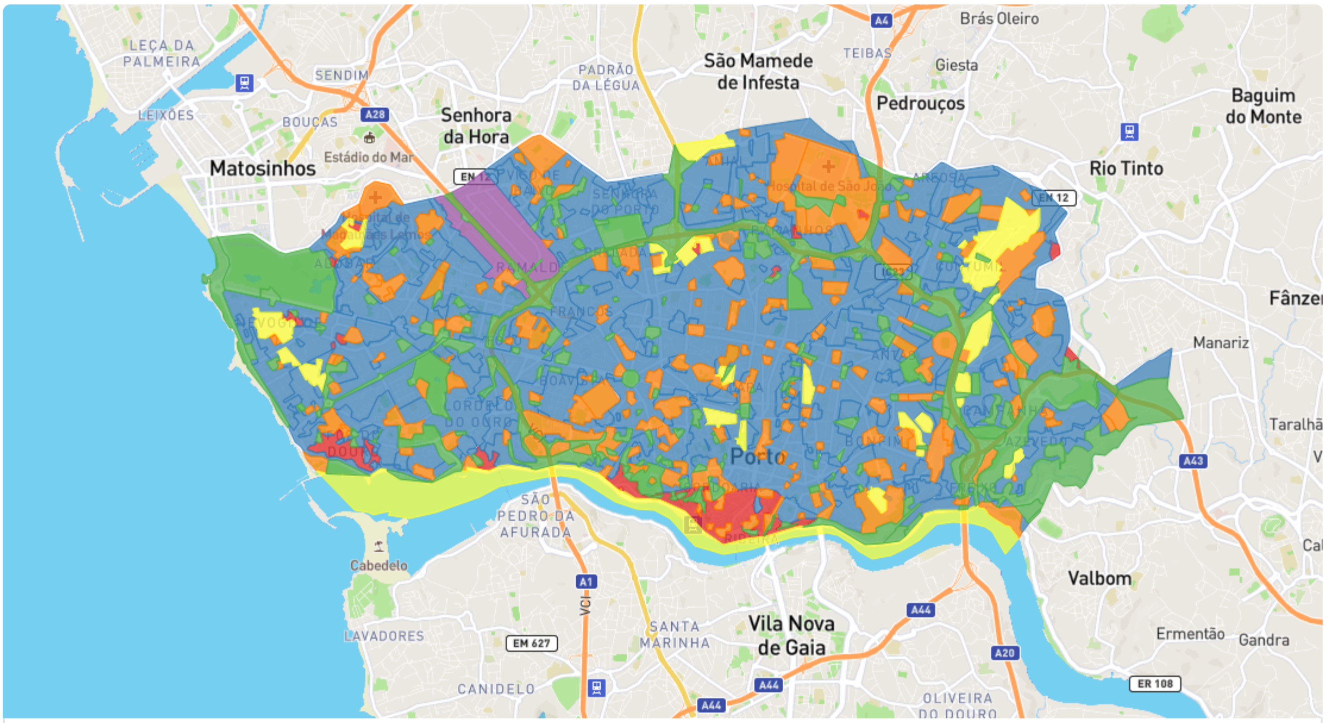
In terms of age, as shown in the 2019 data, 72% of the population of Porto are between 0 and 64 years and the elderly population represents 28% of the total population.



Porto population evolution by age (2001, 2008–2019)
Measured in Item
300k
200k
100k
0
Item
2001-12-31
2008-12-31
2009-12-31
2010-12-31
2011-12-31
2012-12-31
2013-12-31
2014-12-31
2015-12-31
2016-12-31
2017-12-31
2018-12-31
2019-12-31
0–09
10–19
20–29
30–39
40–49
50–59
60–69
70–79
80 ou mais
Generated by Metabolism of Cities

[Data source]

Land use



- Central Space
- Residential Space
- Green Space
- Economic Activities Space
- Special Use Space - Equipment and Infrastructure
- Not Assigned

Porto's land use is urban and mostly classified as space for economic activities with 21.63 ha. The historic area is composed of 1.39 ha and the residential space occupies 1.23 ha of the territory. The green spaces only occupy 0.58 ha of the territory.

Economic context of biomass sector

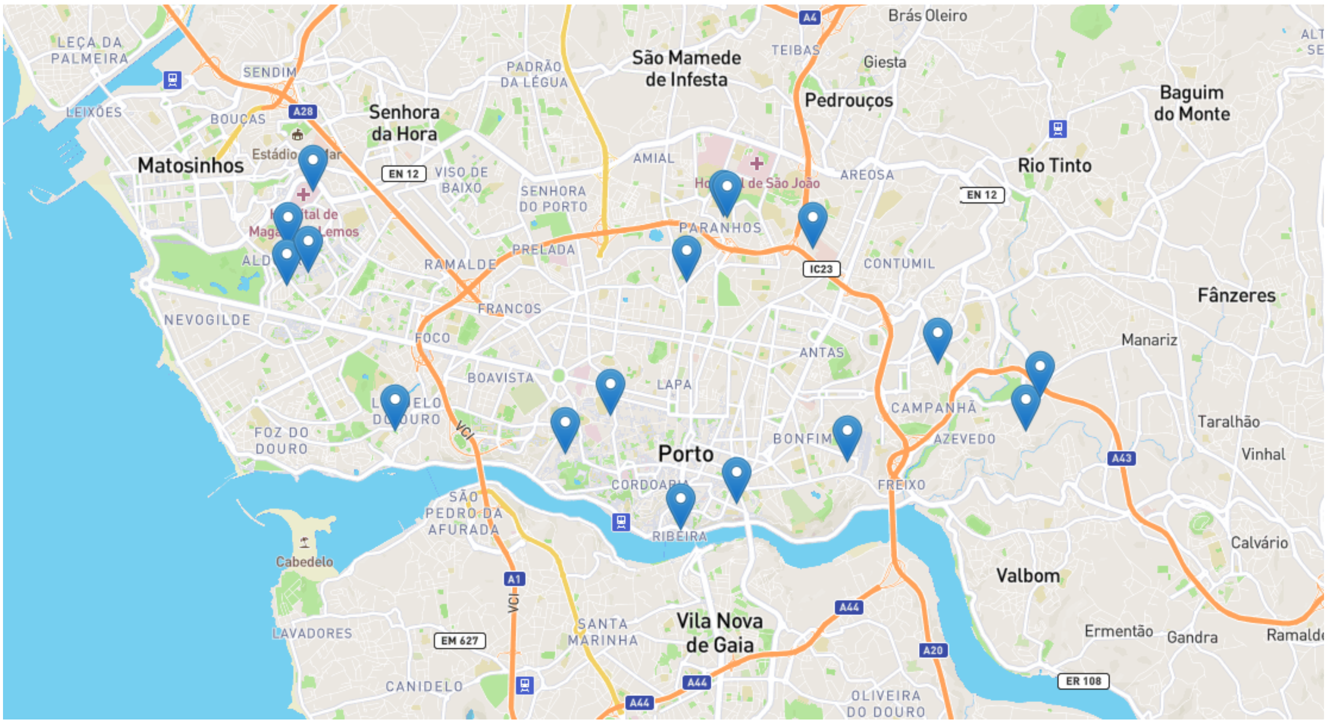
This section puts into perspective the economic context of the sector under study. It describes how many people are employed in this sector, as well as who the main actors involved (from all lifecycle stages for the sector's materials) are.

	GVA (monetary value, in €)	Employees
Porto	548,104,939	31,981
Área Metropolitana do Porto	2,136,865,552	127,700

	GVA (monetary value, in €)	Employees
Norte	3,418,700,948	247,985
Portugal	14,196,449,624	819,111

The biomass sector in Porto

In terms of harvesting, the city of Porto has some small local farmers, producing either for their own consumption, for sale to individuals, or for collaboration with agricultural cooperatives. It is also possible to find in the city the municipal nursery and 13 municipal urban farms available and for the benefit of the community.



[Data source]

Within the City of Porto, as far as manufacturing industries are concerned, it is possible to identify three factories oriented towards the food sector, namely one whose economic activity is sugar refining and two others of which both operating at the cereal milling level, and one of the companies (Cerealis), in addition to the factory located within the limits of the municipality of Porto, also has as a sector of activity the manufacture of pasta and the production of cookies, crackers, toast and preserved pastry, whose manufacturing takes place outside the municipality. There is also, within the beverage industry, some production of craft beer in the city.

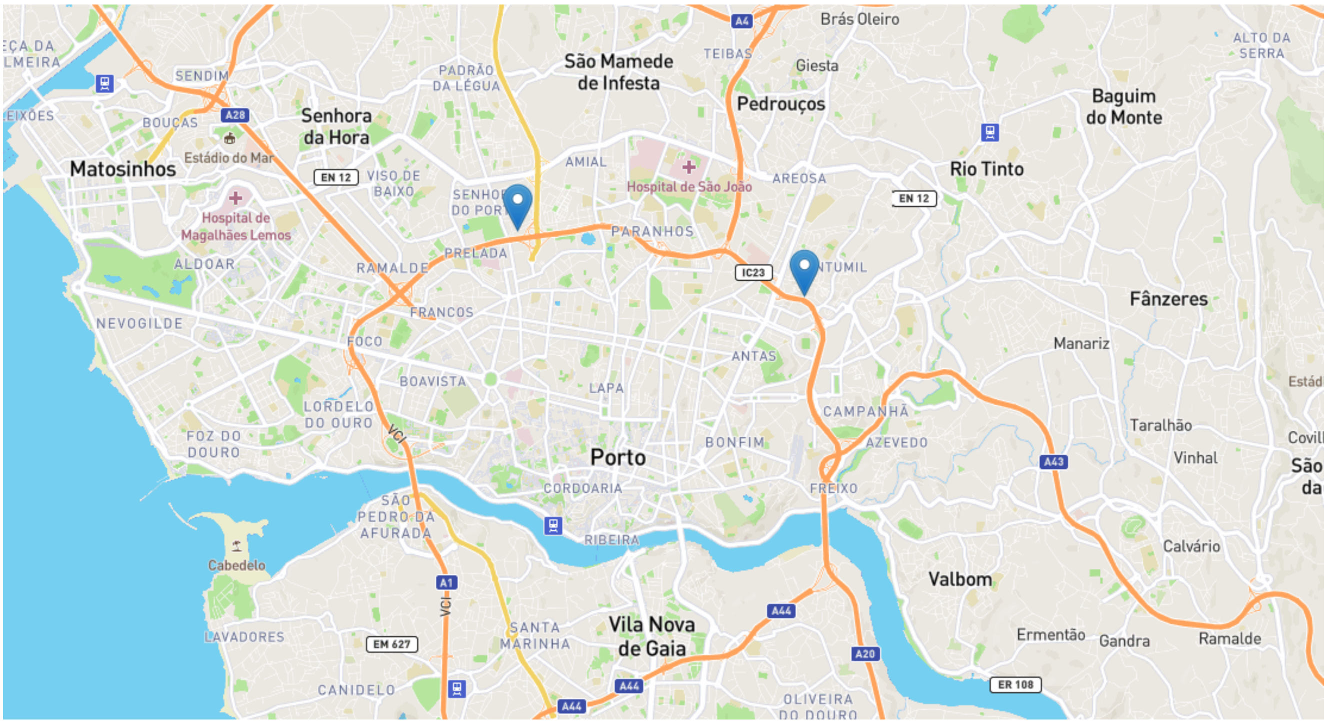
Regarding agricultural production, it occurs mostly outside the limits of the Municipality of Porto. However, although few, it is still possible to identify and locate some independent individual producers in the city, who grow and produce their agricultural products and cooperate with the Cooperative Fruta Feia, to which they sell the fruits and vegetables that they could not sell, due to their appearance or size; and also, independent producers selling their organic products on the platform Reforma Agrária.

The City of Porto is very much dominated by the tourism sector, so you can find a hotel or restaurant almost at every corner. The same can be said about commerce, with plenty of supermarkets and hypermarkets scattered around the city, as well as local markets and fairs (retail infrastructures), in which we can refer the biologic products fair in Porto City Park. Wholesale trade is mainly represented by the Mercado Abastecedor do Porto.

The City of Porto is also home to several educational, research institutions and startups, which contributes to the increase of the qualification of young population as well to the growth of the local economy, making the development of research and technological advances in the biomass sector and beyond possible. Some good examples of innovative projects in the field of food sector, that can be mentioned between many others, are Fairmeals, Noocity, Fruta Feia, Matter and MudaTuga projects.

In 2017, the Municipality of Porto created Porto Ambiente, which is the Environmental Company of the Municipality of Porto, in charge of managing urban solid waste and cleaning the public space (previously performed by private entities). Porto Ambiente is responsible for the collection of urban waste, ensuring the selective collection of recycled waste, such as packaging (plastic and metal), paper/cardboard and glass. Porto Ambiente is also in charge for the separate collection of bio-waste.

As the entity responsible for the management of urban waste in the municipality of Porto, Porto Ambiente provides around 3600 equipment for selective waste disposal and 5200 equipment for depositing mixed waste, distributed throughout the city, as well as two Civic Amenity Sites (CAS of Antas and CAS of Prelada), for the collection of Construction and Demolition Waste and bulky waste.



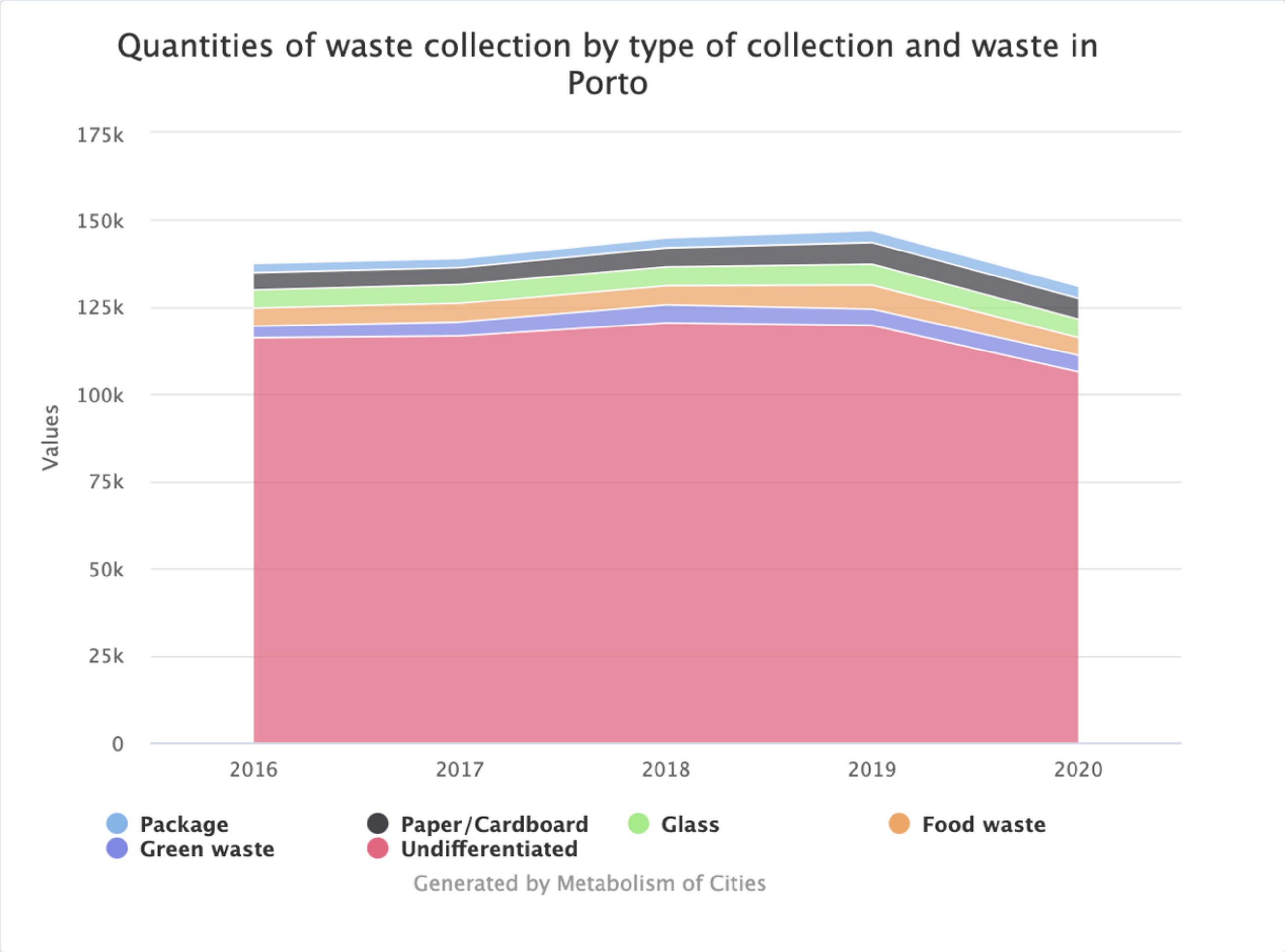
[Data source](#)

With regard to food waste, the door-to-door collection service in HORECA (Hotels, Restaurants, Cafés) channel began in 2008. Only in 2018, this type of food waste collection system was possible to expand to households, in some areas of the city of Porto, covering 30% of the city. Earlier in 2021, a new project for the collection of food waste in residential areas – Orgânico project-, through street bins has begun reaching 60% of the city. It's expected to have around 600 bins by the end of 2021.

The door-to-door collection applied to both sectors, commercial and residential, includes the selective collection of paper/cardboard, plastic/metal, glass and food waste. The collection of mixed waste is also included in this service.

Porto Ambiente also has a free service for collecting garden waste at home as well out-of-use objects (such as furniture) and electrical & electronic equipment.

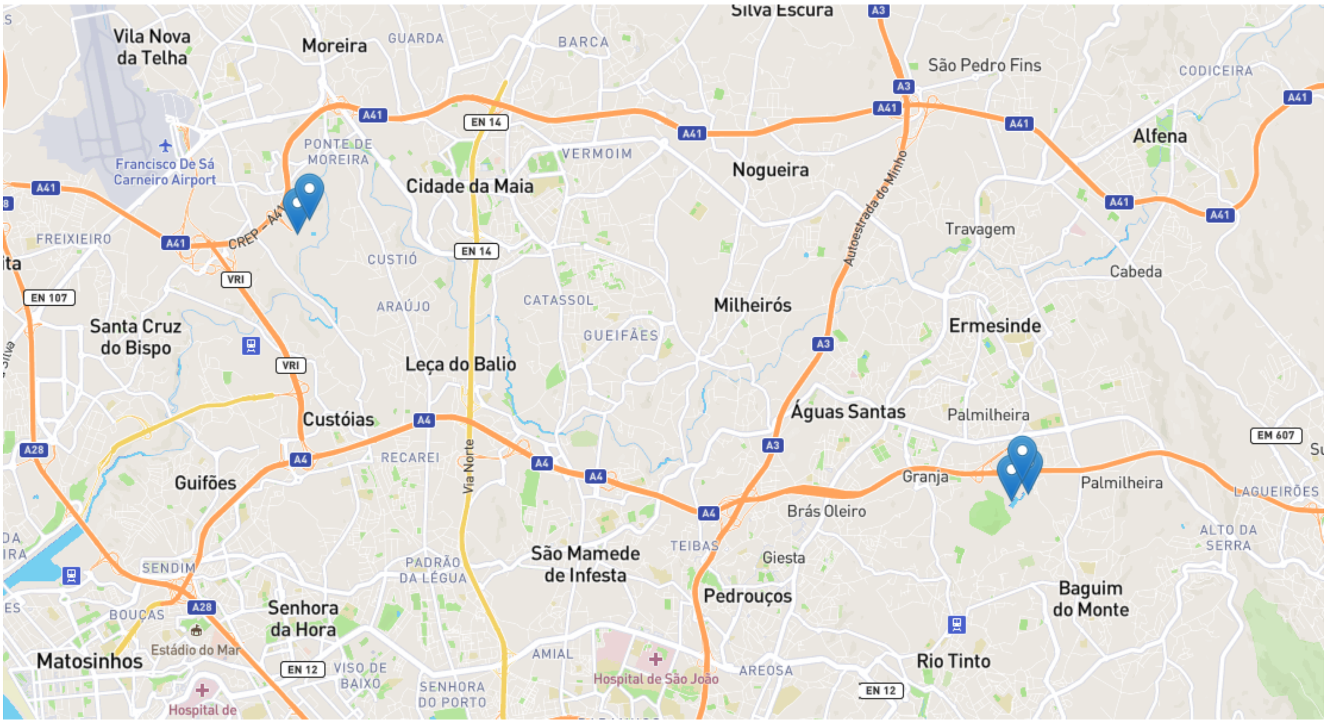
In 2019, the separate collection of food and garden waste had the values of 6,943 and 4,591 tons, respectively. The value of food waste collection is expected to increase in the future with the implementation of the food waste separate collection project, which has begun in 2021 and it's a part of the CityLoops project, more specifically at Demonstration Action 1.



[Data source]

After being collected, the waste is sent to LIPOR that has two main locations both outside the City of Porto. LIPOR is the Intermunicipal Waste Management Service of Greater Porto, an association of 8 municipalities (Espinho, Gondomar, Maia, Matosinhos, Porto, Póvoa de Varzim, Valongo and Vila do Conde) upholder by modern waste management concepts which promote the adoption of integrated systems and the minimization of waste disposal in landfill.

LIPOR has developed an integrated management strategy based on four key components: Multimaterial Recovery, Organic Recovery, and Energy Recovery, supported by a Landfill Site to receive the waste from processes and from previously prepared waste.



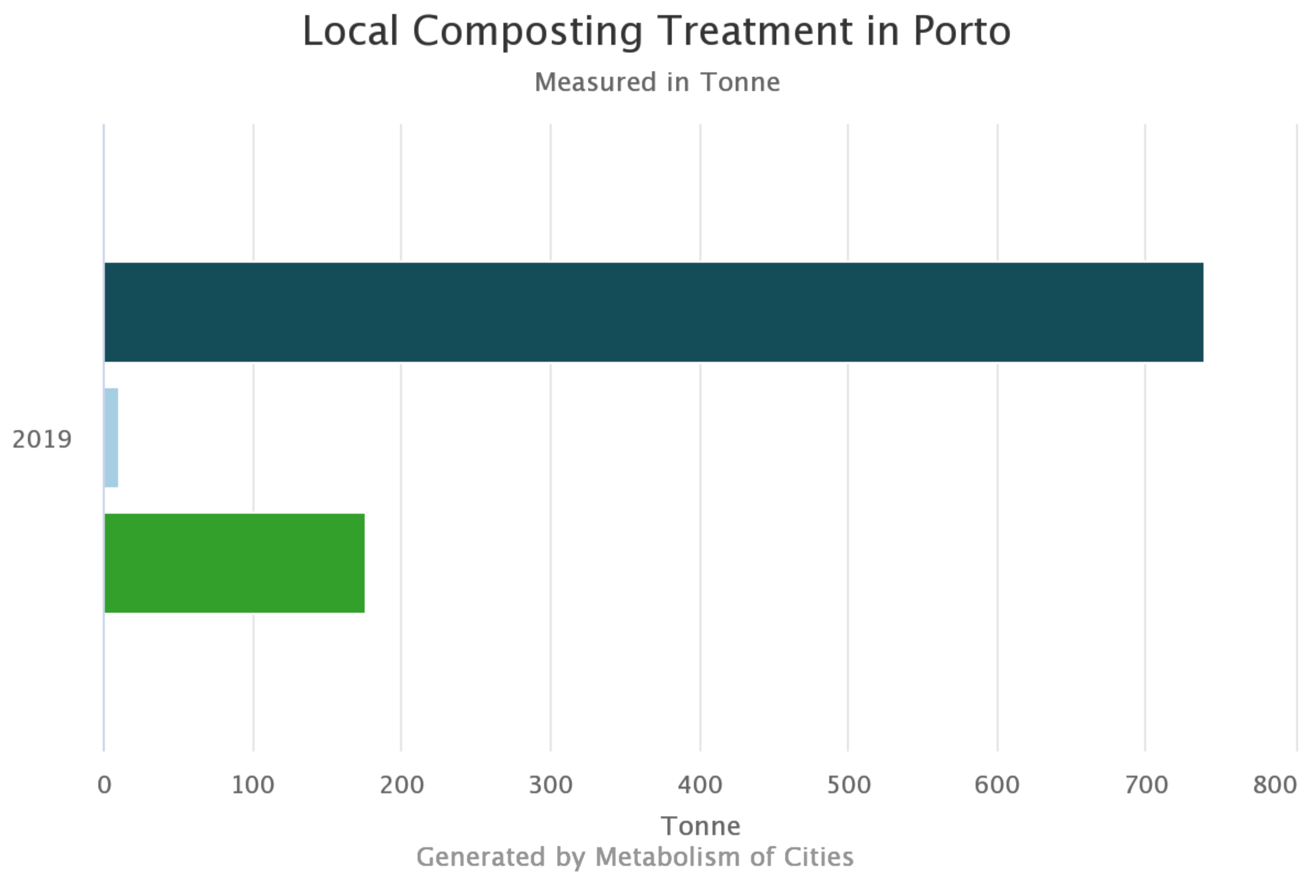
[Data source]

In 2019, LIPOR has received in its facilities approximately 545 thousand tons of urban waste (146,870 tons from the City of Porto), of which, about 74% were sent to the WtE Plant. According to the Integrated Report of 2019, from LIPOR, 58,791 tons of bio-waste waste were delivered to LIPOR's facilities.

The LIPOR Composting Plant, activated in 2002 and located in Baguim do Monte, has the capacity to recover 60 thousand tons/year of bio-waste from selective collection and it uses an in-vessel composting process, generating a high-quality organic soil ammender - the NUTRIMAIS (around 12 thousand tons/year of organic compost).

In the City of Porto, home and community composting is also an applied solution to treat bio-waste locally, and it is possible to find different types of composters (around 2,400) in homes, social organisations, municipal gardens, and composting islands, treating an estimated total of 927 tons of waste treated in local composting per year. The graphic below shows how this is distributed between home composting (dark blue, 740 tons), community composting (light blue, 11 tons) and urban farm composting (green, 176 tons).

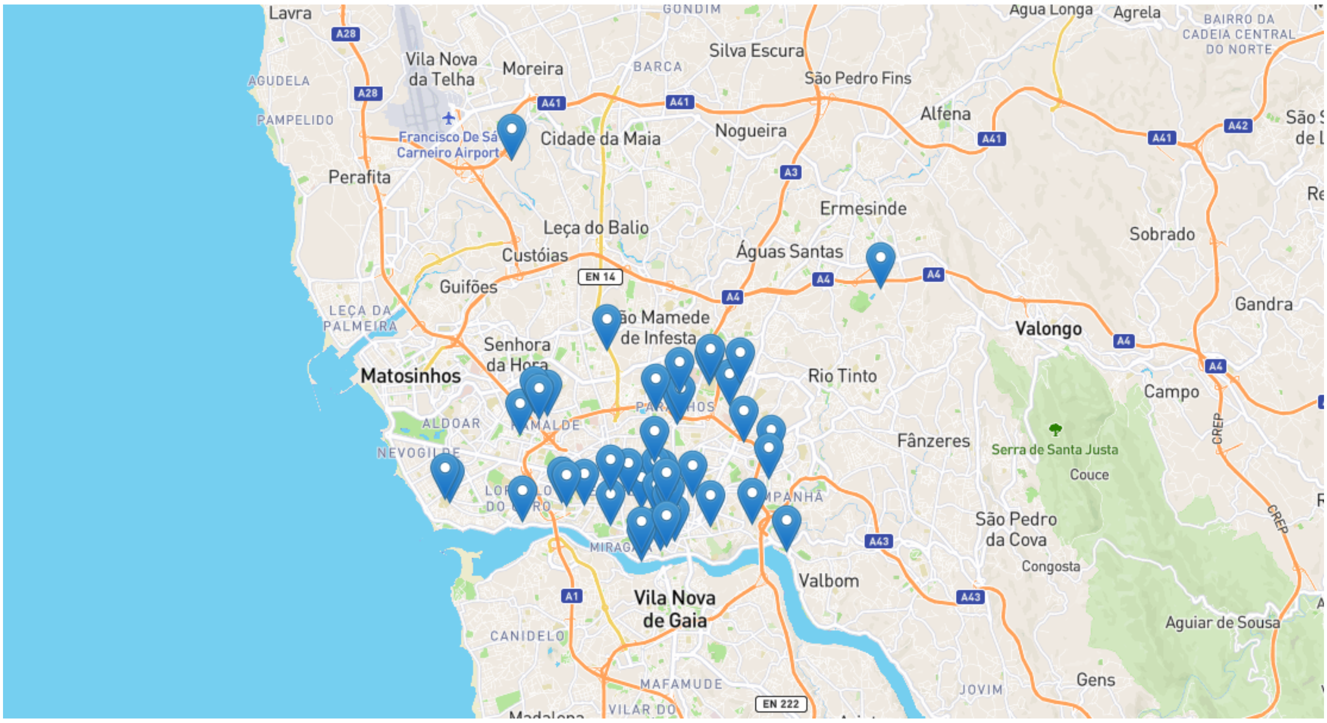
Within the CityLoops project, there were implemented local community composters this year (2021) - two areas with 15 community composters island in total and individual composters distributed to households to feed the new composters. The model is being tested with the vision to expand the local solution of food waste treatment and compost production to other areas of the city.



Data source

The LIPOR Waste-to-Energy Plant, located in Maia, intends to recover, in the form of electric energy, the waste fraction that cannot be used through composting and recycling processes. The WtE process occurs at a high temperature (between 1000ºC and 1200ºC) under excess oxygen conditions. The plant is energetically self-sufficient, that is, the plant has a treatment capacity of 38 000 tons of waste per year and produces about 170 000 MWh of electricity per year, of which about 90% is injected to the Portuguese national electricity grid network.

The actors of the biomass sector



[Data source]

When it comes to harvesting, there are small local farmers who, although it has not been possible to quantify them, entities such as AMAP Porto (Associação pela Manutenção da Agricultura de Proximidade), APANP (Associação dos Proprietários e Agricultores do Norte de Portugal) and the Associação dos Agricultores do Porto have been identified as representative of this subject.

In Porto, there are no extractive industries, but rather transforming industries, at the level of sugar refining (RAR), grain milling and pasta manufacturing, cereal and legume processing, and the manufacture of cookies, crackers, toast and preserved pastry (Moagem Ceres and Cerealis), as well as small several bread and pastry manufacturers, in the food industry, and also, in the beverage industry, it is possible to find some small craft brewers (e.g. Nortada).

The City of Porto also has plenty of retail infrastructures, from supermarkets to hypermarkets or convenience stores, which unfortunately follow the Portuguese trend regarding long food supply chains (90% of the food available); the main wholesale establishment in the city is the Mercado Abastecedor do Porto, where you can buy all kinds of food in bulk. Not forgetting the iconic Bolhão Market, where you can find all kinds of fresh and organic products, from fruit, vegetables, fish and meat, supporting short supply chains with regional food.

There are also several local markets with the purpose to support the local economy, that are usually held on a weekly basis, where can be find a wide variety of products, from clothing, live animals, plants and flowers and food products. There is also the weekly Fair of organic products market - a municipality-led initiative ongoing since 2004. It is organized in collaboration with a food producers' commission and takes place in the Porto's City Park on every Saturday mornings, stimulating local and regional production and consumption.

Porto is also very much driven by the hotel and restaurant (tourism) sector, and some associations representing these sectors have been identified as main actors, such as AHRESP (Associação da Hotelaria, Restauração e Similares de Portugal) and APHORT (Associação Portuguesa de Hotelaria, Restauração e Turismo).

Within the city you can find several educational and research institutions, also very important when it comes to the development of studies related to biomass, for example, the Faculty of Engineering, the Faculty of Sciences and the Faculty of Nutrition and Food Sciences of the University of Porto and the Superior School of Biotechnology of the Catholic University. Or even research institutions such as LNEG (National Laboratory for Energy and Geology), INESC TEC (Institute for Systems and Computer Engineering, Technology and Science) or, when it comes to development and innovation, the UPTEC (Science and Technology Park of the University of Porto) and the Porto Innovation Hub (an initiative of Porto Municipality).

Regarding the collection of bio-waste within the municipality, this is the responsibility of Porto Ambiente, as explained previously. Once collected, the bio-waste is sent for treatment in infrastructures outside the limits of the municipality, to the LIPOR infrastructures, where it will be processed and sent for final destination.

Indicators

To monitor the progress of this economic sector towards circularity, a number of indicators were proposed and measured. Altogether, these indicators depict several facets of circularity of the sector. As such, they need to be considered in combination rather than in isolation when assessing circularity. In addition, these indicators can be compared to other cities or spatial scales (such as the country level). However, this has to be done with great care and use of the contextual elements in the previous sections of the report. Finally, the value measured from these indicators can be traced over time to track the sector's progress towards circularity.

Indicator number	Indicator	Value	Unit
34	Domestic material consumption (DMC)	274,666.88	Tonnes/year
41	Share of secondary materials in DMC	1.25	%

Indicator number	Indicator	Value	Unit
48	EU self-sufficiency for raw materials	66.69	%
53	Quantity of material for anaerobic digestion	0.00	Tonnes/year
56	Quantity of material for composting	12,548.38	Tonnes/year
57	Amount of sector specific waste that is produced	39,364.38	Tonnes/year
58	End of Life Processing Rate	19.90	%
59	Incineration rate	68.12	%
61	Landfilling rate	2.04	%

Indicators #34, #41, #48

• Domestic material consumption (DMC): 274,666.88 ton

• Share of secondary materials in DMC: 1.25%

• EU self-sufficiency for raw materials: 66.69%

In the first indicator (DMC, #34) it was estimated a value of 1,268 ton per capita, lower than the value for Portugal (3,367 ton per capita).

Considering the value of the share of secondary material in DMC, the value is very low (1.25%), but with the increasing values for separate collection of bio-waste and the subsequent production of compost in LIPOR composting plant, located outside the city boundaries, and its partial application in the City of Porto, the value of this indicator will increase in the following years. For the increase of this value, it will also contribute the increase of local composting, considering the home composting, community composting and urban farms composting.

Indicators #53, #56, #57

• Quantity of material for anaerobic digestion (#53): 0.00 ton

• Quantity of material for composting (#56): 12,548.38 ton

• Amount of sector specific waste that is produced (#57): 39,364.38 ton

Analyzing these three indicators, it is possible to observe that 31,9% of the bio-waste produced in the City of Porto (39,364 kton) went to LIPOR composting plant (12,548 kton) in 2019. This might be the result of the implementation of the separate collection system of food and garden waste in the city. This percentage is rapidly increasing due to recent investments done by Porto Ambiente and will have a significant increase during the following years, as a result of these investments, including the investment in CityLoops Demo Action #1.

We can refer that LIPOR is preparing an investment on a new anaerobic digestion to treat bio-waste from the increasing separate collection systems being implemented in all the eight Municipalities in LIPOR region. This means that in the future indicator #53 won't be zero like it happens now.

Indicators #58, #59, #61

- EOL processing rate (#58): 19.90%
- Waste-to-energy rate (#59): 68.10%
- Landfilling rate (#61): 2.04%

The bio-waste sent to LIPOR composting plant, will produce a high-quality compost, commercialized with the brand "Nutrimais". The processing rate is 19.90%, which means that each ton of bio-waste received in this plant will produce 0.19 tons of compost.

Analyzing the waste-to-energy rate indicator, we can notice that 68.10% of the bio-waste collected in the City of Porto. However, as mentioned before, with the significant increase in the separate collection of bio-waste in the following years, increasing the circularity in the management of the bio-waste produced in the City of Porto, this indicator will decrease.

Considering the bio-waste send to the LIPOR waste-to-energy (WtE) plant, the sub-product of this treatment process (ashes) will be landfilled. Considering that the total amount of bio-waste send to the LIPOR WtE plant will originate 3% of ashes to be landfilled, the landfill rate estimated (#61) is 2.04%.

Visualisations

Measuring circularity is a data heavy exercise. Numerous datasets were collected and visualised throughout the sector-wide circularity assessment process. To synthesise these findings, a Sankey diagram illustrates how material flows from the studied economic sector are circulating from one lifecycle stage to another. The height of each line is proportional to the weight of the flow. This diagram therefore helps to quickly have an overview of all the materials flows that compose the sector and their respective shares. The flows that are coloured in light blue in the Sankey diagram, are return flows. This *means that they flow in the opposite direction of the lifecycle stages and are subjected to reuse, redistribution, or remanufacturing. Their size relative to the others is a good indication for the materials' circularity.*

The Sankey diagram describes the large import of materials for the biomass sector in the City of Porto (more than 282 kton in 2019) comparing to the extraction/harvesting activities (only 261 tons in 2019). These means that for the City of Porto almost all the materials required for the biomass sector came from outside the city boundaries.

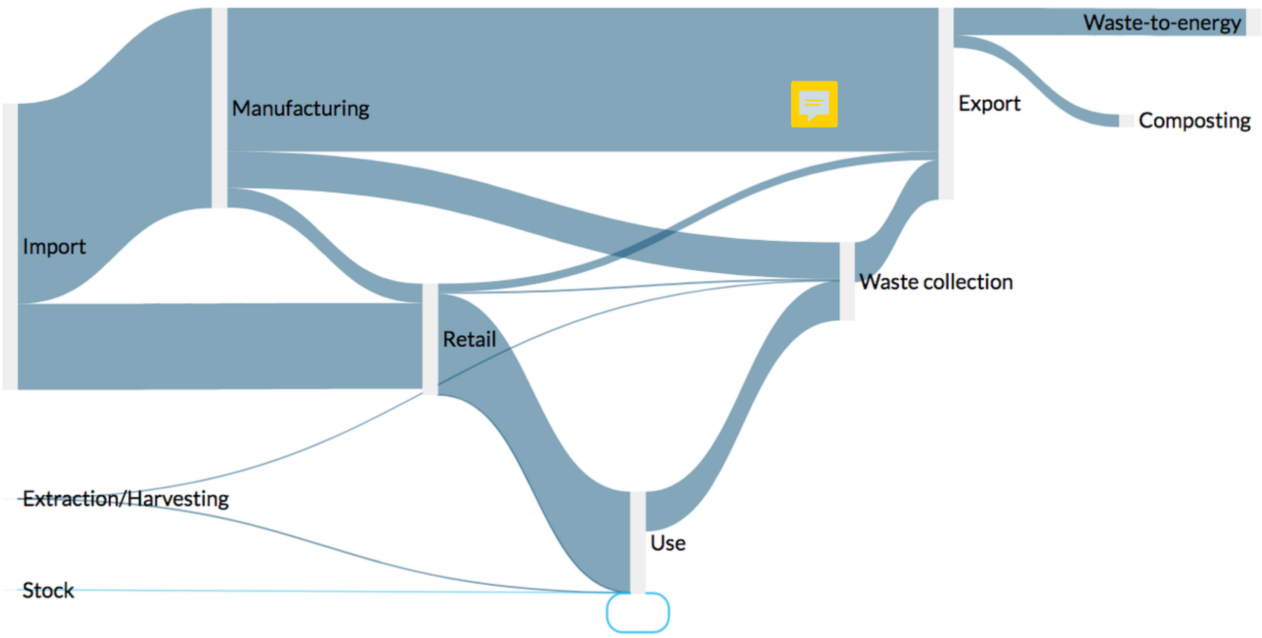
Most part of the imported materials goes to the manufacturing sector, composed by two medium sized factories (one sugar refinery and two cereal mills) and several small bakeries and patisseries and also some small craft beer brewing companies. The rest of the imported materials goes directly to the retail sector, including wholesale.

Considering this, almost all the food consumed by the citizens or served in restaurants, hotels and canteens aren't produced locally.

At Porto, there also exist some food donation projects implemented in the city, avoiding the production of food waste, increasing the circularity of bio-waste management.

Considering the bio-waste produced in the City of Porto, including both food and garden waste, almost all the bio-waste collected – separated and mixed waste collection – is exported to LIPOR plants (composting and waste-to-energy plants) located outside the city boundaries. Only a small portion is treated locally, through home and local composting.

Finally, considering the export, besides the export of the bio-waste collected, we have the export from the manufacturing sector, mainly from the two medium sized factories above mentioned, and from the retail sector. This numbers were estimated because it wasn't found data that allows us to include precise and accurate data for the City of Porto.



Data source

Data quality assessment

Numerous datasets were collected and considered in the sector-wide circularity assessment. In some cases, datasets were not available for some materials or for some lifecycle stages for the studied sector. Therefore, estimations need to be done by looking at data at higher spatial scales (region or country). This section qualitatively assesses how reliable the data used is.

Data quality

Before describing data gaps and assumptions, the overall data quality is considered. It is expressed through four data quality dimensions that are depicted in the data quality matrix: reliability, completeness, temporal correlation, and spatial correlation. Each dimension has its own criteria for the ranking of high (green), medium (yellow) and low (red), which is based on this Pedigree report and shown in the table below. There can be additional explanations in some cells, as supporting information.

Rating	*Reliability*	*Completeness*	*Temporal correlation*	*Spatial correlation*
high	*Reviewed or measured data*	*Data exists for all of the single materials and their respective economic activites*	*Data less than 3 years difference to the time period of the data set*	*City-level data*
medium	*Estimated data*	*Data exists for most single materials and most economic activities*	*Data less than 6 years difference to the time period of the data set*	*Regional-level data (NUTS 3)*
low	*Provisional data*	*Data exists for the sector only for the Life Cycle Stages*	*Data less than 10 years difference to the time period of the data set*	*NUTS 2 and country-level data*

Data quality matrix

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
Extraction/Harvesting				
Manufacturing				
Retail				
Use				
Stock				
Waste collection				
Landfill				
Incineration				
Recycling	Not applicable	Not applicable	Not applicable	Not applicable

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
Anaerobic digestion	Not applicable	Not applicable	Not applicable	Not applicable
Composting				
Imports				
Exports				

EXTRACTION AND HARVESTING

Data source was the National Institute of Statistics (INE), namely, regarding permanent and temporary crops in the City of Porto.

There is no data or information about other type of extraction/harvesting taking place in the City of Porto.

MANUFACTURING

Apart data from the sugar refinery (data estimated considering information from the annual financial report), the remaining manufacturing data (grain milling, brewing, local bakery and pastry) were obtained by downscaling 2019 statistical data from INE at the country level to the city scale. The data was considered to cover the main actors and manufacturing infrastructures identified in Porto.

RETAIL

INE data was found at the Metropolitan Area of Porto (AMP) level for production (of products created during the accounting period), in euros, for all types of economic activities, including retail and wholesale trade for different biomass materials. Subsequently, the respective annual quantity was estimated for each of the materials, considering the average market price, with the consequent downscaling of the data to the city level.

USE

Statistical data on food consumption, of the different biomass materials, were collected from INE (per capita consumption, kg/inhab) at the country scale and, from income and number of inhabitants, it was possible to convert to the city of Porto. We also collected data from some ongoing projects of food waste prevention that have been implemented in the City of Porto, such as the recovery of leftovers from restaurants, canteens and supermarkets, and also data on meals served in social/municipal and school canteens.

STOCK

Data regarding existing animals in the municipality of Porto was obtained from INE. Although it is known that there is tree stock in the city (green spaces and nursery), it was not possible to obtain or to convert this information in tons.

WASTE COLLECTION

Waste collection data was provided by Porto Ambiente and LIPOR. The bio-waste selective collection data was provided by Porto Ambiente. The mixed waste collection was provided by LIPOR. Nevertheless, we should mention that this data was calculated since LIPOR can´t provide an exact number for the waste collected. Although LIPOR can provide an exact figure for the mixed waste collection in Porto, the waste characterization is made for the whole system (8 municipalities), so the figure presented for bio-waste in the mixed waste for Porto must be calculated. Additional information was collected regarding local composting initiatives.

Data gaps and assumptions

The only real data that has actually been obtained for the City of Porto is in terms of crops (temporary and permanent crops), animal stock, waste collection and food donation projects. All other data were obtained by downscaling to the city or by doing estimations (local composting projects).

The main source used for data collection was INE, and other data was obtained from LIPOR, Municipality of Porto City and Porto Ambiente.

For the downscale, besides having resorted to income figures and the number of employees, it was also necessary to find some average values, such as market prices of products and mass quantities of meals.

Data regarding the number of employees and GVA of the biomass sector in Porto (considering all the associated economic activity sectors) could be improved and could be more realistic if more detailed information were available (4-digit NACE codes), so these values had to be estimated from the other geographical scales (NUTS 3, NUTS 2 and Country).

Since no specific data was found for biomass for imports and exports, it was assumed that the value of imports would be equivalent to the total value of manufacturing and a portion of retail, and for exports it was assumed that all collected waste is exported out of the city (to neighboring municipalities).

Data analysis

This section analyses the Sankey diagram developed in the previous section. It discusses and interprets the results for the sector-wide circularity assessment. It also reflects on how the current demonstration actions fit within the bigger picture of the sector, as well as how they could be upscaled to accelerate the transition towards a more circular sector.

Insights on status quo of the biomass sector

The Sankey diagram of the City of Porto shows us that almost all the materials of the biomass sector comes from import. This means that, to decrease the import of materials and to avoid bio-waste production, it should be implemented several measures to promote more circular flows in the city as well to upscale the ongoing circular projects For instance, the ones related with separate collection of bio-waste (associated with the production and use of high-quality compost), local composting treatment (like home and community composting), food waste reduction initiatives (Embrulha), food donation networks, local/regional sustainable food production and sustainable food procurement.

The current circular initiatives in the biomass sector have currently a small impact in the circularity in the City of Porto, despite all the efforts already done by public and private entities. But we need to be aware that some of these initiatives are very recent, like the new municipal separate collection of bio-waste or the promotion and implementation of local community composting schemes and even food waste prevention programs.

The food donation projects, linking sectors like retail and restaurant sectors with institutions from the social sector helping families with low-income or in a situation of social exclusion, as well some projects promoting food waste prevention coordinated by LIPOR or other entities (DariAcordar Association – Zero Desperdício Program; or Refood4Good Association), needs to be upscaled to assure bigger impact than it happens today.

But, considering the current situation, it won't be easy to promote a full circular biomass sector in the City of Porto because most of the materials included will continue to be imported since it won't be possible to produce most of them locally, inside the city boundaries.

Connection to and upscaling of demonstration actions

The CityLoops demonstration actions (DAs) in Porto target mainly the food waste, which is a very important flow of bio-waste within the urban solid waste, with the goal of promoting a more circular management of bio-waste. But the DAs at the City of Porto aim also to promote a more sustainable and local/regional food production as well the use of new tools to adjust the food procurement to the real needs of the institutions participating in the two pilots' projects: pilot hotel (tourism sector) and a private social solidarity institution (social sector).

DAs like the implementation of new bio-waste selective collection in high-rise residential areas and local treatment solutions like community composting islands (DA#1), will promote more circular destinations for the food waste increasing the mass of bio-waste exported to LIPOR composting plant (1.500 ton/year, 10% of the population of the City of Porto), located outside the city boundaries, as well the increasing of the bio-waste treated in local composting (15 ton/year). This DA upscaled to other parts of the City of Porto could have a relevant impact in the circularity of the management of the food waste management produced in Porto.

Another DA which could have a relevant impact when upscaled is the bio-waste circularity models (DA#2) that will be tested during CityLoops in a pilot hotel (tourism sector) and a private social solidarity institution (social sector). These models were designed to significantly reduce food waste in both the tourism (hotels and restaurants) and social economy sectors (canteens), which are currently big local producers of bio-waste. This means that, these circularity models, after being tested and validated, being upscaled could represent an opportunity to promote bio-waste reduction and prevention, closing the loop of organic matter from farm to fork. In these pilots it will be implemented actions like the promotion of local consumption (promoting food from local/metropolitan producers), local and regenerative production (including local vegetable production with growbed kits), more sustainable menus (promotion of sustainable food), surplus food redirection, bio-waste local treatment and separate collection of bio-waste.

Another DA that can improve the circularity in the biomass sector is the launch and implementation of the green space certification system (DA#3), seeking to increase the sustainable management of green spaces, as well to promote biodiversity. The certification system will specifically encourage dedicated gardening practices to promote the use of the compost produced at LIPOR's composting plant, in order to highlight the importance of returning bio-waste to soil in the form of compost and the sustainable management of green spaces, increase its circularity. The upscale of this DA could have a relevant impact in the circularity of the management of materials of the green spaces, publics and privates, in the City of Porto.

A fourth DA is the promotion of Circular Entrepreneurship Initiatives (DA#4), which consist of a a Contest for Circular Ideas, designed during CityLoops, in order to promote the circular transition in bio-waste and more broadly in the food system. For now it's impossible to estimate the potential impact of this DA, but, after the submission and selection of 20 ideas and after choosing the 5 best ideas that will have access to a set of resources to support its implementation, it will be created all the conditions to increase the number of new circular initiatives related with bio-waste and the food sector being implemented in the City of Porto.

Finally, the DA#5 will support and expand the food donation network, already occurring in the city, which connects food distribution (restaurants and similar, hotels and companies in the wholesale and retail sector) and social economy sectors to support citizens with low income and social needs in the city of Porto. This action will also allow food waste reduction in the city and could have a relevant impact in the circularity of the biomass sector.

Recommendations for making the biomass sector more circular

The recommendations for making the biomass sector more circular in the City of Porto are aligned with 3 of the axis of the Roadmap for the city of Porto circular in 2030 (see below), namely: promoting sustainable production and consumption (axis 1); ensure the availability of natural resources and the environmental balance (axis 2); and, undertake innovative solutions to transform waste into resources (axis 4). And also, with the ambitions of the city to a circular and regenerative food system.

Some of the recommended actions are:

- Encourage the transformation of food production sector (at city and metropolitan scale), requiring less negative impacts and reducing the production of food waste throughout the value chain;
- Promote the increase of small production units (local and metropolitan producers) in Porto Metropolitan Area as well the increase of urban farming in the City of Porto;
- Disseminate the inclusion of circular economy criteria (efficiency in the use of resources, proximity to the production site, separate collection, local composting, e.g.) in the public procurement procedures of the Municipality of Porto, specially for procedures related with municipal canteens and maintenance of green spaces;
- Support the creation and development of new business models that promote the closing of nutrient cycles and an urban bioeconomy in which nutrients are properly returned to the soil, with a reduction in waste;
- Support initiatives to collect food leftovers, in particular through the Horeca and Retail channels, developing systems to collect and dispose of food leftovers, whether for social purposes or for recovery by industry;
- Upscale the separate collection of food and garden waste to all the City of Porto, promoting the closing of the loop for these materials exporting the bio-waste collected to LIPOR's composting plant (current), located outside the City boundaries. In the following years LIPOR will invest in an anaerobic digestion plant, which will help to make the sector more circular;
- Disseminate the use of the compost produced in LIPOR's composting plant in green parks, privates and publics, in the City of Porto;
- Increase the number of citizens engaged in home composting, as well the increase the community composting islands.

Food System City Approach

These recommendations are aligned with a bigger ambition and Porto's Food System City Approach. Since 2017, Porto is committed to become a circular city by adopting a Roadmap for Circular Economy in 2030 . With the collaboration of different organisations and citizens, four main axis were defined:

1. Promote sustainable production and consumption;

2. Ensure the availability of natural resources and environmental balances;
3. Create and maintain shared infrastructures, rehabilitate buildings and create circularity guidelines for new constructions;
4. Promote innovative solutions to transform waste in resources.

Prevention of food waste is a key part of this strategy, and with regard to the circular economy the management of bio-waste sector is one of the pillars to address it.

However, Porto believes that reducing food waste requires a holistic approach regarding the local food system, in this sense, a holistic vision to the food system including organic waste in an integrated way by jointly addressing food waste reduction, bio-waste management and food production was established, with the collaboration of Ellen MacArthur Foundation and other national stakeholders.

This vision is based on three ambitions:

1. Promotion of a regenerative and local agriculture through local and regional production;
2. Promotion of healthy food through design, market and public procurement;
3. Prevention of food waste through making the most of the food - prevention, reduction and valorisation.

CityLoops is contributing to achieving the vision of a circular and regenerative food system and the sector-wide circularity assessment is a fundamental piece to support decisions.

References

- Portugal
- Norte
- Área Metropolitana do Porto
- Population evolution of Porto (1981-2019)
- Land Use Charter - Porto
- Main Actors in Porto map

SECTOR-WIDE CIRCULARITY ASSESSMENT
FOR THE BIOMASS SECTOR
SEVILLA

Introduction

The EU Horizon 2020 funded CityLoops project focuses on closing the material loops of two central sectors of any city in terms of material flows, societal needs and employment, namely the construction and biomass sectors. Due to their sizes, they represent a considerable opportunity for cities to transform their metabolism and economy towards a more circular state.

Within this project, seven European cities, amongst those also the City of Sevilla are planning to implement demonstration actions to kickstart their circularity journey. To better understand what the current circularity status quo is, as well as the impact of these actions, and the efforts needed to transform their sector, a Sector-Wide Circularity Assessment method was developed. This method combines a circular city and circular sector definition, a material flow and stock accounting method, as well as circularity indicators. The sector itself was defined in terms of a number of representative materials that make up a large share of the sector and associated economic activities. The biomass sector is made up of 12 materials, depicted as icons here, which were studied along the entirety of their supply chains. Altogether, these elements help to set a solid knowledge and analytical foundation to develop future circularity roadmaps and action plans.

Cereals

Dairy products

Fish

Fodder crops

Fruits

Garden and park materials

Live animals

Oil-bearing crops

Roots, tubers

Sugar crops

Timber

Vegetables

The assessment was carried out by the cities themselves after receiving extensive training in the form of courses on data collection (construction and biomass) and data processing. Numerous additional insights can be found in the individual Data Hubs of each city.

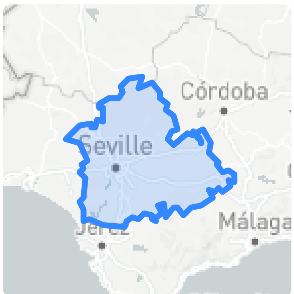
This current Sector-Wide Circularity Assessment report provides contextual information on the city and the economic sector under study. It then illustrates how circular these sectors are through circularity indicators and a Sankey diagram. Finally, it analyses and interprets the results, presents the limitations from the data used and offers recommendations about how to make this sector more circular.

(The italic texts in this report were written by Metabolism of Cities' Aristide Athanassiadis and Carolin Bellstedt. They provide relevant general information and serve as connecting elements of the single report parts.)*

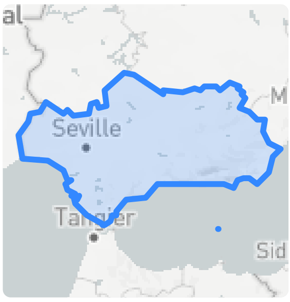
Urban context

To contextualise the results of the sector-wide circularity assessment, this section provides population and land use information data of the city. In addition, population and area of the city under study, as well as its corresponding NUTS3, NUTS2 and country were included. Data for these scales were added to better understand how relevant and important the approximations are when downscaling data from these scales to a city level.

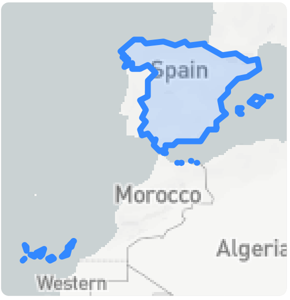
Sevilla
688,592
142 km^2



Sevilla
1,942,389
14,036 km^2

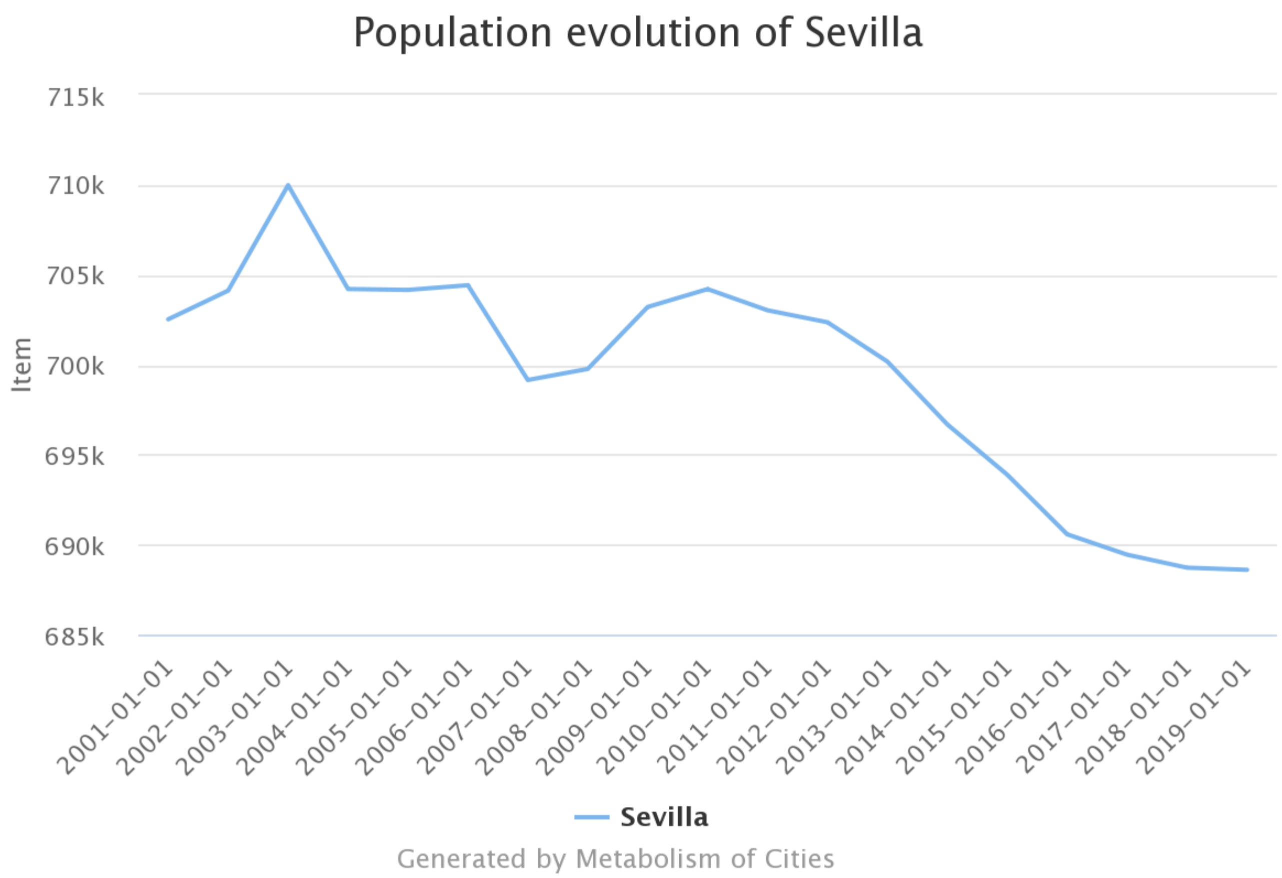


Andalucía
8,414,240
87,600 km^2



Spain
47,026,208
505,990 km^2

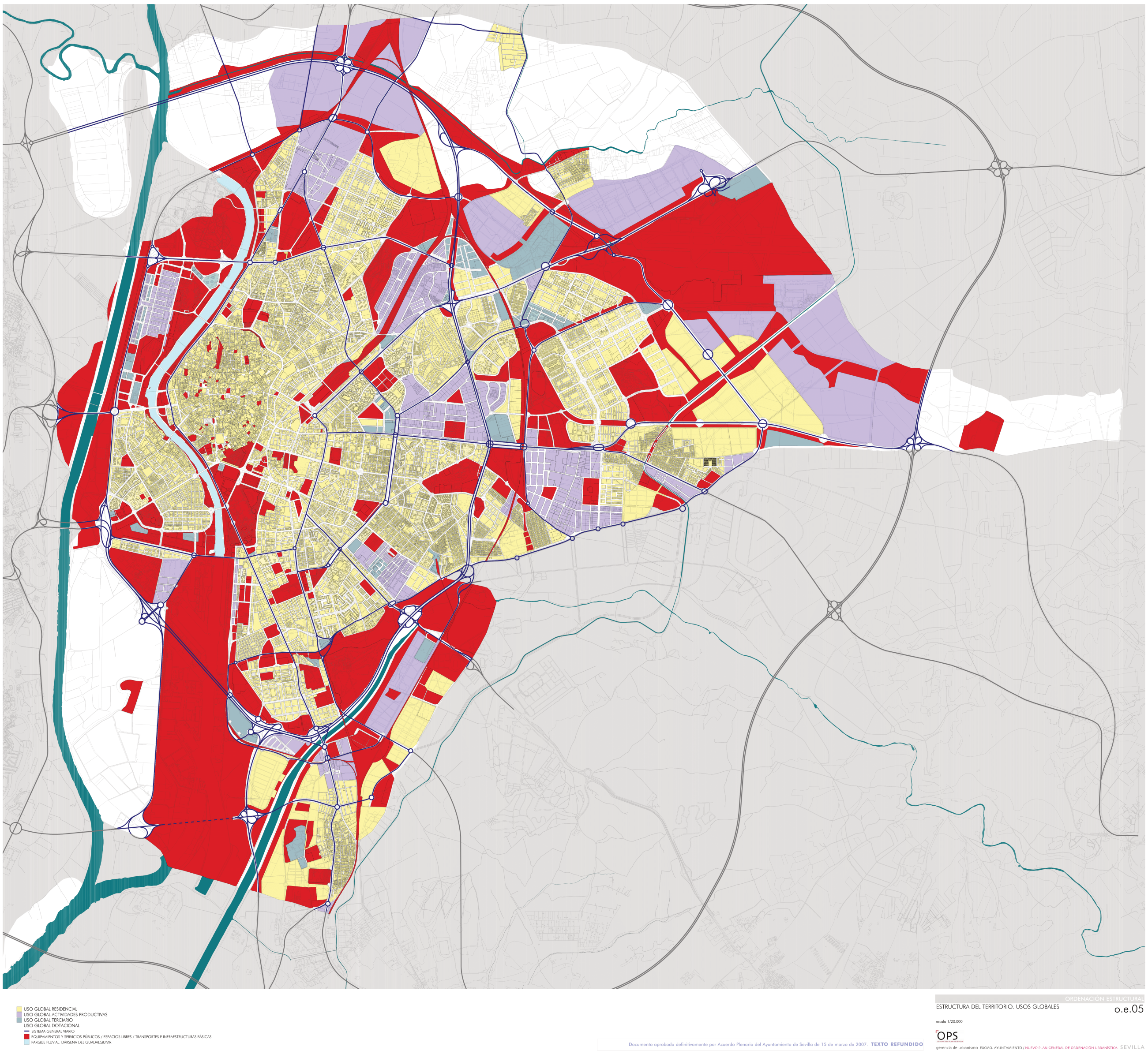
Population of Sevilla



Data source

The municipality of Seville is made up of 11 districts, which are administratively subdivided into 108 neighbourhoods and these, in turn, into 542 census sections. As of January 1, 2019, the population amounted to 688,592 inhabitants, which represents a loss of 10,098 people compared to January 1, 2017, with the South district being the one that loses the most inhabitants. If the comparison is made with respect to January 1, 2013, the loss of people is even greater, reaching 11,577 inhabitants i.e., 1.65% of the total population. The highest concentration of population is found in the East district, where there are 105,964 inhabitants registered. This population represents 15.10% of the total population of the city.

Land use



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Seville's land use is urban and mostly classified as residential, but has public facilities, services, free spaces, transport and basic infrastructures. The historic area is composed of 3.9 km². The green spaces only occupy 1.8 km² of the territory.

Economic context of biomass sector

This section puts into perspective the economic context of the sector under study. It describes how many people are employed in this sector, as well as who the main actors involved (from all lifecycle stages for the sector's materials) are.

	GDP (monetary value, in €)	Employees
Sevilla	854,408,809	22,975
Sevilla	2,190,068,000	64,847
Andalucía	10,771,369,000	312,866
Spain	32,553,000,000	949,500

The biomass sector in Sevilla

The city of Seville is located on the plain of the Guadalquivir River, South-Western Spain, in the region of Andalusia. The region is also the national leader in the biomass sector. Seville has a municipal population of about 688,592 and a metropolitan population of about 1.9 million, making it the fourth-largest city in Spain and the 31st most populous municipality in the European Union.

Agricultural waste includes all plant waste that is generated directly in the field. Depending on the crop, they can be grouped as woody crop residues that include the pruning of fruit, citrus, vine, and olive trees; and herbaceous crop residues, which are formed by the remains of herbaceous species that remain after harvest. They are traditionally used in animal feed, as fuel or as an organic and structural amendment by incorporating them into the soil.

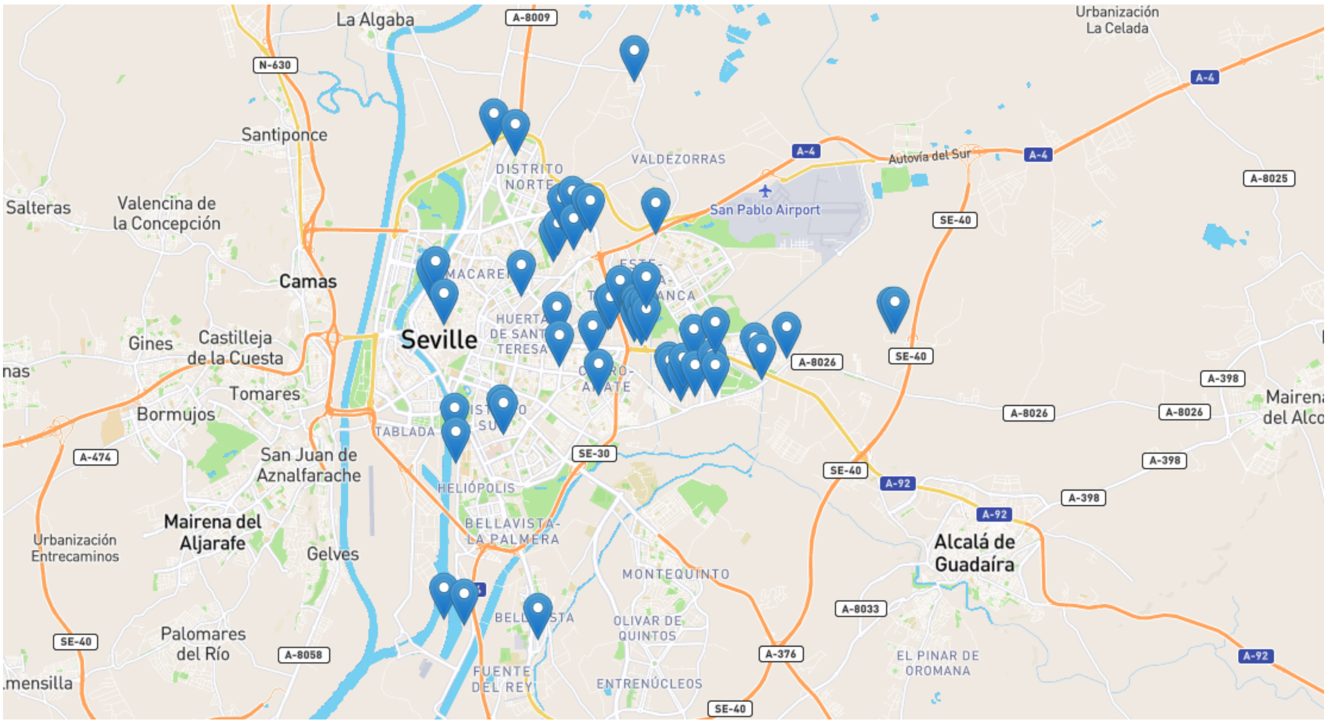
The organic waste generated in the manufacturing sector is mostly part of the by-products generated by these industries, which on many occasions have an alternative use in the market as raw materials that find applications in other industries or sectors. The industries and waste with the greatest use and potential in Seville are the olive grove industry, rice plants, juices and canned vegetables, cotton waste or breweries, and meat industries and slaughterhouses.

By urban waste, we understand that which is generated in an urban environment by the daily activities of human beings. The urban waste that can be considered biomass is the organic fraction of municipal waste, wastewater and sewage sludge, used vegetable oils and vegetable waste from parks and gardens.

Urban waste is subjected to operations for its classification to separate those recoverable or recyclable materials and is subsequently disposed of by depositing it in landfills and subsequently sealing it, when it has reached its capacity limit. In these sealed landfills, after a period in which biogas has been produced, because of the degradation of organic matter, they are degassed and the biogas obtained can be recovered to be used as fuel, as is done in Aborgase.

In the same way, the management and purification of wastewater, Emasesa's wastewater treatment stations (WWTPs) have anaerobic digestion facilities for sludge that recover the biogas generated for thermal uses in the purification process itself or the generation electrical.

Extraction and harvesting infrastructure



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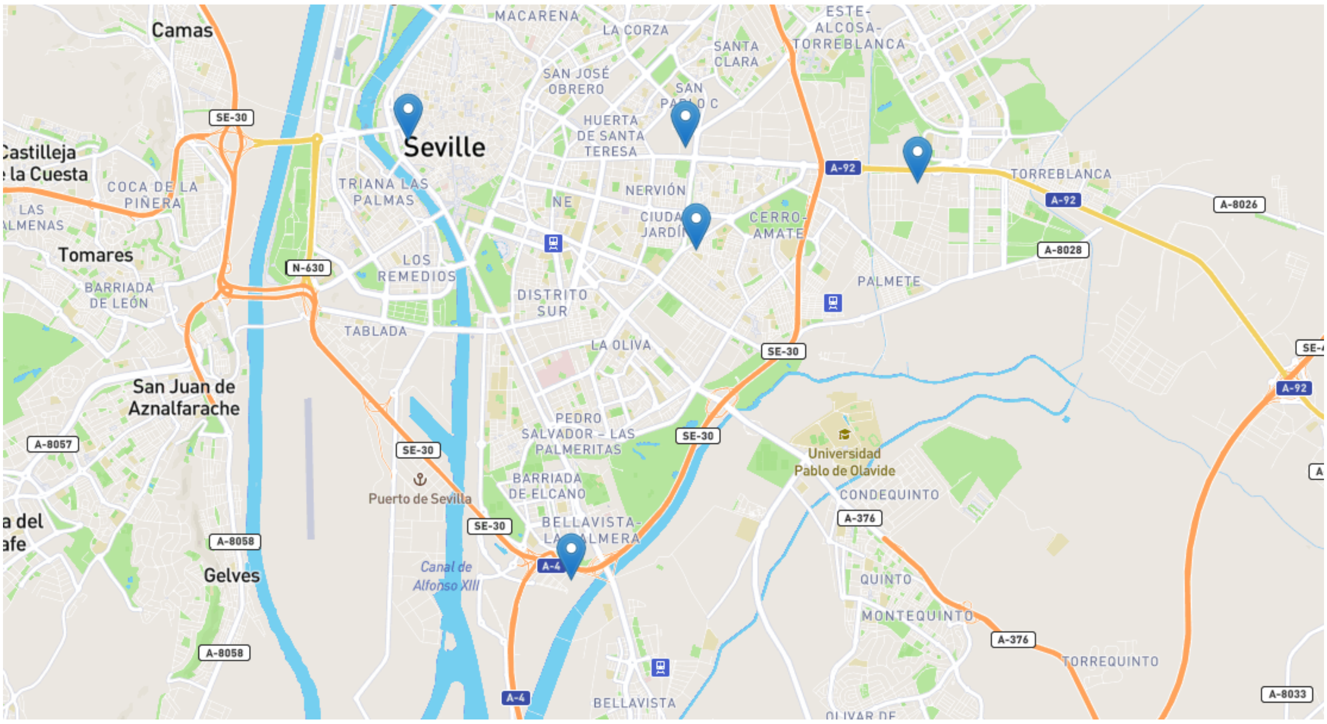
Waste collection infrastructure

[Data source](#)

Cogeneration plants



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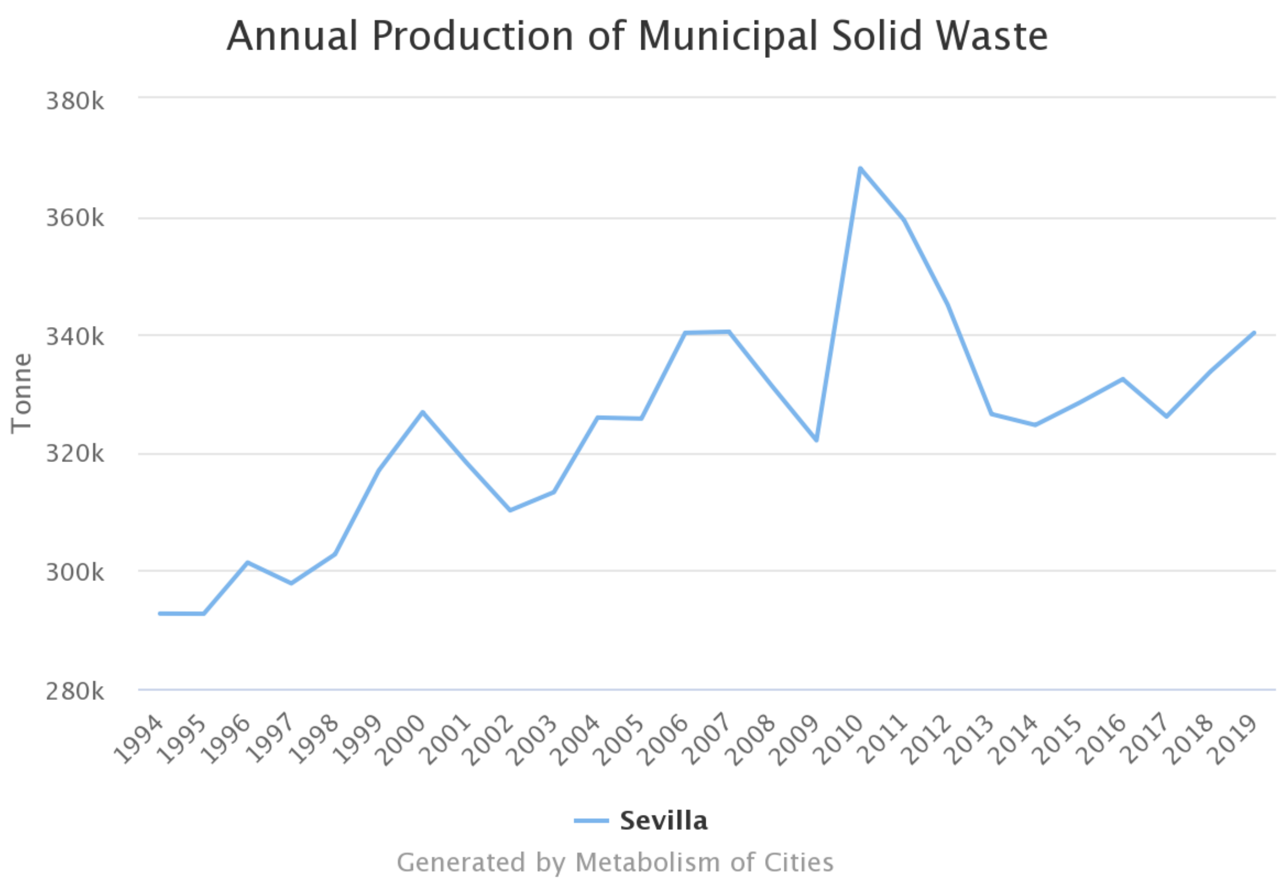

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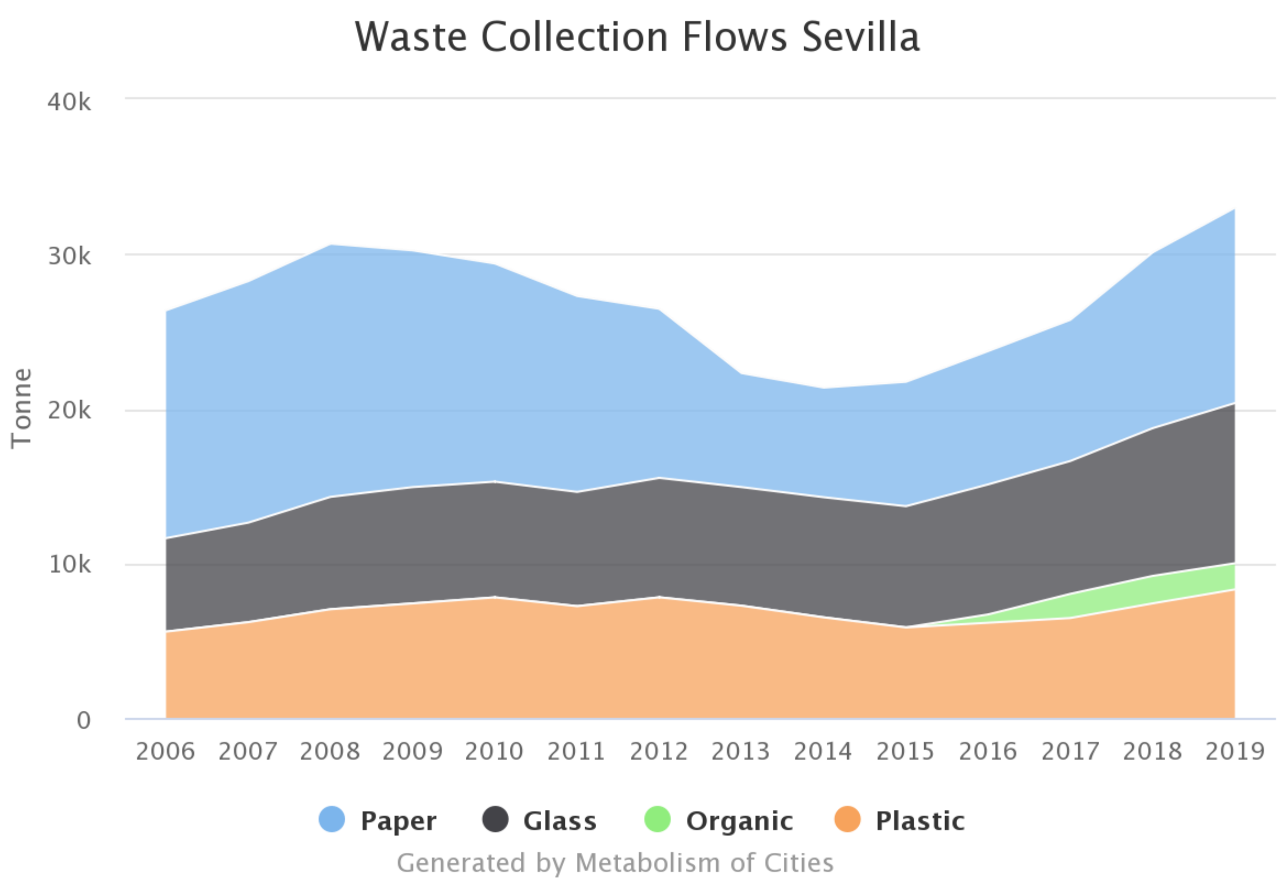

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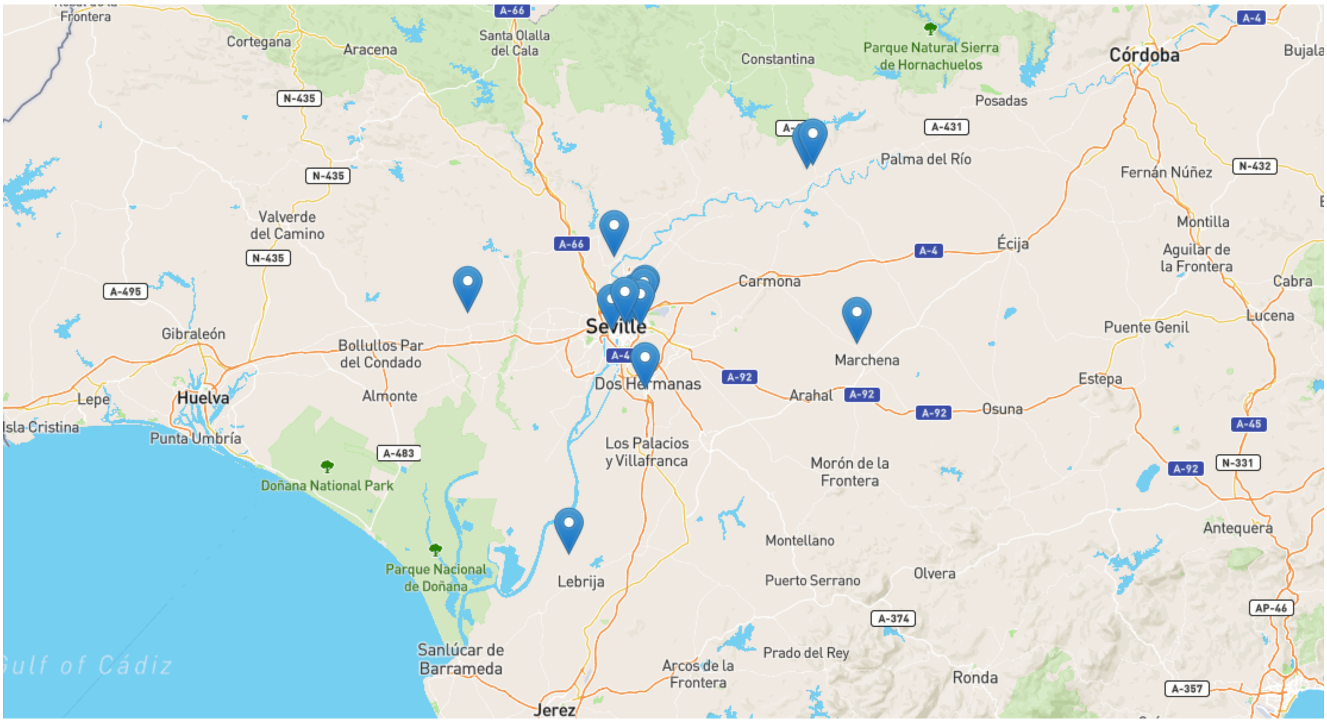
The actors of the biomass sector



[Data source]

Sevilla shows the higher useful agricultural area in the Andalucia region with more than one-fifth of the total area. The main cultures are cotton, potatoes, oranges, olives, and rice but there are also significant exploitations focused on Wheat, Barley, Chickpeas, Dried beans, Dried peas, Sugar beet, Sunflower, Tomato, Sweet orange, Tangerine, Peach, Plum, Almond among other.

In Seville, there are both extractive industries and transforming industries, one of the most emblematic manufacturing examples is the Heineken manufacturing plant. In 1904, the first La Cruz del Campo beer factory was founded in Seville and, in that same year, the first Cruzcampo beer was launched on the market. In 1995, the Cruzcampo Foundation was born, based in Seville. In 2000, Heineken International bought the Cruzcampo Group creating the Heineken Spain group. Heineken Spain, the current German firm that owns the mythical Cruzcampo, moved production to the new factory on the Seville-Mairena del Alcor highway in 2008, becoming one of the most modern and advanced technology factories in Europe. On a 71-hectare site, it has a storage capacity of 3,000 m2, being able to produce 450 million litters per year. In the extractive sector, Andalucia is the region with the highest rice production in Spain, representing 42% of the national total and just over 10% of the European Union. The area dedicated to rice cultivation is 40,715 hectares, with 94% being concentrated in Seville.

The City of Seville also has plenty of retail infrastructures, from supermarkets to hypermarkets. The main wholesale establishment in the city is Mercasevilla, which is the provider of both retail infrastructures and big hostelry.

There are 18 local markets distributed around the 11 districts in Seville to support the local economy, reducing the value chain between producer and users. There are also weekly local markets, where can a wide variety of products, from clothing, plants and flowers and food products can be found. The municipal waste collection in Seville is managed by the municipal Public Cleaning company i.e., Lipasam, of the Seville City Council. Lipasam is responsible for the cleaning of the 1,077 km of roads, the collection of urban waste and its subsequent treatment to save resources and avoid contamination of the environment. For this task, LIPASAM has a staff of 1,987 men and women, 750 vehicles of different types, a Central Machinery Park, six Auxiliary Cleaning Parks, five Clean Points, a Transfer Station, four Pneumatic Waste Collection Centres (three fixed and another mobile), and some Central Offices and finally with an annual budget (2020) of more than 107 million euros.

The collection of bio-waste began in Seville in June 2017 with the implementation of the system in markets, hotels, and hospitals in the city, as well as in various points of the Old Town. Later it was introduced in neighbourhoods such as Sevilla Este, Bellavista, Bermejales, Jardines de Hércules, Heliópolis, Pineda, El Cano and Pedro Salvador. To date, more than 5 million kilograms of bio-waste have been collected. In 2020, Lipasam carried out the implementation in the San Jerónimo and La Bachillera neighbourhoods of the Northern district of the new bio-waste containers for the selective collection of biodegradable organic matter (for citizens) through a new model of containers that present as a particularity the opening by means of a contactless electronic card and the brown cover. Within the framework of the CityLoops project, Lipasam contemplates the expansion of bio-waste collection in the city. Once collected, the bio-waste is sent for treatment in infrastructures outside the limits of the municipality, to the Aborgase infrastructures, where it will be processed, valorised, and sent for the final destination.

Indicators

To monitor the progress of this economic sector towards circularity, a number of indicators were proposed and measured. Altogether, these indicators depict several facets of circularity of the sector. As such, they need to be considered in combination rather than in isolation when assessing circularity. In addition, these indicators can be compared to other cities or spatial scales (such as the country level). However, this has to be done with great care and use of the contextual elements in the previous sections of the report. Finally, the value measured from these indicators can be traced over time to track the sector's progress towards circularity.

Indicator number	Indicator	Value	Unit
34	Domestic material consumption (DMC)	19,047,323.39	Tonnes/year

Indicator number	Indicator	Value	Unit
41	Share of secondary materials in DMC	0.4	%
48	EU self-sufficiency for raw materials	135.85	%
53	Quantity of material for anaerobic digestion	75,000.00	Tonnes/year
56	Quantity of material for composting	600	Tonnes/year
57	Amount of sector specific waste that is produced	144,110.00	Tonnes/year
58	EOL processing rate	99.21	%
59	Incineration rate	0.07	%
61	Landfilling rate	24.52	%

Indicators #34, #41, #48

- Domestic material consumption (DMC) (#34): 19,047,323.39 ton
- Share of secondary materials in DMC: (#41) 0.4 %
- EU self-sufficiency for raw materials (#48): 135.85 %

In the first indicator (DMC, #34) it was estimated a value of 27.66 tons per capita, higher than the value for Spain (2.67 tons per capita). Considering the value of the share of secondary material in DMC, the value is very low (0.4%), but with the increasing values for separate collection of bio-waste and the subsequent valorisation in the Aborgase plant and in the Emasesa's Anaerobic Digesters, the value of this indicator will increase in the following years. For the increase of this value, it will also contribute to the increase of local composting, considering the home composting, community composting and urban farms composting.

Indicators #53, #56, #57

- Quantity of material for anaerobic digestion(#53): 75,000.00 ton
- Quantity of material for composting:(#56) 600.00 ton
- Amount of sector specific waste that is produced (#57): 144,110.00 ton

Analysing these three indicators, it is possible to observe that Seville shows a good scenario that results from the implementation of the separate collection system of biowaste for the huge producers by Lipasam as well as the cogeneration facilities operated in Emasesa's facilities. These indicators will be increasing due to recent investments done by Lipasam with the implementation of the separate collection of biowaste in some neighbourhoods recently and will have a significant increase during the following years, as a result of these investments, including the investment from CityLoops for the Demo Actions in Seville.

Indicators #58, #59, #61

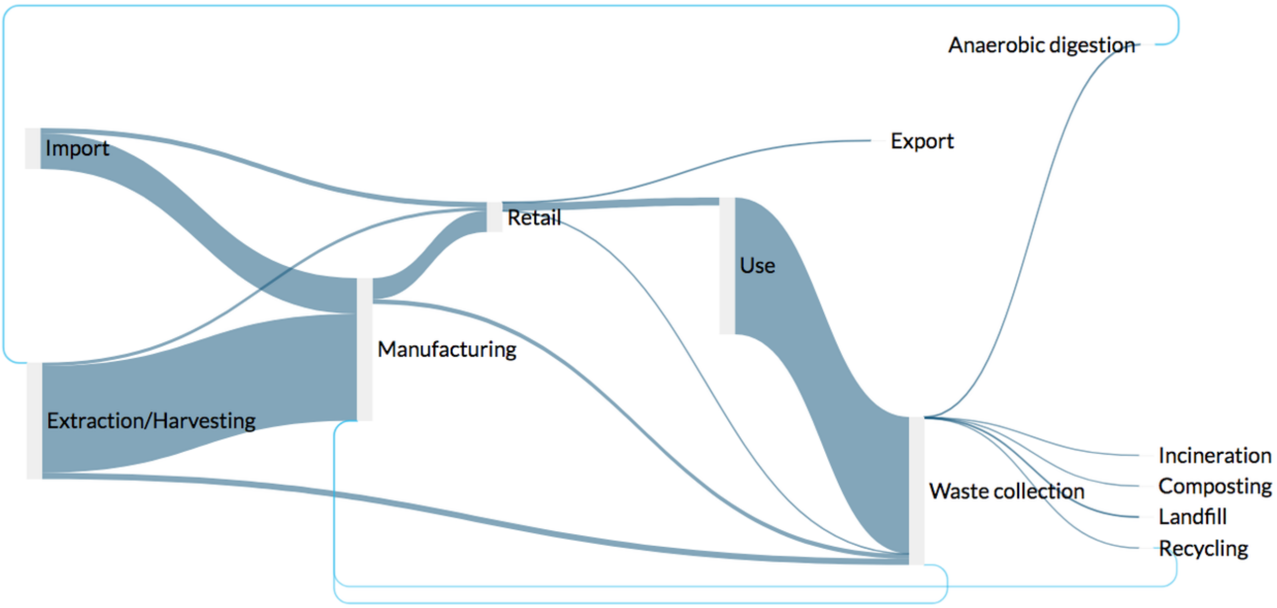
- EOL processing rate (#58): 99.21 %
- Incineration rate (#59): 0.07 %
- Landfilling rate (#61): 24.52 %

These three indicators show a good status of municipal waste management in Seville. Lipasam is committed to valorising and reducing the landfilling and incineration of municipal solid waste. Lipasam is focused to increase the circularity of municipal solid waste management in the following years not only with the implementation of the separate biowaste collection in the city but also promoting the valorisation of the biowaste by cogeneration in collaboration with Emasesa. Additionally, several advertising campaigns will be delivered in order to improve the management for the rest of the kind of municipal solid waste as well as to improve the use of the local "clean points" that collect different kinds of waste such as CDW, Electronics, Metals, etc.

Visualisations

Measuring circularity is a data heavy exercise. Numerous datasets were collected and visualised throughout the sector-wide circularity assessment process. To synthesise these findings, a Sankey diagram illustrates how material flows from the studied economic sector are circulating from one lifecycle stage to another. The height of each line is proportional to the weight of the flow. This diagram therefore helps to quickly have an overview of all the materials flows that compose the sector and their respective shares. The flows that are coloured in light blue in the Sankey diagram, are return flows. This means that they flow in the opposite direction of the lifecycle stages and are subjected to reuse, redistribution, or remanufacturing. Their size relative to the others is a good indication for the materials' circularity.

The Sankey diagram describes the large Extraction/Harvesting of materials for the biomass sector in Seville compared to the import. This means that for the City of Seville almost all the materials required for the biomass sector came from the metropolitan area of Seville. Most part of the imported materials goes to the manufacturing sector, mostly from Fish, Live animals, Dairy products and Timber economic activities. The rest of the imported materials goes directly to the retail sector, including wholesale. Considering this, almost all the food consumed by the citizens or served in restaurants, hotels and canteens are produced locally. Finally, considering the export, there is the export mainly from the retail sector. These numbers were estimated, because it wasn't found data that allows the inclusion of precise and accurate data for the City of Seville.



[Data source]

Data quality assessment

Numerous datasets were collected and considered in the sector-wide circularity assessment. In some cases, datasets were not available for some materials or for some lifecycle stages for the studied sector. Therefore, estimations need to be done by looking at data at higher spatial scales (region or country). This section qualitatively assesses how reliable the data used is.

Data quality

Before describing data gaps and assumptions, the overall data quality is considered. It is expressed through four data quality dimensions that are depicted in the data quality matrix: reliability, completeness, temporal correlation, and spatial correlation. Each dimension has its own criteria for the ranking of high (green), medium (yellow) and low (red), which is based on this [Pedigree report] and shown in the table below. There can be additional explanations in some cells, as supporting information.

Rating	*Reliability*	*Completeness*	*Temporal correlation*	*Spatial correlation*
high	*Reviewed or measured data*	*Data exists for all of the single materials and their respective economic activites*	*Data less than 3 years difference to the time period of the data set*	*City-level data*
medium	*Estimated data*	*Data exists for most single materials and most economic activities*	*Data less than 6 years difference to the time period of the data set*	*Regional-level data (NUTS 3)*
low	*Provisional data*	*Data exists for the sector only for the Life Cycle Stages*	*Data less than 10 years difference to the time period of the data set*	*NUTS 2 and country-level data*

Data quality matrix

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
Extraction/Harvesting				
Manufacturing				
Retail				
Use				
Stock				
Waste collection				
Landfill				
Incineration				
Recycling				

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
Anaerobic digestion				
Composting				
Imports				
Exports				

EXTRACTION AND HARVESTING

The data source was the National Institute of Statistics (INE) and Andalusian Institute of Statistics and Cartography (ICA).

MANUFACTURING

The manufacturing data were obtained by downscaling 2019 statistical data from INE at the country level and ICA at the regional level to the city scale. The data was considered to cover the main actors and manufacturing infrastructures identified in Seville.

RETAIL

Retail data were obtained by downscaling statistical data from INE and ICA and Eurostat only from some materials.

USE

Statistical data on food consumption, of the different biomass materials, were collected from INE and ICA at the country and regional scale and, from income and number of inhabitants, it was possible to convert to the city of Seville.

STOCK

Data regarding existing animals in the municipality of Seville was obtained from ICA. Although it is known that there is tree stock in the city (green spaces and nurseries), it was not possible to obtain or to convert this information into tons.

WASTE COLLECTION

Waste collection data was provided by Lipasam at the local level and ICA at the regional level. The bio-waste selective collection and mixed waste collection data were provided by Lipasam.

Data gaps and assumptions

The only real data that has actually been obtained for Seville is in terms of extraction/harvesting, animal stock, and waste collection. All other data were obtained by downscaling to the city. The main sources used for data collection was INE, ICA, municipal statistics, Lipasam and the data obtained from Eurostat. For the downscaling, it resorted to income figures and the number of employees. Data regarding the number of employees and GDP of the biomass sector in Seville could be improved and could be more realistic if more detailed information were available (4-digit NACE codes), so these values were estimated from the other geographical scales (NUTS 2, Country and Regional).

Data analysis

This section analyses the Sankey diagram developed in the previous section. It discusses and interprets the results for the sector-wide circularity assessment. It also reflects on how the current demonstration actions fit within the bigger picture of the sector, as well as how they could be upscaled to accelerate the transition towards a more circular sector.

Insights on status quo of the biomass sector

The Sankey diagram of the City of Seville shows that almost all the materials of the biomass sector come from Extraction/Harvesting, but there is a significant contribution from import activity. This means that several measures should be implemented to promote more circular flows in the city, as well as to upscale the ongoing circular projects i.e., municipal organic waste collection and its valorisation. For instance, the ones related with separate collection of bio-waste (associated with the cogeneration valorisation) and explore other local initiatives such as urban farming, food waste reduction initiatives, food donation networks or sustainable food procurement.

The current circular initiatives in the biomass sector have currently a small impact on the circularity of the city, despite all the efforts already done by public and private entities. But it needs to be taken into account that some of these initiatives are very recent, like the new municipal separate collection of bio-waste.

The food donation projects, linking sectors such as the retail sector with institutions from the social sector, helping families with low-income or in a situation of social exclusion needs to be upscaled to assure a higher impact than it happens today.

Connection to and upscaling of demonstration actions

The CityLoops demonstration actions (DAs) in Seville target mainly organic waste management, which is a very important flow of bio-waste within the urban solid waste, with the goal of promoting more circular management of bio-waste.

DAs like the implementation of bio-waste selective collection in new neighbourhoods and local treatment solutions like cogeneration will promote more circular destinations for the food waste increasing the mass of bio-waste valorised. This DA upscaled to other parts of the City of Seville could have a relevant impact on the circularity of the management of the food waste management produced in Seville.

Another DA that could have a relevant impact regarding the upscaling of the separate organic waste collection is the IT software tool developed to optimise the waste collection routes that will be tested during the CityLoops demonstration phase. This IT software tool was designed to improve the separate waste collection cost to speed up the implementation of the entire city.

Another DA that can improve the circularity in the biomass sector is the launch of a campaign to disseminate the DAs under implementation in Seville and search for the commitment of citizens. The success of these campaigns could upscale the success of these DAs and have a relevant impact on the circularity of organic waste management, in the City of Seville.

Recommendations for making the biomass sector more circular

- Encourage the transformation of food production sector (at the city and metropolitan scale), requiring fewer negative impacts and reducing the production of food waste throughout the value chain;
- Promote the increase of small production units (local and metropolitan producers) in Seville Metropolitan Area as well the increase of urban farming in the City of Seville;
- Disseminate the inclusion of circular economy criteria (e.g., efficiency in the use of resources, proximity to the production site, separate collection, local composting) in the public procurement procedures such as public canteens (schools, high-schools, universities, etc.) or maintenance of green spaces;
- Support the creation and development of new business models that promote the closing of nutrient cycles and an urban bioeconomy in which nutrients are properly returned to the soil, with a reduction in waste;
- Upscale the separate collection of organic waste to all the City of Seville, promoting the closing of the loop.

References

- Spain
- Andalucía
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- Population of Sevilla line graph
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- Sevilla_Geo_localisation_of_main_actors_biomass sector Imagen

FOR MORE INFORMATION, VISIT:

https://cityloops.metabolismofcities.org

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