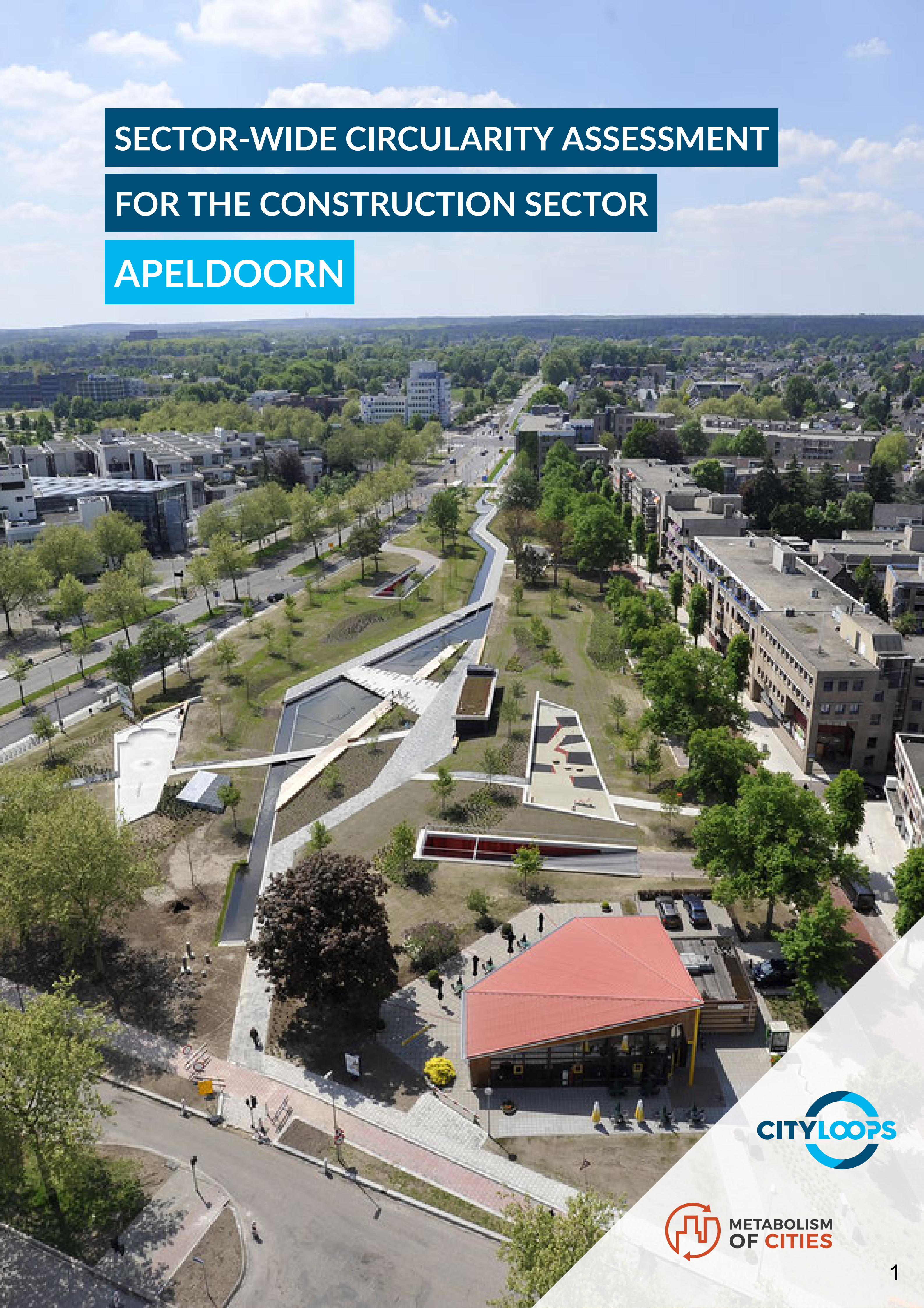
SECTOR-WIDE CIRCULARITY ASSESSMENT FOR THE CONSTRUCTION SECTOR

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 construction sector is made up of 11 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.

Aluminium	Bitumen / asphalt	Bricks
Concrete	Glass	Gypsum
Insulation	Iron (steel)	Sand and gravel
Soil	Timber	

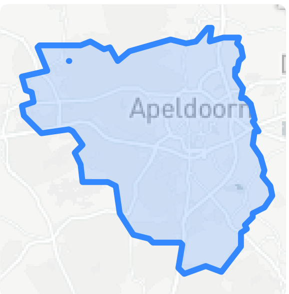
The assessment was carried out by the cities themselves after receiving extensive training in the form of courses on data collection (construction and biomass) and data processing. Numerous additional insights can be found in the individual Data Hubs of each city.

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.



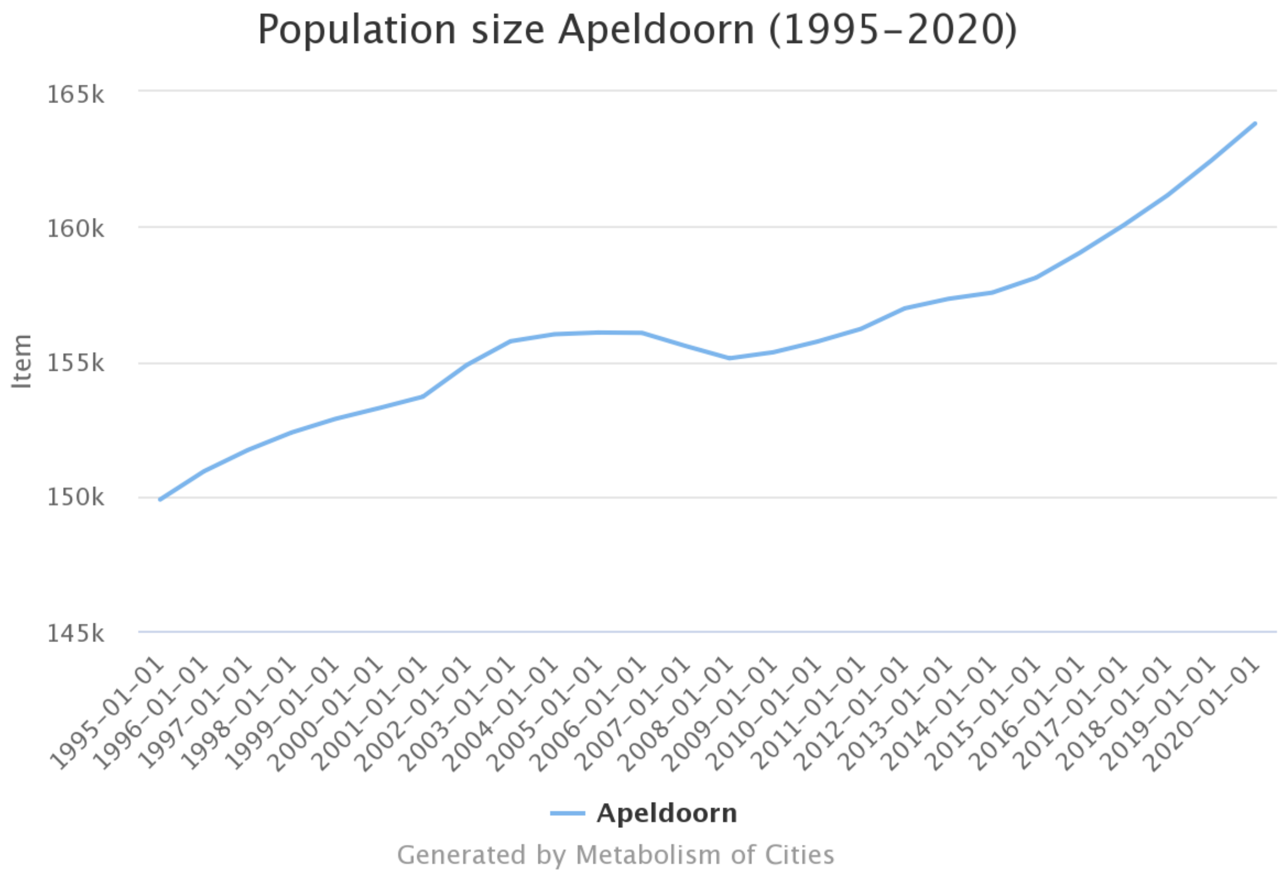
Apeldoorn
164,781
341 km^2

Veluwe
700,975
1,860 km^2

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

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

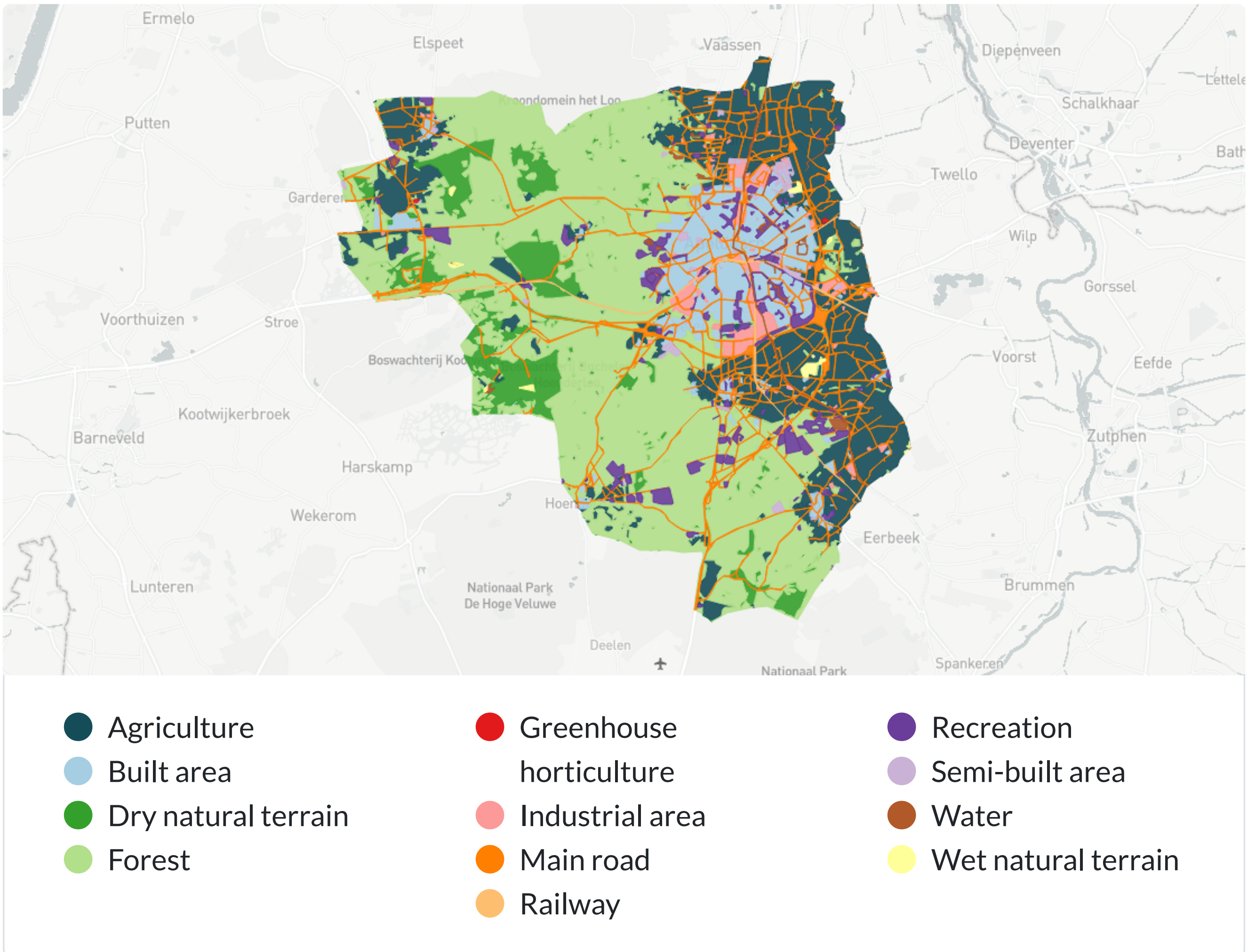
Population of Apeldoorn



[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 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 construction sector

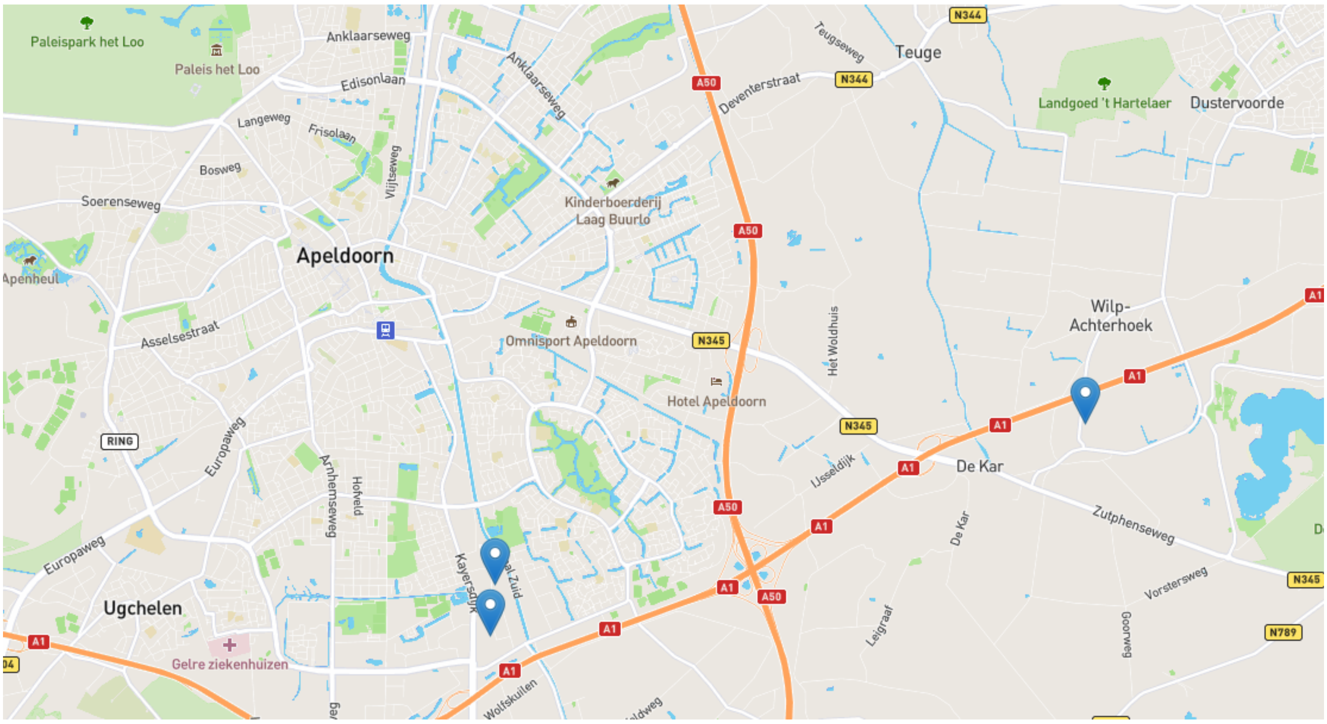
This section puts into perspective the economic context of the sector under study. It describes how many people are employed in this sector, as well as who the main actors involved (from all lifecycle stages for the sector's materials) are.

	GDP (monetary value, in €)	Employees
Apeldoorn	950,000,000	4,200
Veluwe	4,720,000,000	18,900
Gelderland	9,675,000,000	42,800
Netherlands	75,225,000,000	332,800

The construction sector in Apeldoorn

The local construction sector is one of the smaller economic branches in the municipality of Apeldoorn. The biggest sectors in terms of employment are healthcare, wholesale and retail and administrative and support services in Apeldoorn. Important to note is that also not all companies in the construction sector are all active (solely) locally, as well as that there are also various actors active in the region that are not located within the region (Circulaire Atlas Gelderland, 2019).

The actors of the construction sector



Data source

There are no raw material extraction companies in Apeldoorn, making Apeldoorn highly dependent on imports from the region, the Netherlands, or the rest of the world. This is a characteristic of the Netherlands as a whole as more raw materials (minerals, biomass, metals and fossil materials) are imported rather than extracted locally.

There are three local waste collection sites: Circulus-Berkel, SITA Recycling and Atterro Wilp. 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 categorized 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)	853,422.03	Tonnes/year
39	Circular Material Use Rate	-26.55	%
48	EU self-sufficiency for raw materials	0.73	%
55	EOL-RR (End of Life Recycling Rate)	9.28	%
57	Amount of sector specific waste that is produced	44,314.46	Tonnes/year
58	End of Life Processing Rate	30.00	%

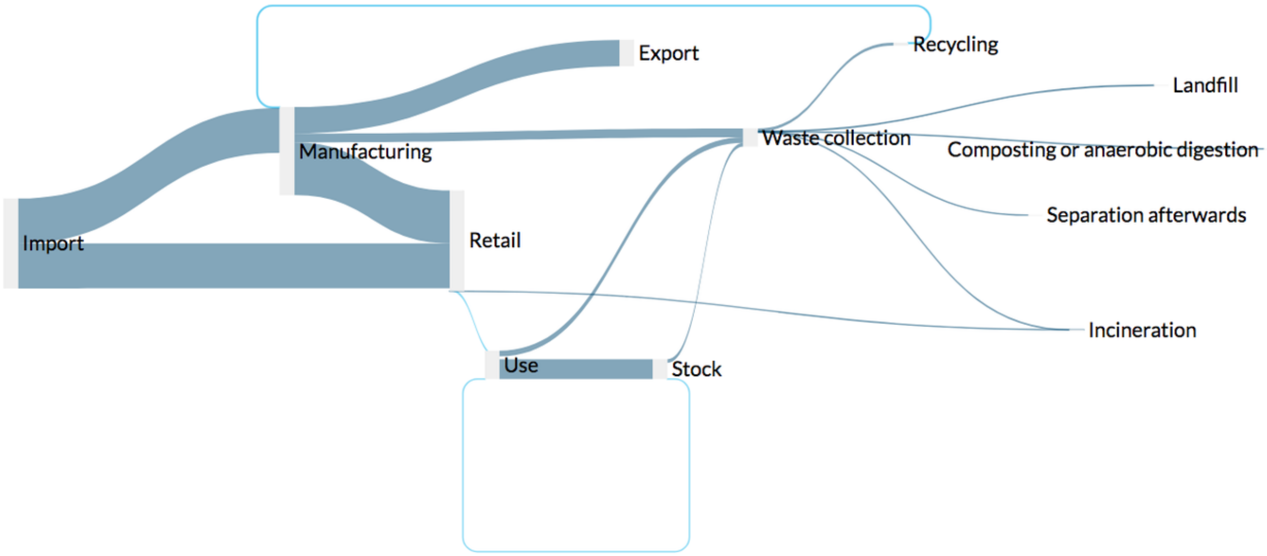
Indicator number	Indicator	Value	Unit
59	Incineration rate	4.77	%
61	Landfilling rate	11.63	%

The indicator table above describes calculated values for the mandatory indicators for 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 of the values of Netherlands as a whole. It is difficult to pinpoint whether Apeldoorn is truly performing on these indicators with the presented values or that the calculated values of the material flows are just not representative for Apeldoorn.

DMC is in Apeldoorn 853,422 tonnes. The per capita value for this is around 5.2 tonnes of domestic (construction) material consumption. For the Netherlands, this value that includes metal ores, non-metallic minerals and fossil energy materials/carriers is around 5.8 tonnes per capita. This indicates that Apeldoorn is performing slightly better in terms of material consumption. However, the stated material consumption of the Netherlands comprises more materials than only construction materials. Therefore, it is likely that Apeldoorn is consuming more non-biomass materials per capita than an average citizen in the Netherlands. Then, the value for the Circular Material Use rate (39) is -27% which is unlikely, as the Dutch CMU rate is 30 percent. It is unclear what could explain the minus value for CMU.

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 municipality of Apeldoorn relies solely on import when it comes to construction materials. 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
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			'Real time' information (2021)	
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	No data
Composting	No data		No data	No 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 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 before 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 SCA material categories, the information would be summed to the sector level. Also, **waste data** as well as information on how waste is processed was difficult to estimate as it depends on the type of waste how it is processed and the information on waste treatment was only found on total company waste 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 'metres' or square meters or 'items'. This could not be properly recalculated to a number of tonnes, and therefore it was decided to leave this information out and only deal with the information present in tonnes, the amount of concrete roads in Apeldoorn.

Proxy information

- **Forested area:** there was no information on which amount of the forested area in Apeldoorn is being managed to produce wood flows. This information was left out of the assessment.
- **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 the Eurostat MFA only uses raw materials and only a couple of materials in product forms. This was particularly difficult for the construction sector, as various materials share the same raw materials and in some cases the Eurostat categories comprised multiple materials that were not part of this SCA.

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 construction sector
The municipality of Apeldoorn has a binding contract with a single concrete processor/provider, located in Nijmegen. For demolishing, the realisation of pathways, roads, etc. or other infrastructural projects there is a multitude of contractors both situated inside and outside of Apeldoorn, any of which will be selected through procurement.

Apeldoorn has it's own land bank, providing contractors with soil/sand if necessary. Contractors will need to acquire concrete through Apeldoorn's concrete processor, other materials can be freely imported. Reuse/recycle requirements per project are defined by Apeldoorn's procurement officers, this is specified in e.g. tonnes of concrete/asphalt that needs to be made from recycles materials. Responsibility of further recycling/reuse of materials is put in the hands of the contractors themselves. While steps have already been taken to ensure a certain reuse/recycling minimum, there is a demand for upcycling methods of CDW materials into higher-value products, which could prove to be a more efficient reuse method.

Connection to and upscaling of demonstration actions
A number of videos (1, 2) have been made in the past, explaining exactly the plans for the near future of Apeldoorn. It is important that inhabitants as well as stakeholders get a say in this process. Saxion University has taken upon itself the task of generating a 3D visualisation of a neighborhood and how improvements can be made on its' circularity. This visualisation will be embedded in the open source platform OpenStad.

During the planned procurement of increasing circularity for this neighborhood, citizen input will be taken into account. The goal is to reach an as-high-as-possible score of circularity. Afterwards this pilot will be evaluated and it will serve as a learning experience, where the municipality aims to incorporate lessons learned into future decision-making processes.

Recommendations for making the construction sector more circular
The main recommendations are as follows:

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 be 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 construction sector actors map