

SECTOR-WIDE CIRCULARITY ASSESSMENT

FOR THE BIOMASS SECTOR

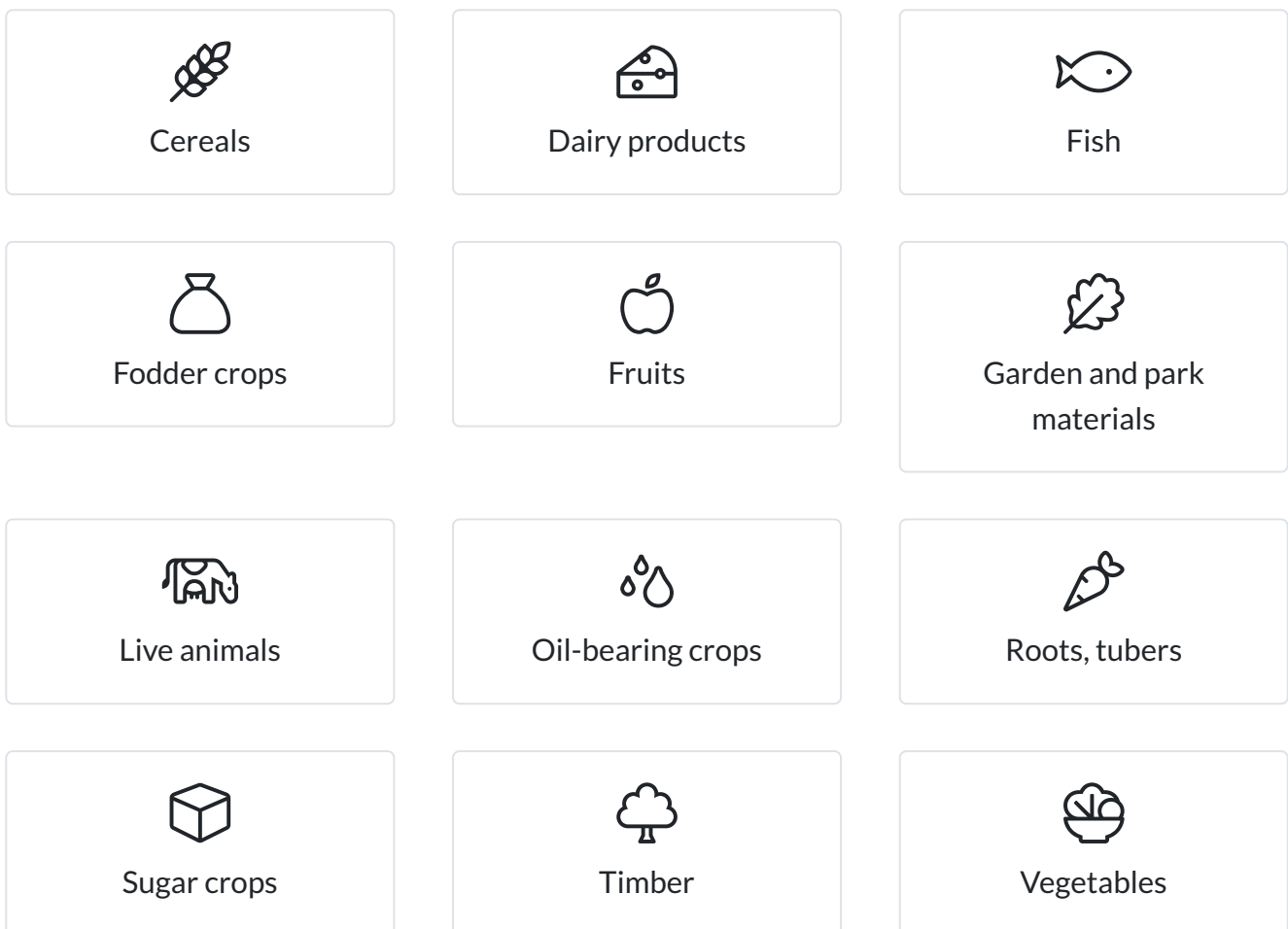
MIKKELI



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.



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

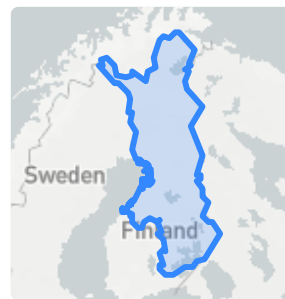
📏 3,229 km²



Etelä-Savo

👤 144,615

📏 19,130 km²



Pohjois- ja Itä-Suomi

👤 1,278,237

📏 236,450 km²

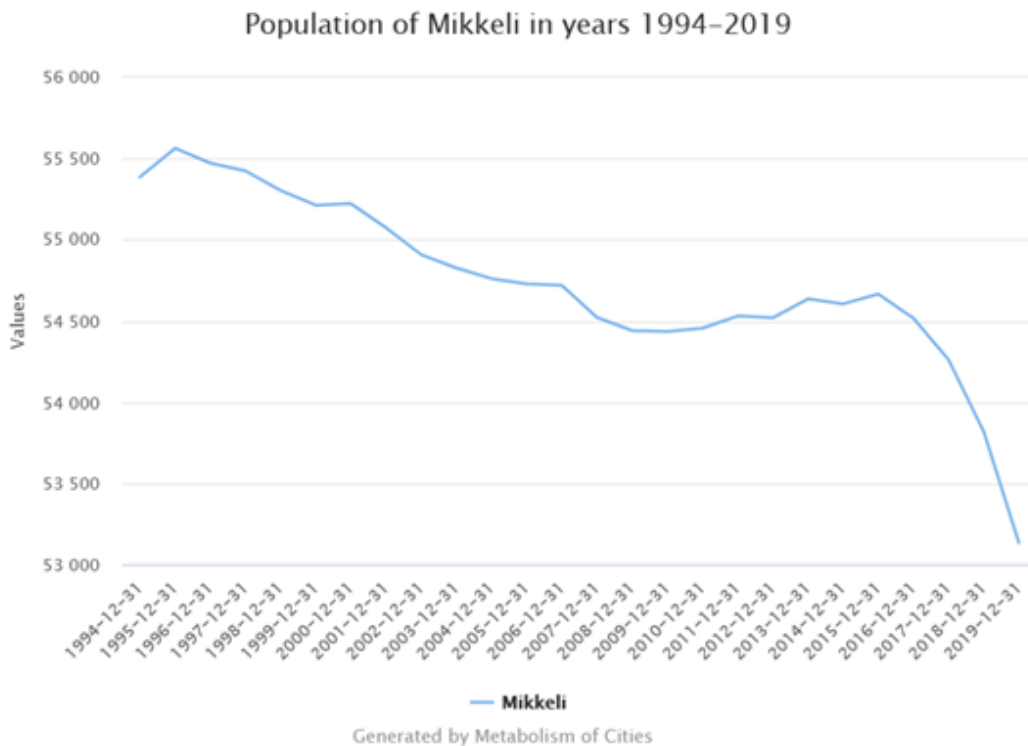


Finland

👤 5,525,292

📏 390,908 km²

Population of Mikkeli



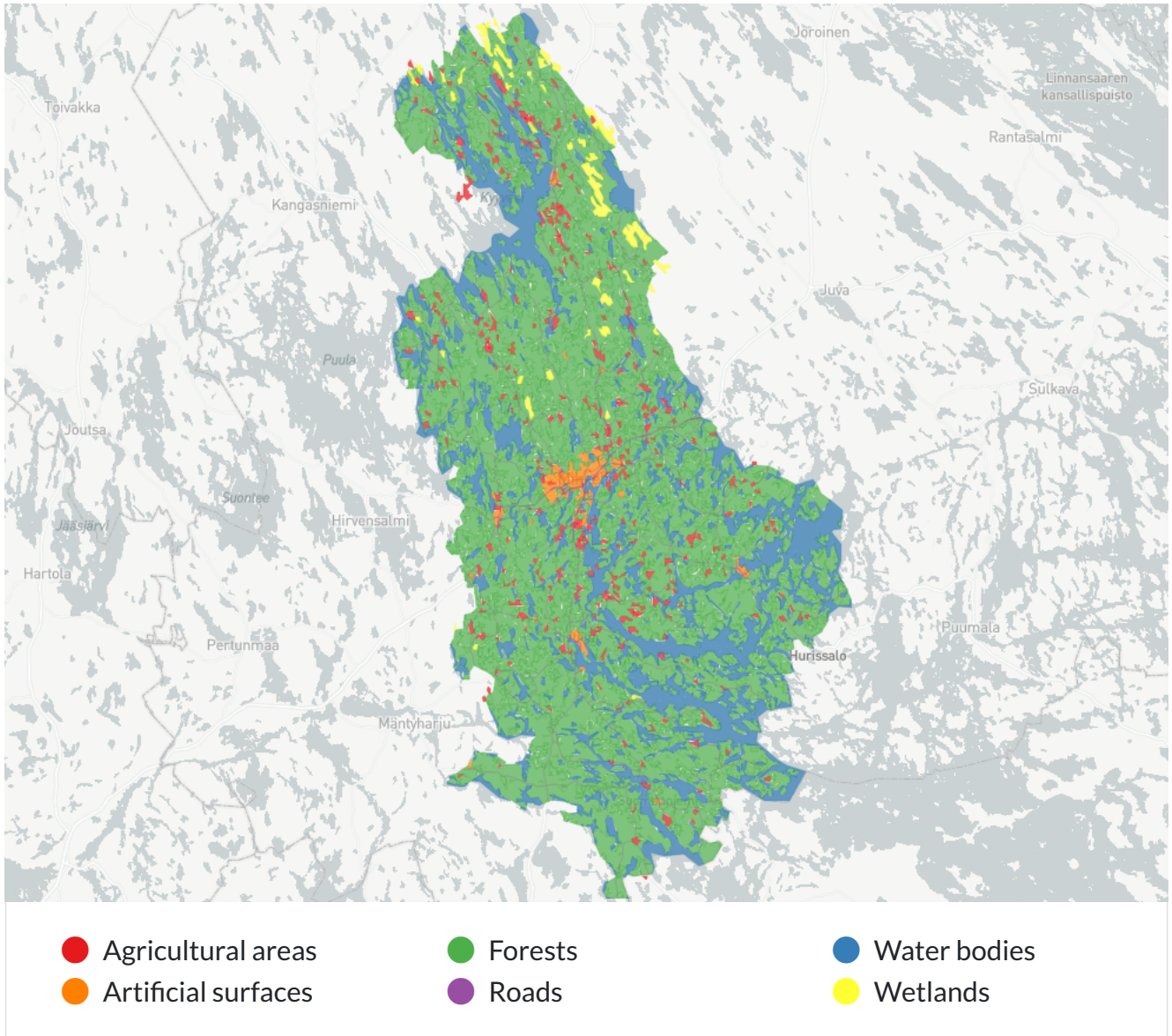
[Data source](#)

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



[Data source](#)

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](#)

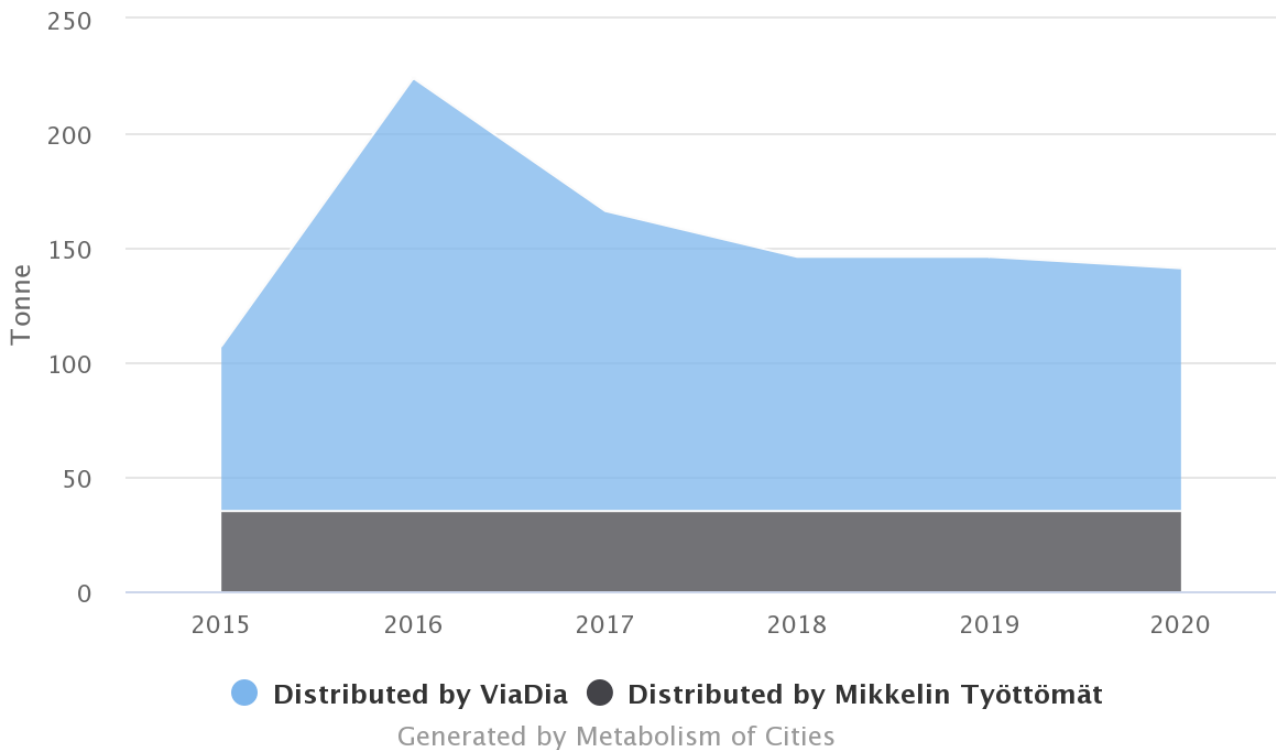
Actors in waste collection and treatment

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.

Food use and recycling through donation in Mikkeli in years 2015–2020



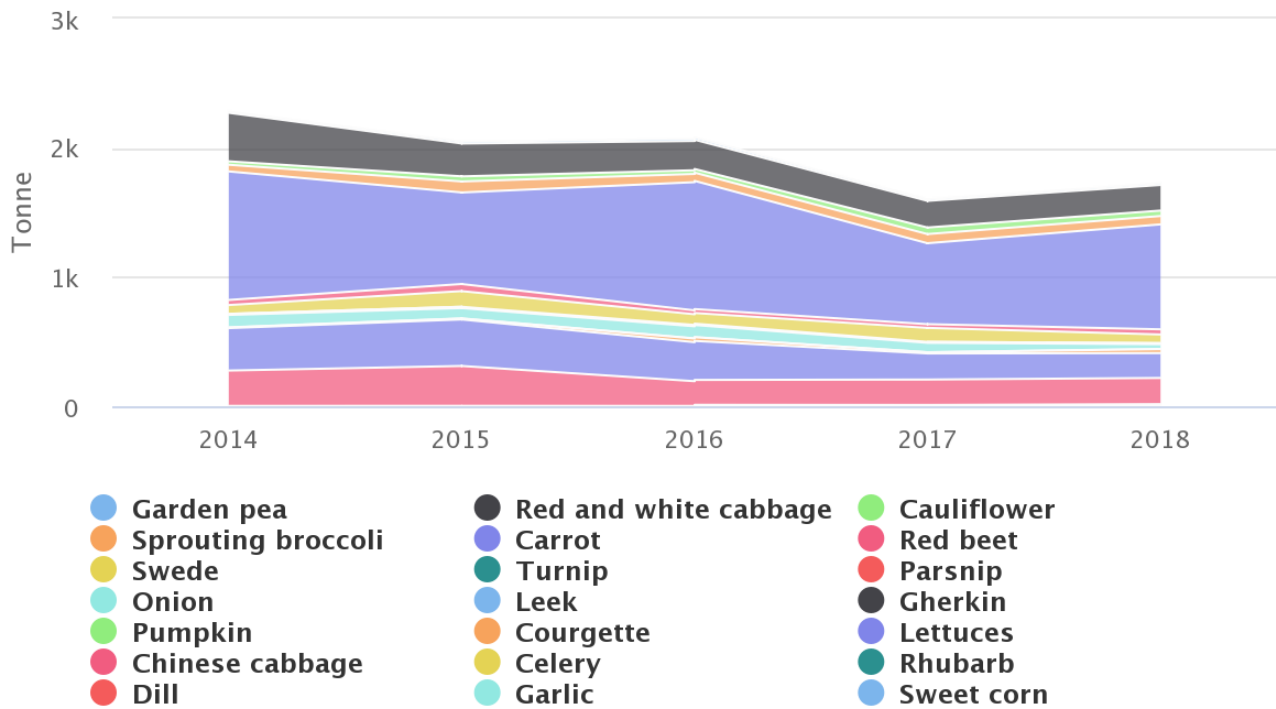
[Data source](#)

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.

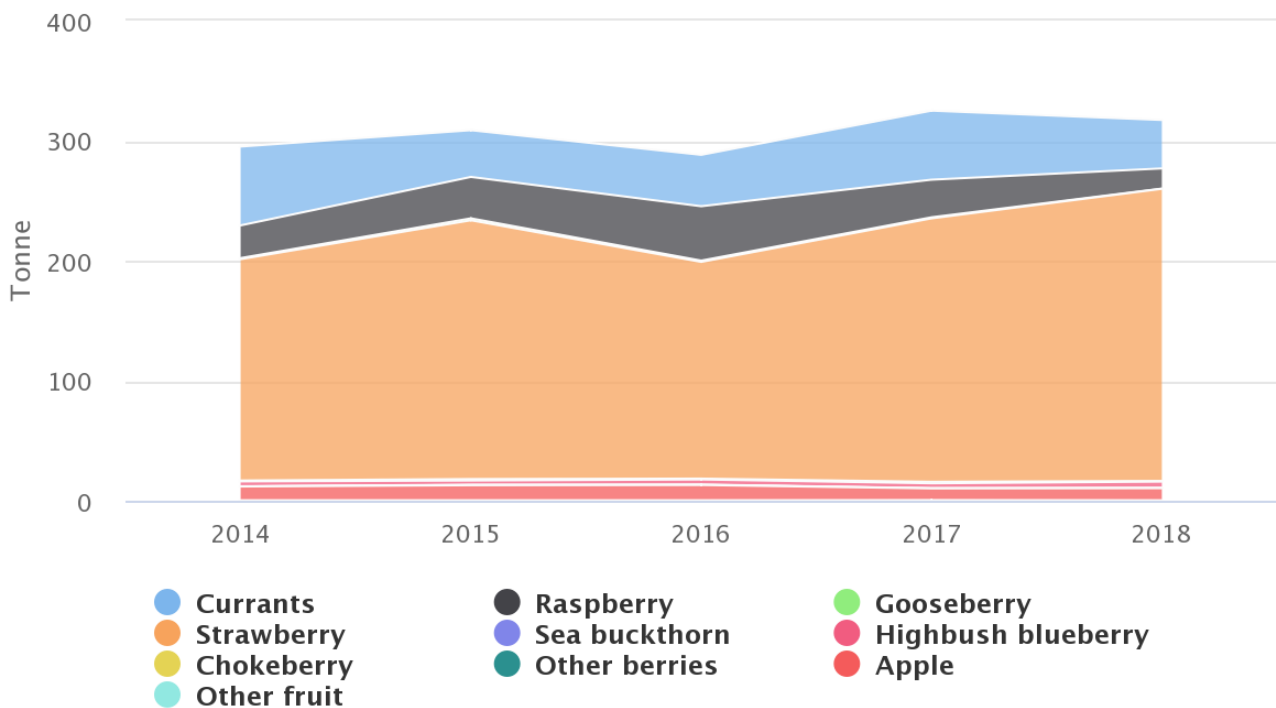
Cultivation of vegetables in Mikkeli (from Etelä-Savo data) in years 2014-2018



Generated by Metabolism of Cities

[Data source](#)

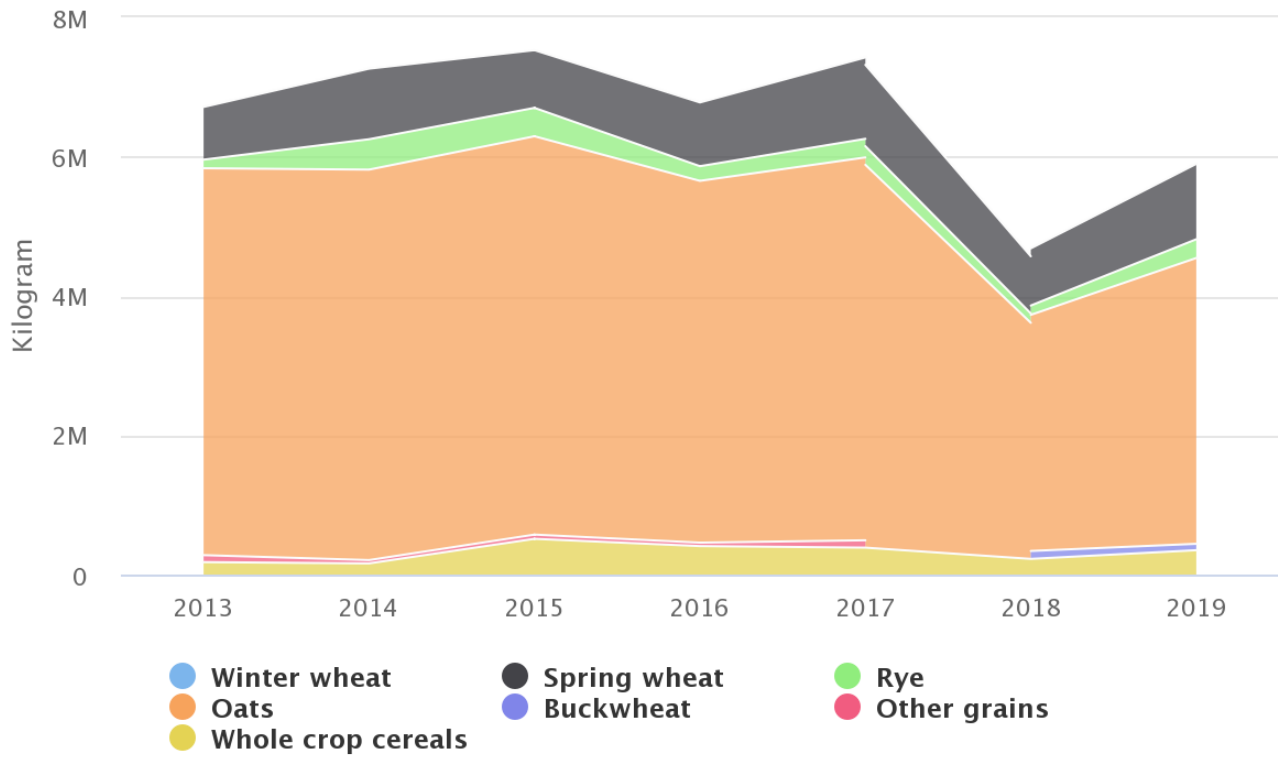
Cultivated amount of berries and fruits in Mikkeli (from South-Savo data) in 2014-2018



Generated by Metabolism of Cities

[Data source](#)

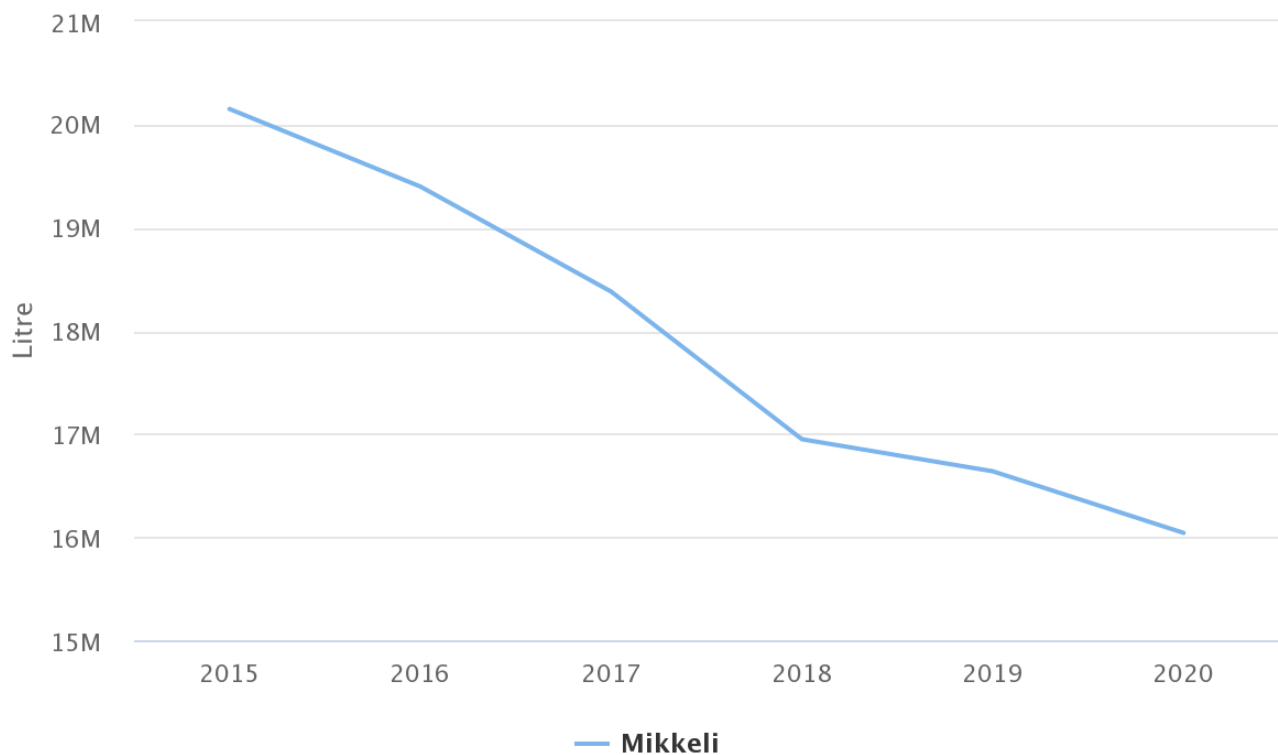
Produced amount of cereals in Mikkeli by species 2013–2019



Generated by Metabolism of Cities

[Data source](#)

Milk production in Mikkeli 2015–2020



Generated by Metabolism of Cities

[Data source](#)

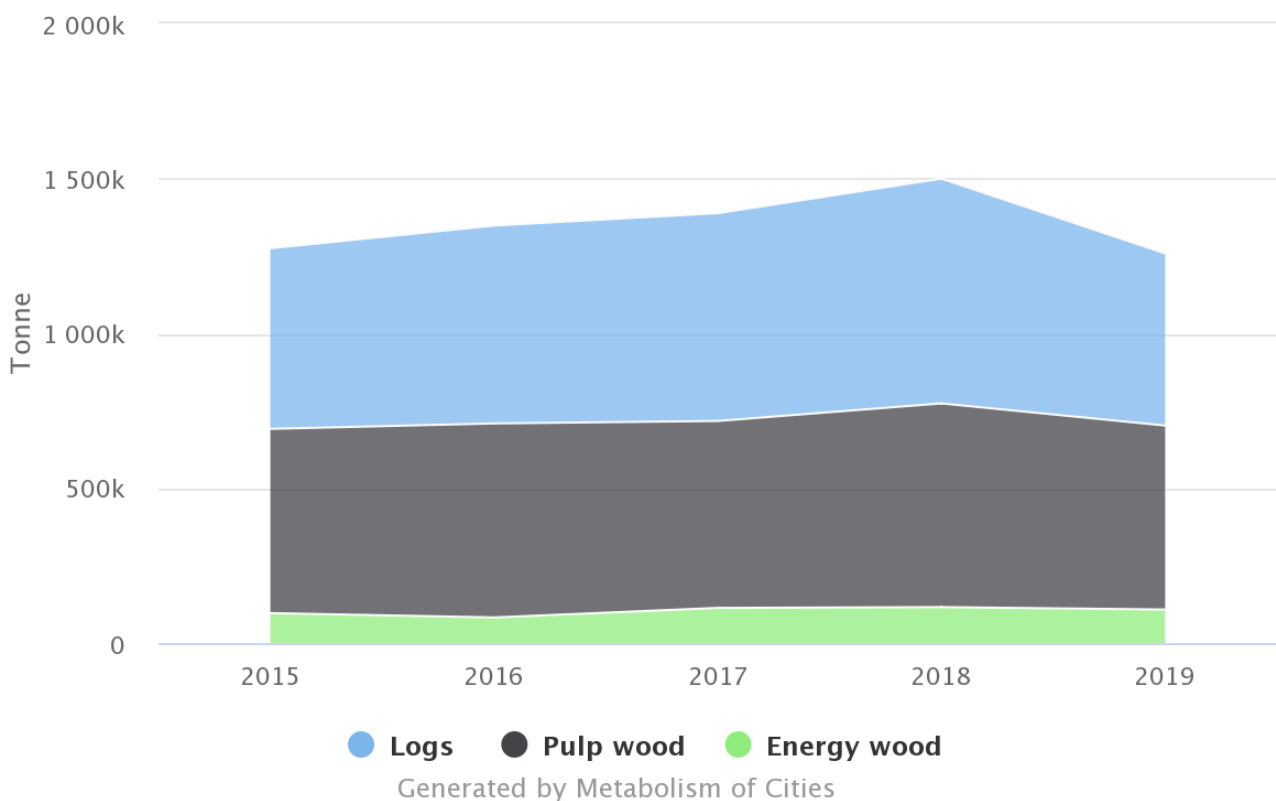
Actors in manufacturing of food

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.](#)

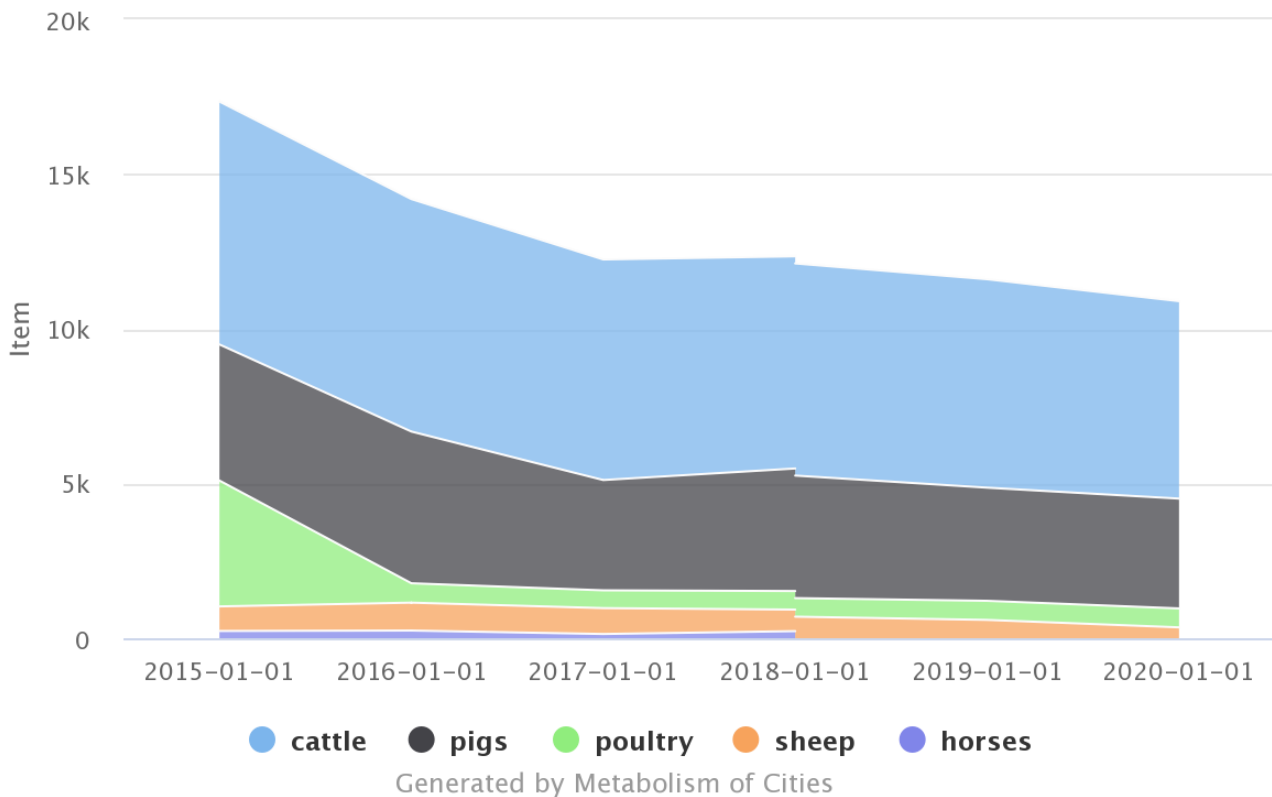
Amount of harvested wood in Mikkeli



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 in order to use as soil improvers for the cultivation of crops.

Number of livestock by species in Mikkeli 2015–2020



[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.

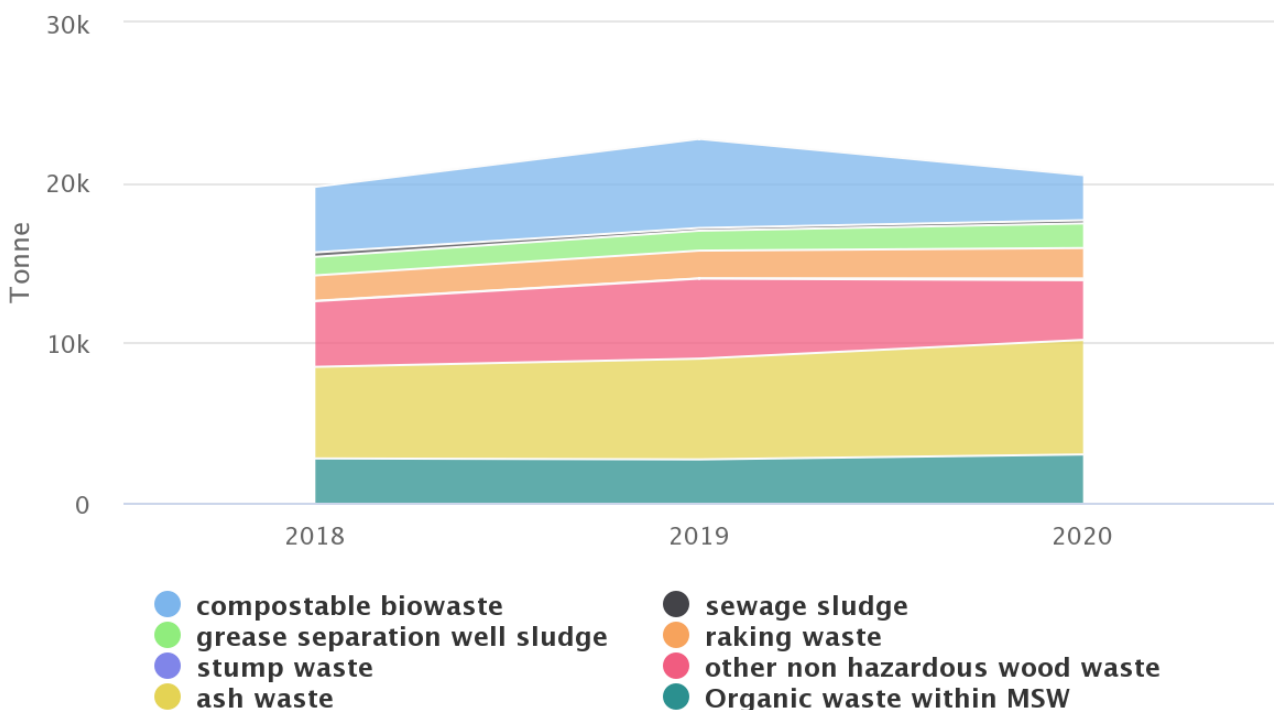
To be able to produce and distribute more biofuels in Mikkeli, more biowaste is needed to be collected in the city. The city strategy (2018-2021) has the aim of increasing the recycling of biowaste by improving sorting and collection (residential waste, waste recycling: Baseline 98.6% / Target 99%).

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.

Various biomaterials by amount in waste collection in Mikkeli years 2018-2020



Generated by Metabolism of Cities

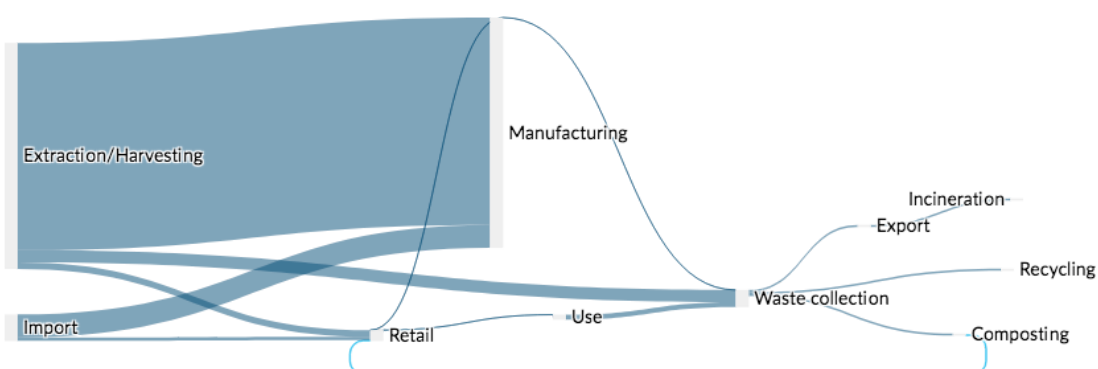
[Data source](#)

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.



Data source

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 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 activities	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	Green		Yellow	
Manufacturing	White			
Retail	White			
Use	Green			Red
Stock	Green			
Waste collection	Green			
Landfill	Green			
Incineration	Green			
Recycling	Yellow		Green	
Anaerobic digestion	White			
Composting	Green			
Imports	Red			
Exports	Red			

Information of extraction and harvesting was mostly obtained from [LUKE, the Natural Resources 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 unknown 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 hectares 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 business 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](#)
- [Mikkeli land use map](#)
- [Waste collection and treatment facilities in Mikkeli map](#)