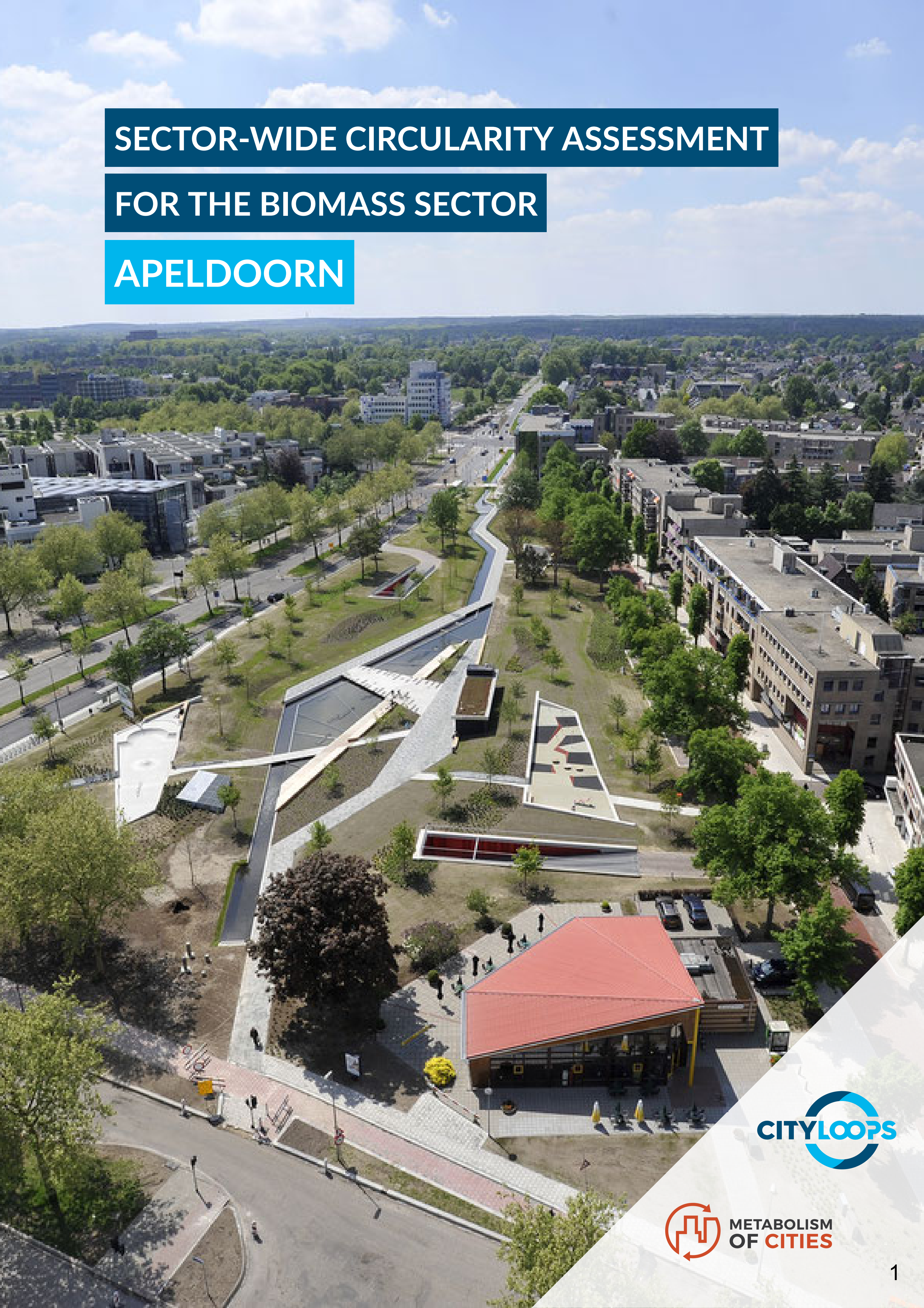
SECTOR-WIDE CIRCULARITY ASSESSMENT FOR THE BIOMASS SECTOR

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

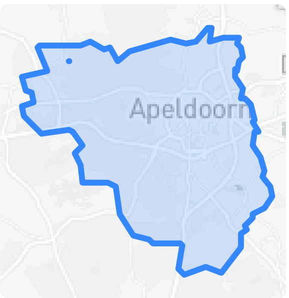
The assessment was carried out by the cities themselves after receiving extensive training in the form of courses on data collection (construction and biomass) and data processing. Numerous additional insights can be found in the individual Data Hubs of each city.

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.



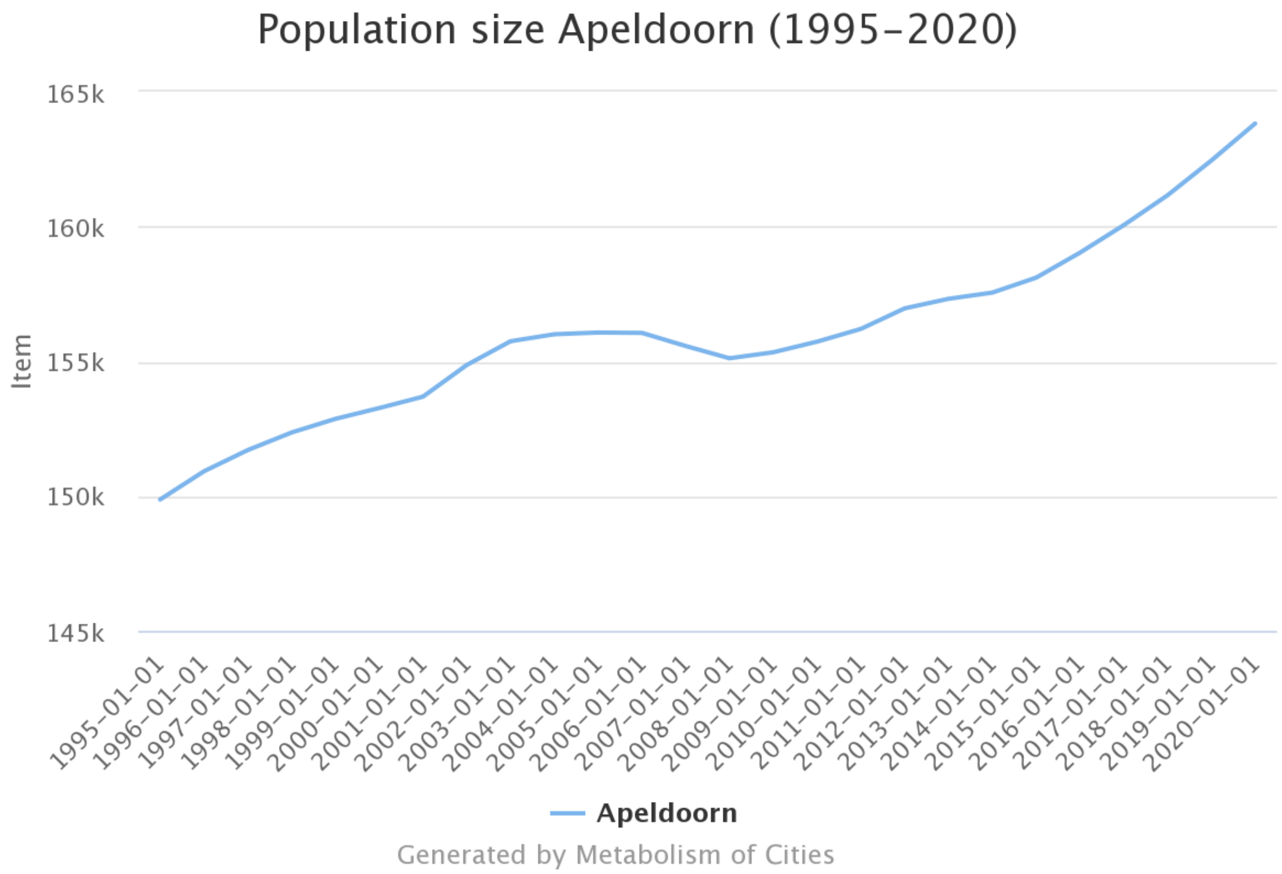
Apeldoorn
164,781
341 km^2

Veluwe
700,975
1,860 km^2

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

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

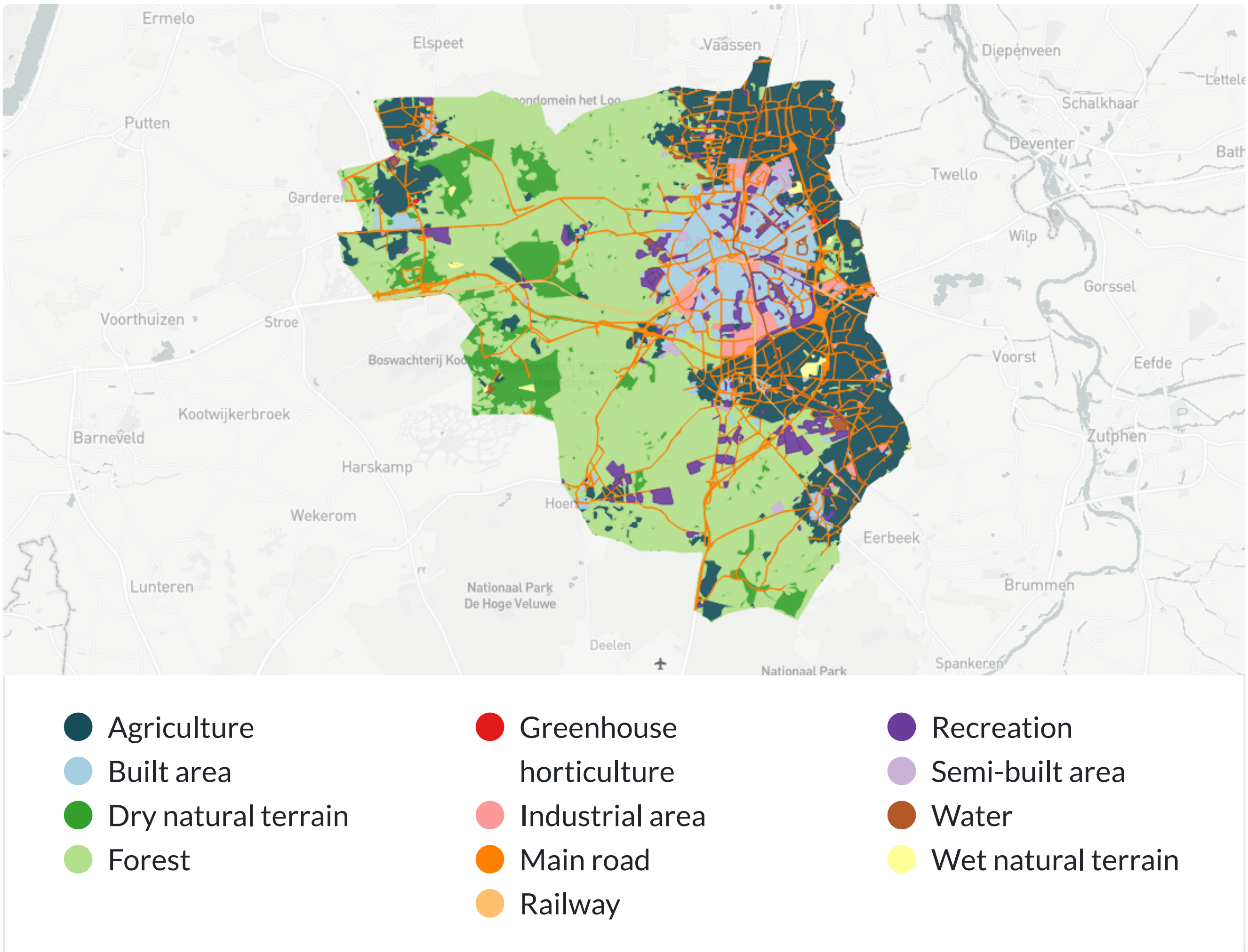
Population of Apeldoorn



[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



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

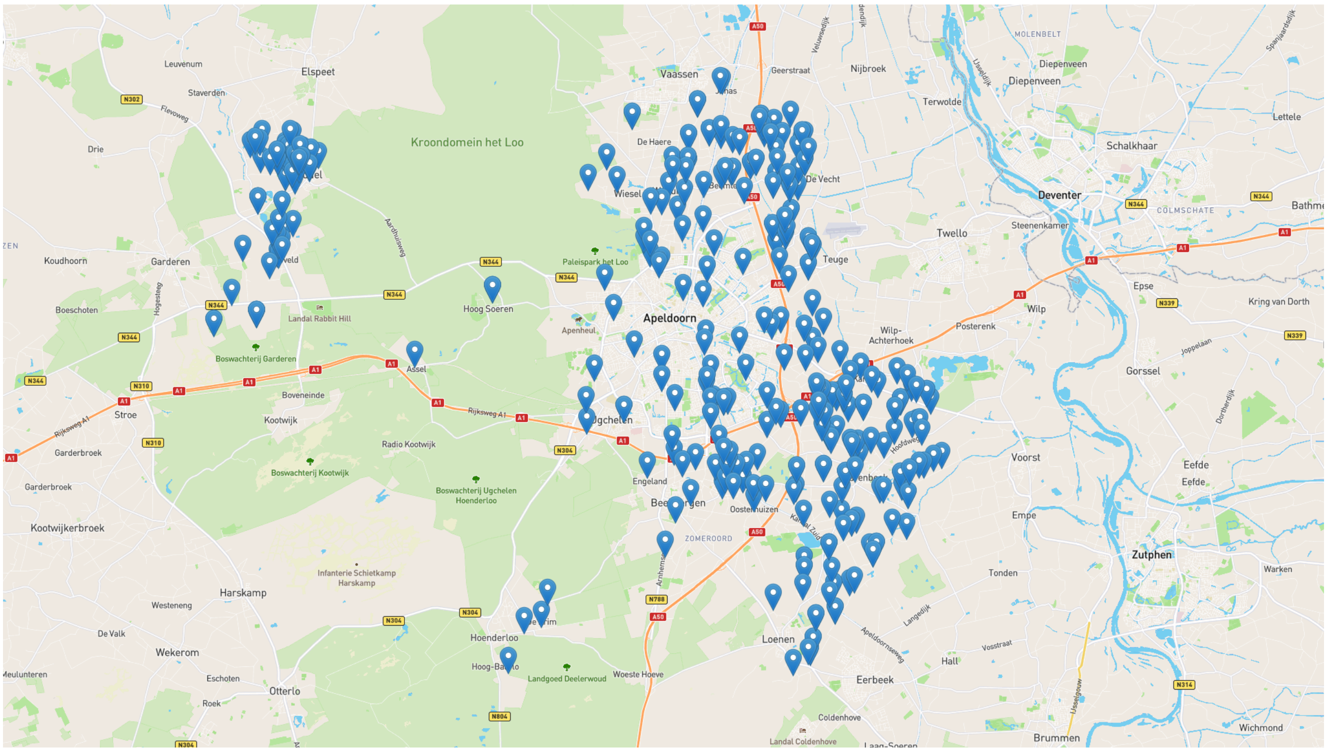
This section puts into perspective the economic context of the sector under study. It describes how many people are employed in this sector, as well as who the main actors involved (from all lifecycle stages for the sector's materials) are.

	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.

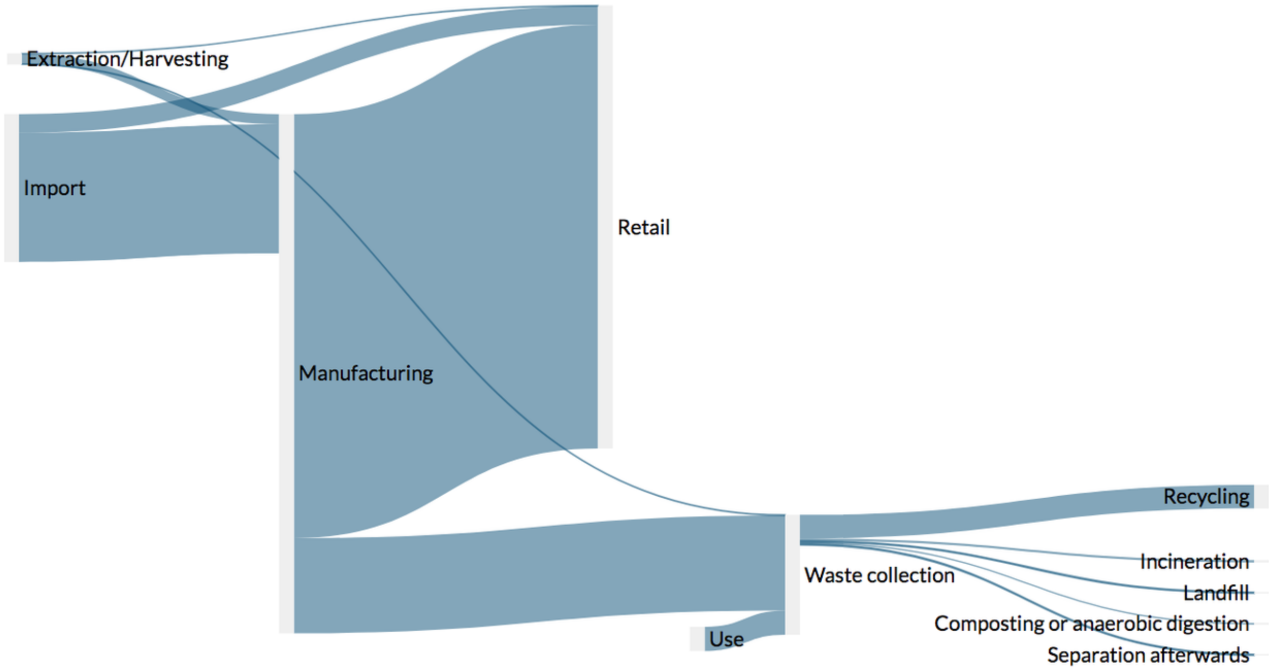
Indicator number	Indicator	Value	Unit
34	Domestic material consumption (DMC)	771,610.06	Tonnes/year
41	Share of secondary materials in DMC	0.00	%
48	EU self-sufficiency for raw materials	97.13	%
53	Quantity of material for anaerobic digestion	2,407.63	Tonnes/year
56	Quantity of material for composting	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.



[Data source]

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 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

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
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
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