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CORE

THEMATIC ANALYSIS IN THE FIELD OF BIOWASTE IN **SOUTH TYROL, ITALY**

INVENTORY OF EXPORTABLE GOOD PRACTICES
&
INVENTORY OF SITES, FACILITIES, AREAS AND INSTRUMENTS TO BE IMPROVED DURING THE COOPERATION

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This analysis has been prepared by **Waste Management Office of the Environmental and Climate Protection Agency** *on behalf of* **Autonomous Province of Bolzano – Alto Adige – SOUTH TYROL** *region in the framework of the Interreg Europe programme project "Composting in Rural Environments" (CORE). This project receives financial support from the European Union through the Interreg Europe programme. This publication reflects the author's views only and the Interreg Europe programme authorities are not liable for any use that may be made of the information contained therein.*

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1. Introduction

General context

Biowaste comprises biodegradable garden and park waste, food waste from households, offices, restaurants, canteens and retails as well as waste from food processing plants.

Composting (treatment in the presence of oxygen) leads to soil improvers; anaerobic digestion (treatment in absence of oxygen) to biogas[1].

Across the EU, between 118-138 million tons of biowaste are generated annually; of them, only 40% is recycled into quality compost and digestate.

Moreover, up to 50% of municipal solid waste - on average - is organic, so this fraction seems central for the circular economy.

In the case of rural environments with low-density population, the management of the organic fraction is environmentally and economically impactful, since a contaminating and expensive process is required to collect, transport and treat small amounts of organic waste dispersed in distant and sparsely populated villages.

Prevention of biowaste and the normalization of quality composting could contribute to the drastic reduction of this fraction and of the effects derived from its management. The product obtained can be used as soil-improving material and fertilizer in local and regional parks and gardens or in the form of biogas, while further uses could be promoted.

Despite the fact that regional and local policies in force all over Europe observe the transition of the waste management sector towards a circular economy, the treatment of biowaste is often not sufficiently developed, notwithstanding its potential to comply not only with circular economy but also with the mitigation of climate change.

The project rationale

In the frame described, the Interreg Europe project CORE – Composting in Rural Environments - intends to be an accelerator for rural territories to develop *composting* further.

The project brings together regional and local administrations with competences on biowaste management from 8 rural regions from all over Europe, which are accompanied and supported in the project by the European Compost Network (ECN), in the role of advisory partner.

[1] Even if the project literature uses the word “*composting*” by default, CORE project addresses both composting and anaerobic digestion and also prevention and separation in rural areas, as steps conditioning the process. However, for the sake of simplification the word “*composting*” is used in a generic way, representing all of them though in practical terms.

For 4 years, the partners will export and import experiences on biowaste treatment, with the expected result of new projects and improved policies with regard to biowaste in all the partner territories.

The purpose of the Thematic Analyses projected

Interreg Europe is a programme for exchange of experiences and policy improvement. In line with it, the “studies/analyses” authorized for financing have not a research or scientific purpose, as this is not the programme rationale.

The goal of “studies/analyses” in an Interreg Europe context has to be them to contribute to and to facilitate the process of exchange of experiences and policy and territorial improvements.

Accordingly, the Thematic Analyses authorized in CORE must serve for each partner territory to prepare, during semester 1, the 4 years of cooperation to come, defining in advance – in the form of a roadmap – (I) what local experiences will be shared with the partners during the years to come and (II) what local resources could be further developed/ improved thanks to the knowledge gained during the cooperation. This information will be systematized in the form of inventories.

These inventories won´t be immovable, as during the project new exportable experiences and new areas for improvement can emerge; but the purpose is each partner territory making, from the very beginning, an exercise of self-reflection useful to plan their part in the cooperation and the benefits they could obtain out of it, listing a good number of experiences to be shared and a series of local gaps that hopefully could be fulfilled thanks to the experience gained in the project.

The following pages offer a template model to inventory such information.

The Thematic Analyses are conceived to be useful for each partner producing them, as they are setting up the milestones for partner during the cooperation: what will be provided, what is expected to be improved. They should be roadmaps for the different project teams, serving as reference documents throughout the project. Despite their primarily local interest, they will be uploaded in the CORE webpage “Library” section as a proof of the work done and as possible inspiration for others.

It is possible that in order to obtain the information required – inventories of practices and improvement areas - different means are needed, such as meetings with different local actors, interviews, surveys, revision of documents. If needed, they are valid in the way that they contribute to the fulfilment of the inventories requested.

Last, but not least, mentioning that stakeholders can play a central role in this exercise of self-reflection and planning. Involve them!

2. Regional Context

The province of Bolzano - South Tyrol has approximately 534,000 inhabitants and covers an area of 7,400 km², 80% of which is considered mountainous, only 6% is inhabitable.

About 60.000 tons of biowaste are collected on average in South Tyrol per year. This waste comes from different sources and is divided into organic waste (38.868 tons in year 2022) and green waste (22.338 tons in year 2022). Organic waste is waste from kitchens and canteens and is collected in special bins for wet waste. Green waste is waste from parks, gardens and landscaping. Organic waste is recovered at composting and digestion plants. Green waste is recovered in composting plants either directly as green compost or as a structural component in the composting of organic waste. Biogenic waste is mostly recovered at the eight composting plants (of which two plants only for green waste) and the two anaerobic digestion plants in the area. A small part of organic waste is composted by South Tyroleans in their own backyards.

Central in the state of play and evolution of Southtyrolean biowaste policies is the "2000 Waste Management plan", approved in its first version in 1993 by the Provincial Council of Bolzano (Resolution 6801). The plan defines the guidelines for waste management and for the transition from landfilling only to the recovery and pre-treatment of waste. From that date, waste management became a matter of public interest. With the approval of the plan, the foundations for public funding were laid. With a special law, public facilities can be built and taken into operation. The implementation of the plan was largely financed by the provincial government.

The Waste Management plant covers prevention, reduction, recycling, treatment and disposal, with the managing of the plants in South Tyrol: 86 recycling plants, 4 waste management plants, 8 composting plants, 4 waste transhipment stations, 4 landfills for waste, 1 waste incinerator

Thereafter, according to the EU Directive 2008/98/CE the Plan has been subjected to several updates to adapt to new focuses of interest: in 1999 (Resolution No. 285: management of urban waste, depuration sludge, green waste), in 2005 (Resolution No. 2594, regulation of municipal waste management up to 2030 with information on user basins and the individual necessary plants), in 2016 (Resolution No. 1431, concerns measures to reduce domestic municipal waste and the collection and recovery of organic waste); the last update took place in 2021 (Resolution No. 1139).

The objective of the last update has been better approaching littering reduction through waste dispersal measures and the reduction of food waste; also particular attention has been paid to waste planning in the province of Bolzano, with the aim of synergistic use of facilities in the province - composting plants, biogas fermenter to improve compost quality.

The waste management office of the provincial environment agency is the competent authority that carries out standardization and rule-making activities for waste management in our province by drafting and periodically updating the Waste Management Plan, is responsible for issuing regulations at local level, and drafting technical standards, provides authorizations for waste management plants, has an advisory function in the construction and management of facilities and has a control function through inspections, sampling and analyses of the compost.

The building of the waste management facilities was financed by municipalities, district communities and the Province of Bolzano with tax money, which is therefore also owned by these actors. The facilities are operated by municipal building yards, the environmental services of the districts, an in-house company of the Province of Bolzano and some private waste management companies.

The actors involved are the different levels of administration in the Province of Bolzano (municipalities, district communities, provincial administration), the public and private operators of collection facilities and waste management plants, and finally each individual citizen.

3. Inventory of Good Practices to be shared during the cooperation[2]

Local Good Practices on Community Composting[3]

Title:	
Location of the practice:	**Province of Bolzano – SouthTyrol**
Short summary:	There is no public Community Composting in the Province of Bolzano
Responsible organization:	

[2] If needed, more tables can be added; equally, those not needed can be deleted.
[3] Even if the Good Practices under this category where already shared in Thematic Seminar I in Ciudad Real, please insert them in the document so that it can be as much comprehensive as possible.

Local Good Practices on Individual Composting[4]

Title: **Individual Composting**	
Location of the practice:	**Each municipality in the Province of Bolzano - SouthTyrol, district communities.**
Short summary:	In accordance with the first waste management plan of the Province of Bolzano, the provincial environment department conducted a comprehensive programme to promote home composting, with information activities and the allocation of funds for the distribution of small composting bins. In cooperation with Ökoinstitut (an environmental research institute in the area), a brochure in both languages (Italian and German) on home composting was published in 2000 and updated in 2015: Pubblicazioni | Agenzia provinciale per l'ambiente e la tutela del clima | Provincia autonoma di Bolzano - Alto Adige Publikationen | Landesagentur für Umwelt und Klimaschutz | Autonome Provinz Bozen - Südtirol
Responsible organization:	**Environmental Agency of the Province Bolzano**

[4] Even if the Good Practices under this category where already shared in Thematic Seminar I in Ciudad Real, please insert them in the document so that it can be as much comprehensive as possible.

Local Good Practices on Centralized/Industrial Composting and Anaerobic Digestion[5]

Title: **From farm composting to robust composting plants in rural areas**	
Location of the practice:	**Province of Bolzano - SouthTyrol**
Short summary:	At the beginning of the 1990s, the Province of South Tyrol focused on the management of organic waste in rural areas by intensifying individual composting and by using windrow composting plants. As a result, several municipalities in South Tyrol tried to process their organic waste in open windrow composting and to use the resulting compost in agriculture as a soil conditioner. In 1993 this was laid down in the "Waste Management Concept 2000". When the "Waste Management Concept 2000" was updated in 1999, the legal and technical provisions for the expansion of supra-municipal composting plants were incorporated. Some of these facilities were expanded and are now robust, medium-sized facilities for organic and green waste in rural areas. In the 1980s, the province of Bolzano tried to solve the waste problem by building landfills and pre-treatment of municipal waste. Therefore, three central plants for the composting of municipal waste were built. The objective was to save landfill volume and to produce waste compost, which could be used in agriculture. Two of the plants were in function for a few years, but never reached the set targets. The limit values in the residual waste compost produced were so far exceeded that it had to be sent to landfill. There it caused the well-known problems with leachate and landfill gas. For two of the plants, a so-called "green line" had already been started in the early 1990s. One of these "green lines" was later expanded into a composting plant. The composting plant in Bolzano did not survive the testing period and had to be closed. The first lesson was that a public administration should only use mature, robust systems for the treatment of waste. Secondly, a mix of de-centralised and centralised plants is needed for the treatment of organic waste. In rural areas, a mix of home composting, farm windrow composting and regional composting plants should guarantee the treatment of organic waste. This was then laid down and implemented in the 1999 update of the waste management plan. Due to the state obligation to separate organic waste (green and bio-waste), the directive on public bio-waste and bio-waste collection as well as composting was issued. Therefore, for rural areas, composting was promoted in different scales. A distinction was made between home composting, farm windrow composting, and regional composting plants. Information campaigns were launched in all the municipalities to intensify home composting, and compost boxes were distributed. In many cases, however, the population misjudged the effort needed for individual composting. It became clear that home composting is more than just putting organic waste in the top of the composter and taking the finished compost out of the bottom. Therefore, it became clear very soon that processing of

[5] Even if the Good Practices under this category where already shared in Thematic Seminar I in Ciudad Real, please insert them in the document so that it can be as much comprehensive as possible.

	organic waste by citizens was only possible to a limited extent. The beginning of the introduction of a country-wide organic waste collection and the expansion of some existing plants into regional composting plants was the next step towards a functioning management of organic waste. In the last 20 years, some of the farm-operated composting plants have been expanded into regional composting plants. The composting plants can process from 2,000 to 10,000 tons of organic waste, depending on the technology and size. The composting process used is the open windrow composting with and without forced aeration. The compost produced today is of very good quality. In agriculture, the compost produced is *preferably used as a soil conditioner.* All the plant are funded with public money. In fact, no individual benefits economically from waste disposal. Financing takes place through the province with waste tariffs and directly with the disposal costs paid by the municipalities per ton of waste. The knowledge gained from the beginnings of biowaste management led to a consistent continuation of the implementation of the waste management plans. The additional construction of a central anaerobic digestion plant made it possible to extend biowaste collection to urban centres. At the same time, composting plants were deprived of the pressure to accept pure wet waste. The partial overloading of the composting plants could therefore be reduced. Today, composting plants in South Tyrol process 40,000 tonnes of the organic waste here produced and are a good solution for rural areas in terms of energy use, costs, and technical effort. Thanks to this mix of plants, South Tyrol is now able to treat all bio-waste and most of the green waste itself.
Responsible organization:	**Waste Management Office, Composting Plants**

Title: **Anaerobic digestion in Province of Bolzano**	
Location of the practice:	**Lana, South Tyrol**
Short summary:	Before the anaerobic digestion plant was installed, in the province of Bolzano, Italy, many municipalities had small composting facilities. As for the largest municipality, namely the city of Bolzano, the collection of organic waste was not done and went to incineration along with other urban solid waste. Therefore, with the establishment of European directives that obliged the municipality of Bolzano to implement separate collection of organic waste, a treatment plant had to be built (exporting waste to other regions was not an option). Not only Bolzano but also other municipalities could from then on deliver their waste to the anaerobic digestion plant. From a technical point of view, the objective was achieved by implementing a wet anaerobic digestion plant for OFMSW with energy recovery. Anaerobic digestion is a process in which microorganisms break down biodegradable material in the absence of oxygen. The process produces a biogas, which is used directly as fuel, in combined heat and power gas engines. The produced electricity is self-consumed and sold to the grid. The process still generates a quantity of digested sludge that must be sent to a composting plant. Both the province and municipalities benefit directly from this process, as well as the citizens who see a low tariff thanks to its efficiency. In addition, clean energy is produced which further lowers the operating costs of the plant.
Responsible organization:	**Waste Management Office, Eco center s.p.a.**

Local Good Practices on Prevention of Organic Waste

Title: **Promotion of initiatives against food and non-food waste: regulation**	
Location of the practice:	**In the whole Province of Bolzano - SouthTyrol**
Short summary:	Provincial law n. 2 (13.03.2018) on the donation and distribution of foodstuffs for social solidarity and limiting waste. In addition to enhancing solidarity and charity activities inspired by the principles of social responsibility, the law also aims to promote better environmental sustainability by reducing waste at each stage of production, processing, distribution and administration of food and non-food products. To pursue the objectives, the Province promotes - the recovery, donation and distribution of surplus food still for consumption and inedible products, such as unsold drugs but still in their period of validity and used clothing, for the benefit of people in situations of social distress; - the autonomous initiative of individuals, citizens and associations and voluntary activities, in compliance with the principle of subsidiarity; - responsible consumption as a means of reducing food and non-food waste; - actions to reduce waste production and to recover and transport food, including for personal or family use; - information and awareness-raising campaigns for consumers, businesses and institutions aimed at the dissemination of the purposes set out . Detailed rules for the disposal and requirements for the conservation of surplus food are laid down. A Table for the Coordination of Waste Reduction and Surplus Distribution Policies and a Technical Committee are hereby established.
Responsible organization:	**Department responsible for social policies of the province of Bolzano**.

Recovering unsold and non-expired food from supermarkets, canteens, cafeterias, pastry shops, fruit and vegetable shops and redistribute it to the needy (voluntary associations involved in several projects). The Province and the local authorities can grant to the donors contributions for the documented expenses incurred for the recovery and distribution of food surpluses and there is a financial allocation to cover these expenses. Some examples of currently active initiatives are listed below:

Title: **Food waste prevention initiatives: Food Bank Trentino Alto Adige – City Cibo Project**	
Location of the practice:	**Many municipalities of the Province of Bolzano - SouthTyrol**
Short summary:	This food bank collects surplus and donated food, stores it, and distributes it to charitable organizations in South Tyrol. With this initiative, long-lasting food donated by customers is gathered in supermarkets and then distributed directly to those in need.
Responsible organization	**Banco Alimentare Trentino Alto Adige**
Title: **Food waste prevention initiatives: Food parcel distribution – Food tables**	

Location of the practice: Short summary: Responsible organization	**8 municipalities of the Province of Bolzano - SouthTyrol** High-quality, wholesome food items are collected and distributed to those in need. Perishable items nearing their expiration date are rescued and given to those in need before they are discarded. **Società di San Vincenzo**

Title: **Food waste prevention initiatives: Crumb hunters - helping without wasting**	
Location of the practice: Short summary: Responsible organization	**Bolzano, Merano, Brunico - SouthTyrol** The crumb hunters are volunteers from the Volontarius Association, who speed through the cities of Bolzano, Merano, and Brunico on their blue bicycles in the evening, collecting bread, pastries, and other unsold food from bars, pastry shops, bakeries, fruit and vegetable stores, and supermarkets. The collected food is distributed through the FoodNet BZ network to charitable organizations (Caritas, La Strada, etc.) and delivered to people living on the streets and needy families. **Volontarius Association**

Title: **Food waste prevention initiatives: Emporio Solidale – Crumb Market**	
Location of the practice: Short summary: Responsible organization	**Bolzano, Merano, Brunico - SouthTyrol** This is another initiative by the Volontarius Association. It is a solidarity emporium with a store where people in need can purchase essential food items such as oil, bread, pasta, rice, and other pre-packaged products in boxes. Instead of money, "purchase points" are used, calculated and assigned based on income and the number of family members. **Volontarius Association**

Title: **Food waste prevention initiatives: Vinzimarkt**	
Location of the practice: Short summary: Responsible organization	**Bolzano - SouthTyrol** VinziMarkt is a grocery store in Bolzano for people in need and is part of the food tables of the Society of St. Vincent of South Tyrol. At VinziMarkt, individuals in need can purchase any food item using points rather than money. The indigence of individuals is determined by the counseling office. The food is provided by the Food Bank, crumb hunters, Volontarius, and 30 other organizations, as well as companies and private individuals. **Società di San Vincenzo**

Title: **Food waste prevention initiatives: VinziBus**	
Location of the practice: Short summary: Responsible organization	**Bolzano - SouthTyrol** VinziBus distributes food and hot meals to people in need in Bolzano. The hot meal is freshly prepared every day, and food and sweets are provided by private donors, crumb hunters, and Vinzimarkt. **Società di San Vincenzo**

Title: **Food waste prevention initiatives: Bottega Santo Stefano**	
Location of the practice:	**Bolzano - SouthTyrol**
Short summary:	At Bottega Santo Stefano, individuals in need can purchase any food item using points rather than money. The products come from stores, the Food Bank, crumb hunters, Aspiag, FoodNet Bz, and City Cibo.
Responsible organization	**Associazione caritativa Santo Stefano**

In the field of food waste prevention also communication campaign and awareness-raising activities are organized by many associations to increase public awareness of food waste and to offer workshops for schools:

Title: **Food waste prevention – Communication campaign: YoungCaritas – Tasty Waste**	
Location of the practice:	**Province of Bolzano - SouthTyrol**
Short summary:	Workshops are organized for middle schools, high schools, vocational schools, and groups of interested individuals throughout the year. Role-playing games and interactive exercises illustrate facts related to food waste. All participants are engaged in discussions and idea exchange, encouraged to reflect on their own relationship with food.
Responsible organization:	**YoungCaritas / Caritas Diocesi di Bolzano – Bressanone**

Title: **Food waste prevention – Communication campaign: Slow Food Alto Adige Südtirol**	
Location of the practice:	**Province of Bolzano - SouthTyrol**
Short summary:	Slow Food is committed globally to a food culture based on appreciation, responsibility, and pleasure. Individuals active in this network are dedicated with conviction and passion to a sustainable food system for the future, one that preserves the variety of flavors and bioculture, strengthens local sourcing, and increases the value attributed to food. The foundation of this concept is the quality of food; therefore, Slow Food's food must be good, clean, and fair. The Slow Food Chefs' Alliance, events, and educational activities in schools are organized to convey the Slow Food philosophy. Presidia support traditional high-quality products, and there's a reinforcement of the supply of local products obtained through traditional methods. The goal is to promote food while indirectly limiting food waste.
Responsible organization:	**Slow Food Alto Adige Südtirol**

Title: **Food waste prevention – Awareness campaign: Initiative “Too good”**	
Location of the practice:	**Bolzano, Bressanone, Brunico, Merano, Silandro - SouthTyrol**
Short summary:	This is an initiative by the hoteliers' association aimed at raising awareness for more conscious consumption. Free take-out containers provided by the Autonomous Province of Bolzano are distributed to interested restaurateurs. This way, people dining out can take any unconsumed food home with them.
Responsible organization:	**Hoteliers- und Gastwirteverband (HGV)**

Title: **Food waste prevention – Communication campaign “Voku Pocu (Popular cuisine)”**

Location of the practice:	**Kaltern - SouthTyrol**
Short summary:	With the food discarded by stores and markets, collected by students, creative and tasty meals are prepared. In this way, VokuPocu collaborates to reduce significant waste, giving social and cultural value to the food during communal preparation and contributing in an environmentally sustainable and socially responsible manner.
Responsible organization:	**Umweltgruppe Kaltern**

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Local Good Practices on Regulation for Composting

Title: **Update of the policy instrument (Waste management plan): Decision GP 01.02.1999, n. 285**	
Location of the practice:	**Province of Bolzano – SouthTyrol**
Short summary:	Publication of the first update to the waste management plan (WMP) with practical and technical guidelines on the processing of organic waste, with particular attention to agricultural practices. Description of the process, prescriptions, and technical provisions, along with funding details for decentralized composting.
Responsible organization:	**Waste management office of the Environmental agency.**

Local Good Practices on Training of Master Composters and
Engagement of Citizens and Organizations of the Rural Areas in Composting

Title: **Home composting guide**	
Location of the practice:	**Province of Bolzano – SouthTyrol, private gardens**
Short summary:	In South Tyrol there is no more a tradition of training of master composters. In the 90s there was rather focused on small domestic composting and at that time, the role of an environmental consultant had been established, who, among the skills, also supported citizens in setting up home composting. Over time, this role has not been continued due to reasons related to training and funding availability. By need, municipalities can request informative sessions for the population from the Waste Management Office. Moreover, citizens are addressed to the guide on composting practices prepared by the Ökoinstitut on behalf of the Waste Management Office, first published in 2000 and updated in 2015, published in both languages (Italian and German). The guide is available on the Website of the Environment and Climate Protection Agency: https://umwelt.provinz.bz.it/publikationen.asp?publ_action=4&publ_article_id=299203 https://ambiente.provincia.bz.it/pubblicazioni.asp?publ_action=4&publ_article_id=299204
Responsible organization:	**Waste management office of the Environmental agency.**

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Local Good Practices on Good Use and Different Uses of Compost and Digestate-based Products

Title: **Use of compost in orchards and agriculture**	
Location of the practice:	**Province of Bolzano – SouthTyrol**
Short summary:	The quality compost produced in the composting plants in the Province of Bolzano is made available to farmers and gardeners at a subsidised price as fertiliser for local crops, thus closing the material loop on site.use of compost in orchards and agriculture. In addition, compost is used as a soil improver in landscaping.
Responsible organization:	**Composting plants.**

Title: **Odour reducing and speeding up the process**	
Location of the practice:	**South Tyrol, some composting plants**
Short summary:	One of the issues often encountered in the composting process concerns the release of unpleasant odours, mainly associated with the early stages of organic matter degradation and the quality of the matter itself. This problem is accentuated by the physical conformation of the South Tyrolean territory, which is predominantly mountainous and does not offer large open areas in which to locate the plants. To overcome this drawback, some plants have introduced rotting boxes upstream to the process (for the hot rotting phase) to reduce odour, thus also speeding up the initial processing of the material. Another practice in use in some green composting plants is the spraying of bergamot essence on the incoming piles when mixing the material, which adsorbs unpleasant odours, neutralising them and thus reducing odour emissions. Moreover, many South Tyrolean composting plants control odour emissions with the use of effective microorganisms (EM)
Responsible organization:	**Composting plants, anaerobic digestion plant.**

4. Inventory of sites, facilities, areas and instruments to be improved thanks to the cooperation

In South Tyrol, there is a need to assess the extent of food waste; this is certainly an identified area for improvement.

Title: **Food waste prevention – State of the art of Food Waste in South Tyrol: SURVEY**	
Location of the practice:	**Province of Bolzano – SouthTyrol**
Short summary:	Objective of the Coordination Table for Waste Reduction is to obtain a reliable measure of the amount per capita of food waste in South Tyrol. Only by knowing the exact quantities of food waste will it be possible to halve them, as foreseen by European regulations. Due to the lack of an easily applicable methodology for this estimate, a methodological study has been commissioned to the University of Vienna as external support to draft an analysis of the state of the art of biowaste in the province of Bolzano, in the frame of CORE project. The output of this study will be a practical calculation tool that, based on the data collected in the ordinary activities of the waste management office, allows quantifying food waste, differentiating between domestic, distribution, collective catering, and production chain sectors. The study is ongoing.
Responsible organization:	**Waste management office of the Environmental agency.**

Local Resources to be improved thanks to the cooperation	
Name: **Green composting**	
Type of resource	▪ **composting site** ▪ installation ▪ product ▪ **potential composting site** ▪ potential installation ▪ potential product ▪ regulation ▪ programme ▪ plan ▪ other: _______________
Short description of the need for improvement:	In South Tyrol the collection of wet waste is widespread and well organised, by contrast there is a trend to leave green waste in wooded areas. There is a need to develop projects to establish new green composting plants serving more municipalities.
Responsible organization:	**Waste management office of the Environmental agency, involved municipalities.**

Local Resources to be improved thanks to the cooperation	
Name: **Master composter training**	
Type of resource	▪ composting site ▪ installation ▪ product ▪ potential composting site ▪ potential installation ▪ potential product ▪ regulation ▪ programme ▪ plan ▪ **other: training courses**
Short description of the need for improvement:	We feel the need to periodically organise training and/or refresher courses for master composters, as we have seen done in other realities involved in the CORE project
Responsible organization:	**Waste management office of the Environmental agency**

Local Resources to be improved thanks to the cooperation	
Name: **Closure of the anaerobic digestate cycle of the Lana biogas plant**	
Type of resource	▪ composting site ▪ installation ▪ product ▪ **potential composting site** ▪ potential installation ▪ potential product ▪ regulation ▪ programme ▪ plan ▪ other: ________________
Short description of the need for improvement:	Digestate from anaerobic digestion at the Lana biogas plant is currently concentrated and disposed of as special waste outside the province. It would be very interesting to provide closure for the processing of organic waste in the province, either by sending the digestate to one of the existing composting plants in the area, or by expanding the Lana plant with a part intended for this activity. The CORE project can be an inspiration, in comparison with project partners who have already adopted similar solutions. We will consider whether to request a pilot project to carry out composting trials with this kind of matrix in one of the existing facilities in South Tyrol.
Responsible organization:	**Waste management office of the Environmental agency, involved plants**

Local Resources to be improved thanks to the cooperation	
Name: **“Smart” platforms**	
Type of resource	▪ composting site ▪ installation ▪ product ▪ potential composting site ▪ potential installation ▪ potential product ▪ regulation ▪ programme ▪ plan ▪ other: **Digitalization of the tracking system in composting plants**
Short description of the need for improvement:	We believe it would be useful to implement automated systems for compost management (App for recording temperatures, movements, pile treatments, digital notebooks and logbooks instead of paper…..) as we have seen done in other realities involved in the CORE project
Responsible organization:	**Waste management office of the Environmental agency**

5. Conclusions

The performance of the waste management in South Tyrol is on a moderate to high level. Over the past 25 years, the Province of Bozen/Bolzano has managed to significantly reduce the proportion of organic waste in its residual waste, thereby increasing the fraction of organic waste that is collected separately and sent for recovery in biogas and composting plants. The importance of reducing organic waste in residual waste was emphasised as early as the first local waste management plan. The amount of separately collected organic waste was increased from 35 kg/capita and year (2006) up to 72 kg/capita and year (2022). In total, the amount of organic waste collected in 2022 is 61,806 tonnes (38,868 tonnes of food waste and 22,338 tonnes of green waste). Of the organic waste collected, green waste and 47% of food waste are composted, while 53% of food waste is treated anaerobically to obtain energy and then composted (the latter stage outside South Tyrol).

The network of actors involved in waste management, organic waste, separate collection, and residual waste, was established by the will of the public administration and with significant public investment since the 1990s. It is widely distributed across the provincial territory.

Currently, there is a good efficiency in recovering various fractions of separate collection (68.9%), and as for the organic fraction, it is entirely directed towards recovery. These results were achievable thanks to what was outlined in the waste management plan of 2000 and subsequent updates. Nevertheless, as of today, approximately 30% of urban solid waste consists of organic waste. The challenge will be to further reduce the organic fraction in mixed waste.

There are therefore opportunities for improvement, especially regarding the treatment of sludge from anaerobic digestion (currently treated outside the province), the quantification of food waste, and the management of green waste that is sometimes abandoned in wooded areas.

In this regard, the CORE project represents an opportunity for the Province of Bolzano to draw inspiration from comparing with other contexts where these issues have already found possible solutions that could be adopted.

6. ANNEX

„FOOD WASTE GUIDELINE“

Guidance for determining the amount of food waste in the province of Bolzano - South Tyrol

Created by

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Preamble

In December 2023, the Institute for Waste Management and Circularity at the BOKU University Vienna (ABF-BOKU) was commissioned by the Office for Waste Management of the Autonomous Province of Bolzano - South Tyrol to develop a guideline for surveying the generation of food waste in the autonomous province Bolzano/Bozen – South Tyrol (hereinafter referred to as the 'Food Waste Guideline').

Over a third of the food produced worldwide is lost along the entire value chain. In the European Union, around 88 million tonnes of food is wasted every year, and the environmental impact of these losses throughout the food supply chain is widely recognised (Stenmarck 2016). Accordingly, waste prevention measures have recently been identified as a priority in the Circular Economy Action Plan (European Commission 2020), among others. As part of the Sustainable Development Goals, the UN General Assembly has set the target of halving per capita food waste at retail and consumer level by 2030 and reducing food losses overall (Sustainable Development Goal 12.3).

Based on the revised EU Waste Framework Directive (European Commission 2008) as part of the Circular Economy Package, the European Union has therefore introduced a reporting obligation on the generation of food waste. The purpose of the reporting obligation is to monitor and evaluate the implementation of measures to prevent food waste by measuring the volume of food waste. The quantities of food waste are to be collected annually separately for the different stages of the value chain (primary production, processing and manufacturing, trade, catering and private households).

Vienna, May 2024

1 Introduction

1.1 Objective

Based on the revised EU Waste Framework Directive (2008/98/EC), which was adopted in May 2018 as part of the Circular Economy Package, a reporting obligation on the amount of food waste is being introduced. The purpose of the reporting obligation is to monitor and evaluate the implementation of measures to prevent food waste by measuring the amount of food waste..

The core aim is to develop a **methodological guideline for surveying the volume of food waste** in South Tyrol according to EU reporting requirements (Delegated act (EU) 2019/1597). The methods developed for each individual stage of the value chain should allow for future regular monitoring that can be realised in terms of administration and costs and enable efficient, transparent and comparable surveys. The guidelines are intended to present the survey process concisely and clearly.

The quantities of food waste are to be measured separately for different stages of the food chain and reported separately by sector of the food chain. This includes

- primary production,
- processing and manufacturing,
- retail and other distribution of food,
- restaurants and catering services and
- private households

Due to the new reporting obligation for food waste, there is a need for methods that

- cover the EU reporting obligation,
- enable monitoring of the development of food waste quantities and thus of measures (both for the detailed surveys every 4 years and in the years in between),
- be administratively and cost-wise in an acceptable relation to the result

and on the other hand, the annual data for the reporting obligation must actually be provided.

Although partial data is available for individual sectors or parts of sectors or methods for collecting data are available, it is necessary to develop repeatable and reliable methods for collecting data for each sub-sector (in accordance with Annex III and IV of the Delegated Decision)

The **objectives of the guideline** include, in particular, instructions for determining and extrapolating the generation of food waste by origin (e.g. economic sectors) and collection channels.

1.2 European requirements for the collection of food waste data

Article 9(5) of the Waste Framework Directive (WFD) (European Commission 2008) stipulates that Member States shall monitor and evaluate the implementation of their food waste prevention measures by measuring the amount of food waste on the basis of the methodology laid down in the delegated act. The relevant documents to be considered are

1. Delegated Decision (EU) 2019/1597 of May 3, 2019: It establishes a common methodology and minimum quality requirements for the uniform measurement.
2. Implementing Decision (EU) 2019/2000 of November 28, 2019: It regulates the formats for the transmission of data on food waste and for the submission of a quality control report.

1.2.1 Definition of food and food waste

Article 3(4a) of the Waste Framework Directive (WFD) defines food waste “*as all food as defined in Article 2 of Regulation (EC) No 178/2002 (Commission 2002) of the European Parliament and of the Council (1) that has become waste”.*

For the purposes of Regulation 178/2002 (Commission 2002), 'food' means “*any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by human”s*. Explicitly excluded and not defined as food are, among others feed as well as plants prior to harvesting

In addition the Commission Delegated Decision (EU) 2019/1597 (Commission 2019) explains: “*The definition of ‘food’ laid down in Regulation (EC) No 178/2002 of the European Parliament and of the Council (2) encompasses food as a whole, along the entire food supply chain from production until consumption. Food also includes inedible parts, where those were not separated from the edible parts when the food was produced, such as bones attached to meat destined for human consumption. Hence, food waste can comprise items which include parts of food intended to be ingested and parts of food not intended to be ingested. (3) Food waste does not include losses at stages of the food supply chain where certain products have not yet become food as defined in Article 2 of Regulation (EC) No 178/2002, such as edible plants which have not been harvested. In addition, it does not include by-products from the production of food that fulfil the criteria set out in Article 5(1) of Directive 2008/98/EC, since such by-products are not waste.*

The European Commission (2007) published a communication on interpretation issues relating to waste and by-product. A by-product is a substance or object that is the result of a production process whose main objective is not the production of that substance or object. It can only be considered a by-product and not a waste if certain conditions are met.

The cumulative conditions to be fulfilled for a substance to be considered a by-product are

- it is certain that the substance or object will continue to be used.
- the substance or object can be used directly without further processing beyond normal industrial processes
- the substance or article is produced as an integral part of a manufacturing process
- the further use is lawful, i.e. the substance or article fulfills all relevant product, environmental and health protection requirements for the respective use and does not lead to overall adverse environmental and health impacts.

1.2.2 Methodology and minimum quality requirements for measurement

According to the Delegated Decision (EU) 2019/1597 (Commission 2019), "*the amounts of food waste shall be measured separately for the following stages of the food supply chain:*

(a) primary production;

(b) processing and manufacturing;

(c) retail and other distribution of food;

(d) restaurants and food services;

(e) households."

Food waste shall additionally be attributed to each of the stages of the food supply chain specified in Annex I of the Delegated Decision (EU) 2019/1597 (Commission 2019) and the measurement shall cover food waste that is classified under the waste codes referred to in Annex II or under any other waste code for waste that includes food waste.

Table 1: relevant waste codes referred to in Annex II of the Delegated Decision

Primary Production
02 01 02 animal-tissue waste
02 01 03 plant-tissue waste

Processing and manufacturing
02 02 wastes from the preparation and processing of meat, fish and other foods of animal origin
02 03 wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea and tobacco pre.n and processing; conserve production; yeast and yeast extract production, molasses preparation and fermentation
02 04 wastes from sugar processing
02 05 wastes from the dairy products industry
02 06 wastes from the baking and confectionery industry
02 07 wastes from the production of alcoholic and non-alcoholic beverages (except coffee, tea and cocoa)

<table>
<tr><th>Retail and other distribution of food</th><th>Restaurant and food services</th><th>Households</th></tr>
<tr><td colspan="3">20 01 08
biodegradable kitchen and canteen waste</td></tr>
<tr><td colspan="3">20 01 25
edible oil and fat</td></tr>
<tr><td colspan="3">20 03 01
mixed municipal waste</td></tr>
<tr><td>20 03 02
waste from markets</td><td colspan="2"></td></tr>
</table>

16 03 06 organic wastes other than those mentioned in 16 03 05	

For each stage of the food chain, the amount of food waste shall be measured and reported in the unit "metric tons of fresh mass" and shall be reported for a full calender year. In actual implementation, there are difficulties in separate reporting for different areas of the value chain. In most cases, household-type commercial waste is collected together with household waste as part of municipal collection. However, this means that food waste from smaller catering businesses, but also from smaller retail stores, is rarely collected separately but is collected as a mixed fraction as part of the municipal residual waste or organic waste collection. Accordingly, there can be no separate identification by value chain for the key numbers concerned.

A thorough measurement of food waste must be carried out every 4 years. The methods to be used in each case are listed in Annex III of the Delegated Decision, whereby a combination of the proposed methods is also permissible in each case.

Table 2: Annex III of Delegated Decision (EU) 2019/1597 - Methodology for the thorough measurement of food waste

<table>
<tr><th>Stage of the food supply chain</th><th colspan="5">Methods of measurement</th></tr>
<tr><td>Primary production</td><td rowspan="5">— Direct measurement</td><td rowspan="3">— Mass balance</td><td rowspan="2"></td><td colspan="2" rowspan="2">— Questionnaires and interviews
— Coefficients and production statistics.
— Waste composition analysis</td></tr>
<tr><td>Processing and manufacturing</td></tr>
<tr><td>Retail and other distribution of food</td><td rowspan="3">— Waste composition analysis</td><td rowspan="2">— Counting/scanning</td><td></td></tr>
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<tr><td>Households</td><td></td></tr>
</table>

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2 Guideline for determining the amount of food waste

The procedure for the determination of the amount of food waste is structured in three consecutive worksteps along with related sections, namely

1. the **general procedure with an overarching view** of the food supply chain, all usable data sources and methods that could be used or applied with different levels of efforts and data quality,
2. the selection and implementation of **surveying methods by stage of food supply chain**, and
3. detailed **guidelines for selected methodologies**, e.g. the planning, tendering and implementation of waste composition analyses.

2.1 General procedure

The general procedure contains up to four steps in consecutive order, whereby each step is building upon data, methods and intermediate results of preceding steps, concretely

1. surveying the **structure of potential food waste generators** in terms of e.g. number, size and characteristics of companies and households,
2. **identifying** and **measurement of** all **waste streams** potentially containing food waste, e.g. by waste type and code, potential mixture with other fraction, and potential origin-related mixture in collection tours,
3. if necessary, **allocating waste collection streams by origin** in terms of stages in food supply chain, sectors or mixture from households and companies in municipal collection, and
4. if necessary, **conducting waste composition analyses** in case of mixture of food waste and other fractions.

For each of these steps

- the motivation for recommended methods at the background of uncertainties, data gap and other methodological challenges,
- the concrete objectives of procedural steps,
- recommended secondary data including databases and applied methods,
- potential methods to be conducted, and
- example data for expected intermediate results are described and displayed.

2.1.1 Surveying the structure of food waste generators

2.1.1.1 Motivation and objectives

Getting a picture about the structure of potential food waste generator is the essential first step, as waste generation, type of waste collection and its allocation strongly depend on e.g. the business size and types of activities that suggest the generation of certain food waste. In any case, precise knowledge of the structural data is necessary in order to carry out stratifications in sample surveys, if necessary and to make corresponding efficient extrapolations.

Objectives of the structural overview of potential food waste generators could cover

- the **number of potential food waste generators by activities** e.g. based on NACE codes that focus on principal activities,
- if possible, **reference to secondary and auxiliary activities** with potential food waste generation,
- the **size of businesses in terms of employees** or employee number classes based on EU's SME thresholds for classification into micro (up to 9), small (up to 49), medium-sized (up to 249) and large enterprises,
- if available, classification of **turnover** based on SME classification,
- if useful, other structural data like sales area type of enterprise that might be relevant for extrapolation of data
- the **socio-economic characteristics of households** at district level (NUTS 3) or municipality level (LAU 2)

2.1.1.2 Potential Sources and Databases

Following data can be used as sources for orientating investigations, namely

- **structural surveys of food waste relevant sectors** based on questionnaires and interviews implemented by statistical offices, associations of farmers, food processing industry, food retail and wholesale, gastronomy, tourism etc., and
- **regional statistical reports** about the socio-economic characteristics (e.g. population, employees, building structure as share of multi-family dwellings, settlement density, income), if available, down to district level (NUTS 3) or municipalities' level (LAU 2),
- **specific databases on trade, tourism or other relevant information**
- the **territorial typologies** manual of Eurostat based on the urban-rural typology (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Territorial_typologies_manual_-_urban-rural_typology)
- **additional secondary data, reports, e**.g. from Universities and other research institutions as well as published data from other countries e.g. vor the use of coefficiants.
- **Primary Data: It can not be recommended** to conduct primary surveys concerning the structure of potential food waste generators, but to use solely secondary sources.

2.1.2 Identifying and measurement of waste streams containing food waste

2.1.2.1 Motivation and objectives

The identification of waste streams containing food waste should not be underestimated due to e.g. borderline cases between by-products and waste based on national and EU-wide definitions, food waste generated in typically non-food sectors (e.g. from cantines in furniture trade centers), and other problem areas with difficult recording.

Objectives of the identification of food waste related collection streams should cover

- the **listing of all potentially relevant waste collection streams** as defined by EU waste codes and definition in regional waste management, including by-products streams with potential waste definition (borderline case),
- the **collected mass** per year based on waste registers, or existing estimates, e.g. in case of by-products with potential waste definition,
- their collection as **commercial waste or municipal solid waste**,
- their differentiation concerning **take over of waste** as 1) **company-specific takeover** with weighing and company-specific documentation, or as 2) **collection tour** with aggregated weighing and documentation from enterprises with different activities, and
- in case of collection tours, the **estimated mass share by stages** in food supply chain.

2.1.2.2 Potential sources and databases

Following data can be used as secondary sources for orientating investigations, namely

- Waste registers based on EU regulation containing information about the origin, takeover, collecting company etc.
- Company registers (with further data for enterprise characteristics)
- Waste analyses to determine the waste composition and derivation of coefficients.
- Evaluation of waste management concepts of potential food waste generators in order to classify by-products or food waste …
- **Primary data** (supplementary own surveys) like:
  - Collection of physical data through weighing, volume determination and determination of numbers of pieces of discarded food as part of supplementary case studies
  - Own surveys and questionnaire surveys to determine waste coefficients
  - Implementation of waste sorting analyses .
  - Direct information from stakeholders and experts
  - Estimation of collected mass of total waste stream, if not yet weighed (company allocation not yet relevant) – e.g. temporal sampling over a defined time of two weeks
  - Onsite inspections for classification of by-products or food waste …
  - Questionnaire and interviews of waste treatment operators concerning share of food waste, origin and characteristic of waste or by-products

2.1.3 Allocating waste collection streams by origin

2.1.3.1 Motivation and objectives

As many food waste containing waste streams are generated in different origins by sectors and households, the determination of the share of food waste by origin is necessary due to reporting obligations. As secondary literature investigating e.g. waste generation per employee and sector is scarce, simple primary surveys might be necessary.

Objectives of the allocation waste collection streams by origin should cover

- the **listing of all food waste relevant waste streams potentially collected from different origins** by stage of food supply chain,
- the availability of data on waste bin size and collection frequency by waste generators (e.g. based on waste register, waste management concepts)

2.1.3.2 Potential sources and databases

Following data can be used as secondary sources for orientating investigations, namely

- Waste registers containing bin volume by waste type and collection frequency (e.g. the Austrian EDM, https://edm.gv.at) and enterprise sector
- Waste management concept (Austria)
- Bin list of municipalities (for tariffs)
- Share of commercial waste as part of MSW (literature)
- Coefficients
- Primary sources
    - Share of disposed bin volume per year of a collection tour + relation to no. of employees?
    - Direct sampling of enterprises in different sectors (only mass, not composition)

2.1.4 Conducting waste composition analyses

2.1.4.1 Motivation and objectives

Major waste streams containing food waste typically are mixed stream from municipal collection. Examples are residual waste or mixed MSW and biogenic waste containing yard waste beside kitchen waste. Due to reporting obligations waste composition analysis is the only method to gain information on the proportion of food waste in this mixed waste streams.

Objectives of the conduction of waste composition analyses should cover

- representative sampling according to influencing factors on waste composition,
- sufficient accuracy in order to answer investigated question

Details on sources and methods are provided in chapter 2.3.

2.2 Surveying methods by stage of food supply chain

Based on the European reporting requirements, surveying methods are described in details by stages of food supply chain. In order to transparently deduce the most efficient combinations of methods, in first step single methods for each stage of food supply chain are discussed by procedural steps based on section 0 including 1) framework conditions for data availability and quality, 2) challenges for surveying methods to overcome, and 3) potential methods including an evaluation of efficiency. In a second step methods are combined and evaluated presenting recommended priorities for most efficient ones.

2.2.1 Surveying methods for primary production

2.2.1.1 Surveying structure of food waste generators

Typical **framework conditions** for data availability and quality that might be considered in primary production in South Tyrol:

- **High number of mostly small farming enterprises**: The majority of farming enterprises has utilised agricultural area below 10 hectare.
- **Most employees from own families**: Totally more than 95% of employees are family employees in small enterprises.
- **Dominance of farmers of apples, vines and livestock farming with cattle**

Following **challenges** have to be considered when surveying the structure:

- **High number of small enterprises to be covered, if sampling is needed**: Due to this small-scale structure, large farming enterprises with typically better databases are not very relevant, if representative sampling would be necessary. The heterogeneity can be assumed as relatively high.

Potential methods for surveying farm structure:

- Using aggregate **data from statistical yearbook** Data on number, employees and utilised agricultural area of farm enterprises by cultures are available. The efforts are low as no primary surveys are necessary.
- Using production and other relevant data from chamber of commerce, branch associations and cooperatives,

2.2.1.2 Identifying and measurement of waste streams containing food waste

Typical **framework conditions** concerning data on waste collection streams should be considered:

- **Agricultural food waste mostly defined as by-products, not waste**: Based on the EU rules for classification of waste, it should be checked, which agricultural food wastes are legally defined as waste. Based on Austrian experiences direct agricultural wastes from farm operation are by-products with few exceptions.
- **Identification of types of waste that are not subject to the reporting obligation**. Some sectors might not only produce food, but also industrial products (like potatoe starch for industrial use)

- **Household waste from family business not relevant for primary production:** Waste from e.g. farmers families not related to agricultural operations has to be allocated to the food supply chain stage 'households'.

Following **challenges** have to be considered when surveying waste collection streams:

- Food losses in agriculture occure because of unpredictable weather conditions and weather damage and can therefore fluctuate greatly between individual years
- **Potential co-collection of agricultural waste in municipal collection of biogenic waste**: If agricultural waste is really not defined as by-product but as waste, collection routes should be investigated. If a waste stream is partly collected as part of municipal collection of biogenic waste (together with kitchen waste, yard waste), the relevant mass-related share should be surveyed.

Potential methods for surveying waste collection streams:

Delegated Decision (EU) 2019/1597 proposes the following methods for primary production for thorough measurement:

- Direct measurement
- Mass balance
- Questionnaires and surveys
- Coefficients and statistics on production
- Analysis of the composition of waste

Direct measurement - Evaluation of **waste balance reports**

The annual waste balance report are evaluated for the amount of food waste per waste code. There is an automated allocation of the specified sectors of origin to the five sectors of the food chain via the classification specified in Annex I of the Decision (EU) 2019/1597" via the allocation table.

Not all sectors/waste types for which waste is reported can be attributed to food waste in accordance with the reporting obligation. Based on the Delegated Decision (EU) 2019/1597, notifications of the following origin/waste types, if identifiable, have to eliminated:

- Origin from slaughterhouses, meat processing
- Origin from rendering plants
- Animal feed
- Flowers
- Food supplements
- Food waste that is disposed of as or in wastewater (e.g. drinks, soups, food leftovers in dishwater etc. that are disposed of in the sewage system) Allocation by stages of food supply chain

- Table 3: Evaluation of survey methods for primary production

SURVEY METHOD [SURVEY ID]	**IMPACTS ON DATA QUALITY**	**EFFORTS**	**COST /BENEFIT**
Direct measurement			
Weighed waste according to EWC 02 01 02 animal-tissue waste 02 01 03 plant-tissue waste	→ Potential mixing of data with by-products	↗ data available, collected regularly	😐
Sample surveys and extrapolation	↘ possible mixing of waste with waste from other stages of the value chain (esp. household waste)	↘ high sample size needed! In any case, a direct survey in agriculture must be carried out over several years, as the volume of waste is dependent not least on weather conditions, whereby local influences can distort the result	☹
Mass balance			
Estimation of the expected and actual yield	↘ the accuracy of the estimates should be verified empirically	→ very high or low depending on data availability	☹
Questionnaires and interviews			
Survey among farmers on occurrence and composition of food waste	↘ large differences in the amount of waste generated depending on product type and weather conditions	→ High efforts to get enough participants for a survey to get representative results with corresponding accuracy	☹
Coefficients and production statistics			
Estimation of the expected and actual yield	↘ Transferability of coefficients from other regions is questionable, Coefficients based on categories not suitable for specific products	↘ comprehensive statistics and coefficients are not known	☹
Waste Composition analysis		does not appear to be effective. No corresponding results known	☹
Counting and Scanning		Not foreseen for restaurants and food services	
Diaries	Not foreseen for retail		

In SCHMIDT ET AL (2019), waste quantities are estimated using waste coefficients from the specialist literature. These waste coefficients refer to the proportion of the production volume that is intended for human consumption and suitable for use as food (avoidable & unavoidable food waste).

Table 4: Waste coefficients used in SCHMIDT ET AL (2019)

Food waste	Waste coefficient in mass-%	Source
Cerals	1.7 – 3.3	Themen (2014) – Peter et al. (2013)
Potato	5.2	Peter et al. (2013)
Sugar beet	2.0 – 8.0	Schnepel und Hoffmann (2016)
Oilseeds	1	Graf et al. (2008)
Puses	0.1	Themen (2014)
Fruit	6 - 11	Themen (2014) – Peter et al. (2013)
Vegetables	4.2 - 6	Themen (2014) – Peter et al. (2013)
Meat	1.1-3	LKV (2016) – Momeyer (2011)
Fish	3 -6.4	Hafner et al. (2014)
Milk	0.6	Themen (2014)
Egg	3.4 – 5.5	Damme et al. (2018)

2.2.1.3 Allocation by stages of food supply chain

Typical **framework conditions** concerning potentially relevant allocation of mixed waste collection streams:

Agricultural waste is not usually collected together with waste from other levels of the value chain. In exceptional cases, it may be mixed with household waste from the agricultural business.

- **Random checks of disposal routes of relevant agricultural food waste types, not defined as by-product are recommended**: A list of waste types should be generated. Disposal routes should be randomly investigated for relevant enterprises with relevant cultures.
- **Visual inspection of waste collection streams affected by agricultural waste**: If there is suspected that agricultural waste is co-collected with municipal biogenic waste, visual inspections could be done for first orientation.

Potential methods for allocation of wastes:

- **Allocation of typical waste streams based on waste composition analyses**: If fallen fruits (e.g. apples) are defined as waste, the mass percentage of this fraction could be allocated to agricultural enterprises. For this purpose, the waste composition analyses should be planned in the relevant season with highest expected mass of fallen fruits.

2.2.1.4 Conducting waste composition analyses

Framework conditions concerning fractions in waste collection streams that are mixed in terms of origin (stages of food supply chain) or material (food waste vs. non food waste):

- Mixing food waste with other types of waste should not be the case and is not considered. In individual cases, as mentioned, waste sorting appears to make sense in order to separate the proportion of agricultural waste from that of household waste

Following **challenges** for waste composition analyses:

- **Origin of fractions can not be proved, only assumed:** If e.g. fallen fruit originates from private households or farmers can not be proven. This can only be assumed.

Potential methodological adaptation for waste composition analyses:

- **Scheduling sorting campaigns in relevant seasons with expected higher waste generation**

2.1.1.5 Recommended combinations of methods for primary production

Relevant **framework conditions** for the selection of combinations of methods are:

- Relevant agricultural wastes not defined as by-products: If there are no relevant agricultural wastes based on EU rules for waste classification, surveys are not needed. Otherwise relevant agricultural waste have to be defined and investigated.

Challenges for combinations of methods concerning relevant agricultural wastes are:

- Identifying relevant waste collection streams and the mass share: It has to be found out, in which collection streams these wastes are collected purely or co-collected as a fraction share.

Following **combination of methods** are recommended:

Identification of relevant agricultural waste streams (not defined as by-product) with connex to food and estimation of potentially affected enterprises by type of culture (e.g. fruit growing, livestock breeding)

If available, the **waste balance reports** can be used to fulfill reporting obligation.

  - If necessary: allocation of waste in mixed collection based on **waste composition analyses**

If this data is not available or its accuracy is questionable, a rough estimate can be made using **waste coefficients**. Data from the literature (Table 4) can be used for this purpose. For particularly relevant product groups, it is recommended to collect regional waste coefficients, e.g. via a **survey/questionaire** of farmers.

2.2.2 Survey methods for processing and manufacturing

2.2.2.1 Surveying structure of food waste generators

Typical **Framework conditions** for data availability and quality that might be considered in processing and manufacturing food products in South Tyrol:

- The amount of food waste produced depends on the specific sector. A **classification** of economic activities according **NACE 2 Rev.** is recommended
  - 10.1 Processing and preserving of meat and production of meat products
  - 10.2 Processing and preserving of fish, crustaceans and molluscs
  - 10.3 Processing and preserving of fruit and vegetables
  - 10.4 Manufacture of vegetable and animal oils and fats
  - 10.5 Manufacture of dairy products
  - 10.6 Manufacture of grain mill products, starches and starch products
  - 10.7 Manufacture of bakery and farinaceous products
  - 10.8 Manufacture of other food products
  - 11.0 Manufacture of beverages
- **Dominance of few hundred (mostly) medium-sized companies:** 401 companies with avg. 22 employees are active in the food processing industry. However the market concentration (with potentially dominating few large companies) is not available in the statistical yearbook.

Following **challenges** have to be considered when surveying the structure:

- **Assumed high heterogeneity requiring stratification in sampling**: Due to the different agricultural products (fruits, cattle etc.) high heterogeneity in food processing. If representative surveys are planned, this causes high efforts for stratification of primary surveys.

Potential methods for surveying processing and manufacturing structures:

- Using aggregate **data from statistical yearbook**: Data on number and employees of enterprises for food and beverages are available. The efforts are low as no primary surveys are necessary.
- **Interview of sampled, representative enterprises**: If needed in connection with necessary waste management data, sampling of enterprises can principally considered. The effort would be high and only justifiable, if waste relevance of this stage of food supply chain is given.

2.2.2.2 Identifying and measurement of waste streams containing food waste

Typical **framework conditions** concerning data on waste collection streams should be considered:

- **Questionnable definition of food waste of processing industry as waste or by-product**: Based on the EU rules for classification of waste, it should be checked, which food wastes from food processing industry are legally defined as waste. According to the Delegated Decision Art 1 (4) lit b, animal by-products are not to be measured in accordance with Article 2(2)(b) of Directive 2008/98/EC. Article 2(2)(b) of Directive 2008/98/EC reads: (b) animal by-products including processed products covered by Regulation (EC) No 1774/2002, with the exception of those intended for incineration, landfill or use in a biogas or composting plant; Accordingly, **ONLY animal by-products that are incinerated, landfilled, composted or treated in biogas plants are to be measured**.

Following **challenges** have to be considered when surveying waste collection streams:

- **Potential co-collection of waste in commercial collection or municipal collection as residual waste or biogenic waste**: For those materials classified as waste, different treatment routes are possible, e.g. commercial collection (as separate or mixed waste) or municipal collection as mixed waste (residual waste) or biogenic waste (as mix of non-food waste and food waste).

Potential methods for surveying waste collection streams:

Delegated Decision (EU) 2019/1597 proposes the following methods for primary production for thorough measurement:

- Direct measurement
- Mass balance
- Questionnaires and surveys
- Coefficients and statistics on production
- Analysis of the composition of waste

Direct measurement - Evaluation of **waste balance reports**

Using a **waste register / Waste balance reports** of business operators with indication of origin NACE Code 10 (Manufacture of food products and beverages) and NACE Code 11 (Manufacture of beverages.

Table 5: Evaluation of survey methods for food processing and manufacturing

SURVEY METHOD [SURVEY ID]	IMPACTS ON DATA QUALITY	EFFORTS	COST /BENEFIT
Direct measurement			
Weighed waste according to EWC 02 02, 02 03, 02 04, 02, 05, 02 06, 02, 07 comp, Table 1	→ Potential mixing of data with by-products	↗ data available, collected regularly	😐
Sample surveys and extrapolation	→ possible mixing of waste with waste from other stages of the value chain (esp. household waste low probability	↘ high sample size needed! Waste quantities are sector specific. Not recommended	☹
Mass balance			
Comparison of input and output flows in the food industry by sector	↘Knowledge of the final disposal route and differentiation between waste and by-products is necessary for accurate reporting	→Dependence on the provision of data by the industry	😐
Questionnaires and interviews			
Survey among processing and manufacturing on occurrence and composition of food waste	↘ large differences in the amount of waste generated depending on food industry branches	→ High efforts to get enough participants for a survey to get representative results with corresponding accuracy because of high heterogeneity. Data is usually available at company level	😐
Coefficients and production statistics			
Estimation of the expected and actual yield	↘**R**eliabilaty of coefficients based on categories; Waste rates from the literature differ significantly from one another	↘comprehensive statistics and coefficients are not known	☹
Waste Composition analysis		does not appear to be effective. No corresponding results known	☹
Counting and Scanning		Not foreseen for restaurants and food services	
Diaries	Not foreseen for retail		

Mass balance: In Switzerland Mosberger et al. (2016) made a distinction between input flow (organic quantity that flows into the food company as raw material or semi-finished products), output flow (organic quantity that leaves the food company as food or semi-finished products for further food processing) and loss flow (organic quantity that leaves the food company neither as food nor as semi-finished products for further processing). In the study, all organic materials (edible and non-edible, such as banana peels and bones) that are removed from the food value chain and not used for their intended purpose (the provision of food) are recorded as losses. This also includes losses that are fed to animals and re-enter the food value chain in this way.

Questionnaires and interviews:

In principle, data on waste generation and waste coefficients are available in many companies. However, the classification within the framework of the delegated decision is problematic, as only waste that ends up in disposal facilities is actually taken into account and waste that is fed to animals or other by-products, for example, is not reported.

Waste coefficients:

In Schmidt et al. (2019) the estimation of food waste in food processing is based on sector-specific waste coefficients, which relate to the respective production volumes in the various sectors of the economy.

Table 6: Waste coefficients in food production according to SCHMIDT ET AL. (2019)

	Mean (mass-%)	Standard error (mass-%)	Confidence interval (mass-%)		N (100)
10.1 meat and meat products	0.22	0.12	0.22	± 0.2	6
10.2 fish, crustaceans and molluscs	4.0	1.00	4.00	± 1.64	2
10.3 fruit and vegetables	2.4	0.68	2.40	± 1.11	11
10.4 vegetable + animal oils + fats	0.09	0.04	0.09	± 0.07	0
10.5 dairy products	1.5	0.47	1.50	± 0.78	10
10.6 grain mill products, starches and starch products	0.09	0.04	0.09	± 0.07	2
10.7 bakery and farinaceous prod.	10.82	1.29	10.82	± 2.12	12
10.8 other food products	1.74	0.42	1.74	± 0.68	27
11.0 beverages	2.31	0.51	2.31	± 0.84	30

2.2.3 Allocation by stages of food supply chain

Typical **Framework conditions** concerning potentially relevant allocation of mixed waste collection streams:

- **Typically low probability of co-collection of waste from processing industry**:

Following **challenges for allocation** have to be overcome, if needed:

- **Identification of potential co-collection in municipal collection of biogenic waste**: If waste is really not defined as by-product, collection routes should be investigated. If a waste stream is partly collected as part of municipal collection of biogenic waste (together with kitchen waste, yard waste), the relevant mass-related share should be surveyed.

Potential methods for allocation of wastes:

No realistic allocation of waste in mixed streams feasible due to high heterogeneity of wastes.

2.2.2.4 Conducting waste composition analyses

Due to the high heterogeneity of potentially co-collected waste from food processing industry waste composition analyses can not realistically serve as robust method.

2.2.2.5 Recommended combinations of methods for primary production

Relevant **framework conditions** for the selection of combinations of methods are:

- Differentiation between waste and by-products is necessary.

Challenges for combinations of methods concerning relevant processing and manufacturing are:

- Great heterogeneity of companies.

Following **combination of methods** are recommended:

Identification of relevant waste streams (not defined as by-product) with connex to food and estimation of potentially affected enterprises

If available, the weighed waste according to EWC can be used to fulfill reporting obligation.

  - If necessary: allocation of waste in mixed collection based on **waste composition analyses**

If this data is not available or its accuracy is questionable, a rough estimate can be made using **waste coefficients** (methodology is not recommended due to the large range of the values and the associated uncertainties) or by questionaires and interviews at the level of waste producers.

2.2.3 Survey methods for retail and other distribution of food

2.2.3.1 Surveying structure of food waste generators

The food retail trade in South Tyrol tends to have a small-scale structure. The following types are to be considered

- Supermarkets
- Hypermarketes
- Food discount
- Minimarkets and non-specialised food markets
- Specialised food markets (Fruits and vegetables, Meat and meat products, fish, bread,…)

In addition to food retailers, **wholesalers** are also relevant

Typical **framework conditions** for data availability and quality that might be considered for retail:

- Uniform structures (few large chains) facilitate the overall assessment. Uniform structures (few large chains) facilitate the overall assessment. Many small, independent retailers make the surveys more difficult. South Tyrol is confronted with a high proportion of mini-markets here
- **Wholesale and retail trade must be taken into account**
- **Unsold products are amortized and are therefore recognized in any case**
- **Seasonality**: A high proportion of tourism can cause seasonal differences that must be taken into account in direct measurements

Following **challenges** have to be considered when surveying the structure:

- **If the retail companies provide their depreciation data, a conversion into kilograms must be made**.

Potential methods for surveying retail structure:

- Using aggregate **data from ASTAT**: Data on type, number of stores, are available. More detailed figures on market share and sales area should be available at chamber of commerce
- **Interview of sampled, representative enterprises**: If needed in connection with necessary waste management data, sampling of enterprises can principally considered. The effort would be high and only justifiable, if waste relevance of this stage of food supply chain is given.

2.3.3.2 Identifying and measurement of waste streams containing food waste

Framework Conditions

- Different quantities of waste are to be expected from specialized grocery stores than from supermarkets.

Following **challenges** have to be considered when surveying waste collection streams:

- Potential **co-collection** of waste from retail **in municipal** collection of municipal mixed as well as biogenic waste from households:.
- Food is often disposed of in packaged form, which can lead to a falsification (overestimation) of the results
- Food waste ends up in both residual waste and organic waste
- Potential of food waste from restaurants and food service within municipal collection of **mixed waste (**For food waste in mixed waste, a specific proportion must be determined. Possible data sources for these food waste proportions, which must also be updated regularly, are residual waste or organic waste sorting analyses or data from current literature)

Potential methods to determine waste quantities

Delegated Decision (EU) 2019/1597 proposes the following methods for thorough measurement for "retail and other forms of food distribution":

- Direct measurement
- Mass balance
- Waste Composition analysis
- Counting/scanning

Procedure for random data collection and extrapolation

Table 7: Evaluation of survey methods for retail

SURVEY METHOD [SURVEY ID]	**IMPACTS ON DATA QUALITY**	**EFFORTS**	**COST /BENEFIT**
Direct measurement			
Weighed waste according to EWC 20 01 08 biodegradable kitchen and canteen waste 20 01 25 edible oil and fat, 20 03 01 mixed municipal waste	↘ Partly or fully collected together with household waste. Not available on retail level	↗ data available, collected regularly	😐
Sample surveys and extrapolation	↘ Heterogeneous structure of the food retail sector makes extrapolation difficult and requires large sample sizes	→ mixed waste and seperately collected organic waste have to be taken into account	😐
Mass balance			
Calculation of the amount of food waste on the basis of the mass of inputs and outputs of food into and out of the measured system, and processing and consumption of food within the system	↘ Usually, data is not available in mass but as a monetary value. A conversion to kg must be made.	↘ Determining conversion factors at product group level is complex. Depending on the consent of the companies to provide data	☹
Waste composition analysis			
Sorting analysis of mixed municipal waste and separately collected organic waste to determine the proportion of food waste	→ might be mixed with household waste. Determination of the trade-specific share difficult	→ High personnel and economic expenditure for representative results with corresponding accuracy	😐
Questionnaires and interviews		Not foreseen for restaurants and food services	
Coefficients and production statistics		Not foreseen for restaurants and food services	
Counting/scanning			
Can be carried out via the analysis of depreciation	↘ Usually, data is not available in mass but as a monetary value. A conversion to kg must be made.	→ Determining conversion factors at product group level is complex. Depending on the consent of the companies to provide data, might be easier for depreciation than for sales figures	😐
Diaries	Not foreseen for retail		

2.2.3.3 Allocation by stages of food supply chain

Typical **framework conditions** concerning potentially relevant allocation of mixed waste collection streams:

- **Typically high probability of co-collection of retail waste** with household and other commercial waste:.

Following **challenges for allocation** have to be overcome, if needed:

If a co-collection of food waste from retail waste with other municipal waste were to take place, the proportion of retail-specific waste would have to be estimated. In Germany, an amount of 20 % was assumed here. More precise information is not available and corresponding allocations are only possible with great effort

2.2.3.4 Conducting waste composition analyses

If the measurement of food waste is based on the municipal waste data and/or mixed municipal waste is a major disposal path of food waste from retailers, the actual proportion of food waste must be determined by means of waste composition analysis (cf chapter 2.3).

Framework conditions:

In principle, food waste from food retailers should be collected separately as part of the organic waste collection. Since mixing with other biogenic waste usually only occurs to a small extent, representative weighing of the biogenic waste may be sufficient. In most cases, however, retail waste is disposed of with packaging and therefore often with residual waste. Determining the proportion of food waste that is disposed of in residual waste requires appropriate sorting analyses. Sorting analysis of 48 stores from Austrian retailers in the year 2014 showed, that **59.6 % of mixed waste can be allocated to food waste** (Obersteiner et al. 2016).

The **challenge** is that it is not possible to allocate specific proportions of food waste to a particular part of the value chain. However, it can be assumed that the proportion of food waste in streams collected mixed with other biogenic waste is higher in the food retail than in households. In order to avoid misjudgements when selecting containers for the sorting analyses, care must be taken to ensure that only waste from the food retail store is disposed of in the container.

2.2.3.5 Recommended combinations of methods for restaurants and food service

In Austria and Germany, the amount of food waste from the retail trade is determined via **voluntary reporting** by retailers. Provided that the retail companies agree, this is the simplest method of collection as the depreciation figures are available. The conversion of monetary values into mass should also take place via trading. Theoretically, retailers can be obliged by regulation to provide the data.

The EHI Retail Institute GmbH (EHI, 2011)) published a study which analyzed the sales losses due to food breakage and spoilage in the German food retail. The volume of waste can thus be estimated using known sales figures. Lebersorger and Schneider (2014b) provide an accurate estimation on food losses from food retail in Austria. The five companies which contributed to the study have a market share of 83% and represent the major part of the food retail sector in Austria.

Table 8: Coefficients for average loss of sales based on EHI Retail Institute GmbH (EHI, 2011) and Lebersorger and Schneider (2014a)

Product group	Loss of sales EHI, 2011 % of turnover	Loss of sales in Lebersorger and Schneider 2014) mass-%
Fruit and vegetables	5.12 %	4.62 %
Meat, sausage, fish and poultry	2.10 %	2.75 %
Fresh meat, fish and poultry		2.75 %
Sausage & Smoked meats		2.39
Dairy products	1.55 %	1.34 %
Bread and pastry		3.13 %
Bread and bakery products self-service* without returns	0.95 %	
Bread and bakery products self-service* with returns	10.42 %	
Baking station, bakery store, in-house bakery	6,52 %	
Other food	0.48 %	0.76 %

If only the percentage of turnover is known, the loss of sales must be converted into the resulting mass of food waste (Table 9).

The total amount of food waste can be extrapolated based on sales area, turnover, employees or any other comparable key figures. Specific amount of food waste have been reported from Germany with 7.65 kg per square meter (Schmidt et al. 2019) and can be calculated for Austria with 26.35 kg per square meter (Obersteiner and Stoifl, 2024, https://de.statista.com/statistik/daten/studie/309858/umfrage/verkaufsflaeche-im-lebensmittelhandel-in-oesterreich/

Table 9: Conversion factor EUR/kg (according to Hafner et al. 2012) recalculated for 2024)

Product group	EUR/kg (2011) Hafner et al. 2012 (GE)	EUR/kg (2013) (Lebersorger and Schneider 2014a)	EUR/kg (2024) based on Lebersorger and Schneider (2014a
Fruits	4.04	1.76 – 2.45	2.02 - 2.81
Vegetables	2.3	1.76 – 2.45	2.02 - 2.81
Meat and Fish	10.96	5.02 – 7.65	5.76 - 8.78
Sausage and sausage products		3.21 – 6.66	3.68 - 7.64
Diary products	4.83	2.38 – 3.76	2.73 - 4.31
Bread and pastries	3.36	1.53 – 5.93	1.76 - 6.8
Pasta	3.36		
Other	6.31	2.64 – 2.7	3.03 - 3.1
Drinks	5.71	0.76 – 4.41	0.87 - 5.06
Convenience		3.05 – 4.72	3.50 - 5.42
Sweets and salty snacks		6.99 – 12.83	8.02 - 14.72
Frozen food and ice cream		5.28 – 7.03	6.06 - 8.07

If this is not possible a direct **random measurement at store level** is proposed.

The total amount of food waste can be extrapolated based on sales area, turnover, employees or any other comparable key figures. Specific amount of food waste have been reported from Germany with 7.65 kg per square meter (Schmidt et al. 2019) and can be calculated for Austria with 26.35 kg per square meter (Obersteiner and Stoifl, 2024, https://de.statista.com/statistik/daten/studie/309858/umfrage/verkaufsflaeche-im-lebensmittelhandel-in-oesterreich)

2.2.4 Survey methods for restaurants and food services

2.2.4.1 Surveying structure of food waste generators

A comprehensive direct measurement of food waste is hardly possible. It is essential that any estimates and projections take into account the extremely diverse structure of waste producers

The following types of establishment might be differentiated:

Type of establishment	Recommended unit of measurement	Additional information needed
Restaurants, coffee houses, Snack bars, fast food restaurants	guest numbers:	Type of accomodation
Accommodation industry:	overnight stays	type of accommodation
Hospitals / Healthcare:	number of beds and	occupancy rate
Schools, Childcare facilities, Universities:	pupil numbers and supervision days	proportion of lunch meals
Retirement and nursing homes	number of people	
Company catering	number of employees using the canteen	
German armed forces: on the	meals served	
Prisons	prisoner numbers	

Typical **framework conditions** for data availability and quality that might be considered for food and restaurant service:

- **Subject of investigation:** Focus is laid on restaurants and food-service and not on out-of-home catering: businesses at the periphery of the sector, such as butchers or bakers, which also offer meals, are not included. Similarly, para-catering (e.g. events organised by clubs) and accommodation (e.g. campsites, mountain huts) are not included.
- **Measurement indicator**: the comparable indicator value across all types of establishment is meals prepared per year. This includes main meal and breakfast. Snacks are not taken into account
- **Parameters** taken into account per type of establishment:
  Number of establishments
  Number of meals per day per type of establishment
  Percentage of seasonal establishments (1-season/2-season establishments)
  Number of opening days per year
- **Seasonality**: The number of guests staying overnight and eating out often depends on the season. This seasonality must be taken into account when measuring the amount of waste

Following **challenges** have to be considered when surveying the structure:

- **High number of small enterprises to be covered, if sampling is needed**: Due to this small-scale structure, large farming enterprises with typically better databases are not very relevant, if representative sampling would be necessary. The heterogeneity can be assumed as relatively high.

Potential methods for surveying farm structure:

- Using aggregate **data from ASTAT**: Data on number, employees and utilised agricultural are of farm enterprises by cultures are available. The efforts are low as no primary surveys are necessary.
- **Interview of sampled, representative enterprises**: If needed in connection with necessary waste management data, sampling of enterprises can principally considered. The effort would be high and only justifiable, if waste relevance of this stage of food supply chain is given.

2.2.4.2 Identifying and measurement of waste streams containing food waste

Framework Conditions

The collection of biodegradable waste from restaurants and food services is correctly carried out as waste code number 20 01 08 as part of separate collection in the bio bin or as cooking oils and fats (code number 20 01 25). However, parts are also disposed of in residual waste and liquid components in particular end up in the sewer. It is not possible to clearly delineate the food waste from the restaurants and food services sector, as it is usually collected as similar to household waste as municipal waste together with waste from households and retail.

Following **challenges** have to be considered when surveying waste collection streams:

- Potential **co-collection** of waste from restaurants and food service **in municipal** collection of biogenic waste: If a waste stream is partly collected as part of municipal collection of biogenic waste (together with kitchen waste, yard waste), the relevant mass-related share has to be defined.
- Potential of food waste from restaurants and food service within municipal collection of **mixed waste (**For food waste in mixed waste, a specific proportion must be determined. Possible data sources for these food waste proportions, which must also be updated regularly, are residual waste or organic waste sorting analyses or data from current literature)

Potential methods to determine waste quantities

- **Direct Measurement:** Ideally, the data can be taken from the annual waste balance reports. Very often, however, this data is not available at the value chain level.
- **Random sampling** of the amount of waste for different types of establishments
- **Use of Literature Values** for the amount of waste per portion

Procedure for random data collection and extrapolation

The waste quantities are recorded by means of on-site weighing at individual locations in accordance with the statistical requirements described in chapter 2.3.

At the same time, the portions issued during the survey period are to be recorded by means of a survey at the affected businesses.

Extrapolation is carried out using the formula:

$$FW=n*(FW_{Port}/1000)$$

FW…amount of food waste in tonnes per year

n…number of meals served

FW_{Port}… amount of food waste per portion in kg/serving

Literature values on the amount of foodwaste per portion

	g/portion total	g/portion avoidable	Source
Restaurants, coffee houses, Snack bars, fast food restaurants			
Restaurants	206	105	Schwarzmayr, 2016
Fast Food Resauraunts	29	29	McDonald's, 2018
Restaurants		220	UAW 2014
Accommodation industry:			
	136	109	Borstel et al., 2017
	232	158	Schwarzmayr, 2016
		270	UAW 2014
Hospitals / Healthcare / Nursing homes:			
	152	222	Borstel et al., 201
	456	366	
	152	122	Borstel et al., 2017
Schools, Childcare facilities, Universities:			
Schools	107	107	Borstel et al., 2017
Schools	136	117	Waskow et al., 2016
Schools		253	Luck et al. 2024
Schools		117	Petruzzelli et al., 2024
Universities			Ferreira et al., 2013
Company catering			
	108	78	Borstel et al., 2017
	155	135	Schwarzmayr, 2016
		190	UAW 2014
armed forces	211	108	Part, 2010
Prisons	226	116	Hafner 2012

Table 10: Evaluation of survey methods for restaurants and food service

SURVEY METHOD [SURVEY ID]	IMPACTS ON DATA QUALITY	EFFORTS	COST /BENEFIT
Direct measurement			
Weighed waste according to EWC 20 01 08 biodegradable kitchen and canteen waste 20 01 25 edible oil and fat, 20 03 01 mixed municipal waste	↘ Partly or fully collected together with household waste. Not available on restaurant and food service level	↗ data available, collected regularly	😐
Sample surveys and extrapolation	↘ Heterogeneous structure of the food retail sector makes extrapolation difficult and requires large sample sizes	↗ Weighing with sightings is sufficient, as separate collection can be assumed	😐
Mass balance	Not foreseen for restaurants and food services		
Waste composition analysis			
Sorting analysis of mixed municipal waste and separately collected organic waste to determine the proportion of food waste	→ might also be mixed with commercial waste	↘ High personnel and economic expenditure for representative results with corresponding accuracy	☹
Questionnaires and interviews	Not foreseen for restaurants and food services		
Coefficients and production statistics	Not foreseen for restaurants and food services		
Counting/scanning			
Evaluation of the number of foods that make up the food waste and use of the result for mass determination	→ the proportion of food waste can be determined from experience based on number of meals	↘ a representative database must first be created	☹
Diaries			
one or more persons regularly record or keep records of food waste data	↘ Incorrect or socially desirable information in self-reporting	↗ as soon as panel is found, low efforts	😐

2.2.4.3 Allocation by stages of food supply chain

Typical **framework conditions** concerning potentially relevant allocation of mixed waste collection streams:

- **Typically high probability of co-collection of restaurant and food service waste** with household and other commercial waste:.

Following **challenges for allocation** have to be overcome, if needed:

If a co-collection of food waste from restaurants and food service waste with other municipal waste were to take place, the proportion of restaurant-specific waste would have to be estimated. In Germany, an amount of 20 % was assumed here. More precise information is not available and corresponding allocations are only possible with great effort

2.2.4.4 Conducting waste composition analyses

If the measurement of food waste is based on the collection of other similar to household waste (especially including that of households), the actual proportion of food waste must be determined by means of waste composition analysis (c.f. chapter 2.3).

The **challenge** is that it is not possible to allocate specific proportions of food waste to a particular part of the value chain. However, it can be assumed that the proportion of food waste in streams collected mixed with other biogenic waste is far higher in the catering industry than in households or in the retail sector, where garden waste or flowers are also included, among other things

2.2.4.5 Recommended combinations of methods for restaurants and food service

Based on the above, the following procedure is recommended:

Provided that **separate collection** of the main part of the kitchen waste from restaurants is **guaranteed** and corresponding data on the key number is available, this data is subjected to a **plausibility check** and reported.

If the food waste from restaurants and food service is collected together with other municipal waste, random weighing is recommended (c.f. chapter 2.3), taking into account the diverse structure of this sector. Depending on the data available, the waste can subsequently be extrapolated, e.g. via the number of meals served or the number of employees. For the determination of the number of meals per year per type of establishment, seasonality, opening days etc. have to be taking into account

2.2.5 Survey methods for households

2.2.5.1 Surveying structure of food waste generators

A major difficulty in deriving the per capita quantity from residual waste and organic waste garbage cans is the proportion of food waste that comes from other sources, in particular out-of-home catering and food retail. Various "correction factors" or assumptions for food waste from commercial waste similar to household waste in residual waste or commercial food waste in the organic waste bin are in any case subject to major uncertainties. Given the current data situation, however, recourse to these correction factors or assumptions is unavoidable.

Typical **framework conditions** for data availability and quality that might be considered for household waste:

- The proportion of similar to household waste from restaurant and retail is determined by the settlement structure (urban-rural) but also by the intensity of the tourism volume
- The settlement structure also determines the provision of organic waste bins for separate collection
- Socio-demographic factors such as age, household size, pets, size of the residential community influence the volume of food waste at household level and must be taken into account

Following **challenges** which influence the proportion of food waste within mixed municipal waste or separate collected organic waste have to be considered when surveying the structure:

- **Settlement structure**: In densely built-up urban areas, there is often a lack of opportunities for separate collection and home composting. The proportion of food waste in mixed municipal waste is correspondingly higher
-

Potential methods for surveying structure of households:

Relevant data on the **residential structure** is provided by ASTAT

Data on **separate collection**, such as the number and volume of containers provided, can be obtained from the municipalities or waste disposal companies

2.2.5.2 Identifying and measurement of waste streams containing food waste

Framework Conditions

The current reporting obligation only provides for the reporting of total food waste generated in households. A breakdown into mixed municipal waste and separately collected food waste (and home composting) is not required.

A representative estimate of the volume of food per inhabitant is therefore sufficient. The total amount of food waste from households can thus be calculated by multiplying it by the number of inhabitants.

A major difficulty in deriving the per capita quantity from residual waste and organic waste garbage cans is the proportion of food waste that comes from other sources, in particular out-of-home catering and food retail. Various "correction factors" or assumptions for food waste from commercial waste similar to household waste in residual waste or commercial food waste in the organic waste bin are in any case subject to major uncertainties. Given the current data situation, however, recourse to these correction factors or assumptions is unavoidable.

However, a targeted sampling strategy is necessary in order to create a reliable database that also allows the per capita volume of food waste to be monitored..

Following **challenges** have to be considered when surveying waste collection streams:

- **Subject of investigation:** To determine food waste in households, the relevant disposal channels of the municipal waste collection system (residual and organic waste) have to be examined. **Other disposal routes** (home composting, sewage system and animal feed) are per definition out of scope. In order to estimate food waste in other disposal channels, studies using household diaries or surveys might be used voluntarily.
- Potential **co-collection** of food waste from restaurants and food service as well as retail within municipal collection of **mixed waste and biogenic waste collection. Allocation to Households**: The amount of mixed municipal waste (20 03 01), including commercial waste similar to household waste, is published regularly in obligatory waste management plans on a national basis. From this amounts the specific amount of household waste is determined by subtracting the proportion of commercial waste. The same is relevant für separate collected biodegradable waste (20 02 01),
- **Proportion of food waste:** The proportion of food waste (biodegradable kitchen and canteen waste 20 01 08) in the municipal waste collection system (mixed municipal waste and biodegradable waste bins) has to be determined on the basis of sorting analyses (c.f. chapter 2.3). or data from current literature
- **Edible oil and fat** (20 01 25) have to be considered

Potential methods to determine waste quantities

Delegated Decision (EU) 2019/1597 proposes the following methods for the thorough measurement of private households:

- Direct measurement
- Record keeping (one or more persons regularly record or keep records of food waste data)
- Analysing the composition of the waste

Direct Measurement: Direct recording of food waste by households poses similar problems to recording it using food diaries. There is a lack of representativeness of the voluntary participants and there is an underestimation due to socially desirable behavior. Direct recording at container level requires careful container selection and consideration of waste from other levels of the value chain (see Challenges). Ideally, the data can be taken from the annual waste balance reports. Very often, however, this data is not available at the value chain level. A direct measurement at container level requires an analysis of the waste composition in any case

Record keeping (one or more persons regularly record or keep a record of food waste data): Over the last decade, food diaries have been applied successfully in numerous studies worldwide, representing a useful tool in food waste research, although with several limitations. Its application presents several difficulties and some disadvantages. First, a majority of the authors found it hard to recruit households and noticed high dropout rates during the experimental periods, with potential risks of self-selection – only interested people take part in the experiment – and poor data quality due to undervaluation and approximation. Moreover, if online-based food diaries are applied, the majority of aged people (60 years old or older) are unable to take part to the measurement. In addition, to adopt “more socially acceptable” behavior during the accounting period, participants tend to eat differently than normal or dispose food in more sustainable manners, and diary keepers, in the absence of coaching, are usually not aware of the waste generated by their relatives/cohabitants or are confused during measurement. Lastly, people who take part in experiments are generally not representative of the entire population, and adjustments are sometimes extremely difficult and aleatory.

Analysis of the composition of the waste: Details are described in Chapter 2.3 and the Annex

Table 11: Evaluation of survey methods for households

SURVEY METHOD [SURVEY ID]	IMPACTS ON DATA QUALITY	EFFORTS	COST /BENEFIT
Direct measurement			
Municipal waste data (European Waste Catalogue codes 20 01 08 biodegradable kitchen and canteen waste 20 01 25 edible oil and fat 20 03 01 mixed municipal waste	↘ not available at household level only- including similar to household waste commercial waste from e.g. small retail and restaurants	↗ data available, collected regularly	😐
Mass balance	Not foreseen for households		
Questionnaires and interviews	Not foreseen for households		
Coefficients and production statistics	Not foreseen for households		
Waste composition analysis			
Sorting analysis of mixed municipal waste and separately collected organic waste to determine the proportion of food waste	→ might also be mixed with commercial waste	→ High personnel and economic expenditure for representative results with corresponding accuracy	😐
Counting/scanning	Not foreseen for households		
Diaries			
one or more persons regularly record or keep records of food waste data	↘ Incorrect or socially desirable information in self-reporting	↗ as soon as panel is found, low efforts	😐

2.2.5.3 Allocation by stages of food supply chain

Typical **framework conditions** concerning potentially relevant allocation of mixed waste collection streams:

- **Typically high probability of co-collection of restaurant and food service waste** with household and other commercial waste:.

Following **challenges for allocation** have to be overcome, if needed:

If a co-collection of food waste from restaurants and food service waste with other municipal waste were to take place, the proportion of restaurant-specific waste would have to be estimated. In Germany, an amount of 20 % was assumed here. (More precise information is not available and corresponding allocations are only possible with great effort

2.2.5.4 Conducting waste composition analyses

Waste composition analysis appear to be essential for the measurement of food waste at household level.

Typical **framework conditions** concerning fractions in waste collection streams that are mixed in terms of origin (stages of food supply chain) or material (food waste vs. non food waste):

- **Potential waste collection in biogenic municipal waste:**

Following **challenges** for waste composition analyses:

- The **extrapolation of food waste** is based on the proportions that are detected in residual or organic waste. However, these are also heavily dependent on the volume of other fractions such as leaves or grass and shrub cuttings, especially in the case of separate organic waste collection

Potential methodological adaptation for waste composition analyses:

- **Scheduling sorting campaigns in at least two seasons with expected different share of food waste**

2.2.5.5 Recommended combinations of methods for restaurants and food service

Estimate based on regular collection of municipal waste

The volume of mixed municipal waste, including commercial waste, is usually measured and serves as a basis for determining the amount of food waste. To do this, the specific proportion of household waste must be determined by **subtracting the business waste quantities** and the specific proportion of food waste must be determined by **sorting analyses**. The procedure applies equally to separately collected biowaste and mixed municipal waste.

Extrapolation on the basis of random samples

In order to avoid falsification of the household-related data by waste from other parts of the value chain, sampling is recommended in regions where mixing with waste from restaurants and retail is as low as possible or can be ruled out. This can be done on the basis of specific selection of bins or in general the selction of areas in which there are no businesses, in particular none of the "restaurants and catering services" and "retail trade and other forms of food distribution" categories (or areas in which it can be ruled out that these businesses dispose of food waste via residual waste).

The samples might be taken either for both municipal solid waste and separate collected biowaste or one can focus on regions where no separate collection of biowaste takes place. Home composting should be excluded for households included in the analyses

The sampled residual waste and organic waste quantities have to be set into relation to and extrapolated with the number of inhabitants.

-> kg food waste residual waste per inhabitant + kg food waste organic waste per inhabitant = per capita mass of food waste in households

It is important that both the analysis of residual waste and organic waste bin contents must be based on the number of inhabitants.

2.3 Guideline for sampling food waste using weighing and sorting analyses

Taking samples of food waste from waste generators is recommended in all cases, where

- no direct food waste mass measurement is done sector-specific (e.g. by weighing pure food waste solely originating from food processing industry), or
- food waste is mixed with other wastes, e.g. mixed municipal waste, or garden waste as co-collected in mixed biogenic waste bins.

Aim of this guideline is to highlight

- **required basic information** on structure of food waste generators, waste collection streams and practice on waste collection is needed for sample planning ,
- **recommended methods** of sampling, weighing and sorting to be selected or combined (
- the **dimensioning of sampling** as expressed by the required number and mass of individual samples, differentiated by methods (e.g. weighing and/or sorting) ,
- the procedure for **weighing bins** containing food waste including evaluation, and
- the **sorting procedure** including stratified random drawing of samples, sampling from bins and documentation.

2.3.1 Investigation of required basic information

In a first step, basic structural and waste related data have to be collected including

- the **structure** of food waste generators, split up into
  - **households** with the number of persons **by regional structure** in rural, intermediate, and urban municipalities as differentiated by the **settlement density** as ratio of inhabitants per developed settlement area with recommended threshold values of 4 inhabitants per hectare between rural and intermediate, and 10 inhabitants per hectare between intermediate and urban municipalities
  - **business operators** to be differentiated into small-sized (<9 employees), medium-sized (10-49 employees) and large (>50 employees) business operators based on **EU SME classification**,
- the **waste collection streams** containing food waste: if containing pure food waste or a mix with other wastes (based on practice, independent of potential EU waste codes), as well as the collected mass per year, and
- estimated **dominating way of waste collection** by food waste generator concerning allocability of bins and waste generators with the options of
  - no collection of defined waste stream (-),
  - collection with a bin shared with other households or business operators (SB=shared bin),
  - collection with an own bin (OB=own bin), or
  - Own collection with separate weighing and waste tracking documentation, typical for large business operators (OC=own collection).

Table 12: Exemplary basic data with dominating collection from food waste generators with 1) no collection (-), 2) shared bin (SB), 3) own bin (OB), or 4) waste tracking including weighing (WT).

Sector	Structure of household or business operators	Persons / employees	Mixed municipal waste (MSW)	Kitchen waste (KW)	Mixed biogenic waste incl. yard waste (BIO)	Sector-specific food waste (SEC)
Quantity collected (tons/y)			77800	5000	33900	800
Primary production	Small	10 000	-	-	-	-
	Medium	4 000	-	-	-	-
	Large	1 000	-	-	-	-
Processing	Small	2 000	-	-	-	-
	Medium	1 000	-	-	-	OB
	Large	800	-	-	-	OC
Retail	Small	20 000	OB (60%) SB (40%)	-	-	-
	Medium	10 000	OB	-	-	-
	Large	4 000	OB	-	-	-
Restaurant and food service	Small	20 000	OB (60%) SB (40%)	OB (60%)	-	-
	Medium	3 000	OB	OB	-	-
	Large	1 000	OB	OB	-	-
Households	Rural	100 000	OB (100%)	-	- (70%)	-
	Intermediate	100 000	OB (90%)	-	OB (60%)	-
	Urban	300 000	SB (70%)	-	SB (60%)	-

2.3.2 Recommended methods

Recommended methods are 1) weighing and 2) sorting.

1) Weighing

To estimate the amount of food waste collected as **almost pure food waste** fraction random weighing is sufficient. The methodology is proposed e.g. when kitchen waste from the catering industry is collected separately, but is picked up together with biogenic waste from households. As a result, it is not possible to clearly allocate the volume of food waste to the catering value chain, even if total figures for waste code 20 01 08 are available. An extrapolation of the food waste volume can then be carried out by extrapolating the food waste volume of selected businesses

Waste bins containing almost pure food waste fractions based on visual inspection with a mass percentage over about 95% **have not to be sorted**. This may be typical for kitchen waste containing no other biogenic wastes, such as yard waste. The visual inspection should be done on site. In case of doubt, the top layer of the bin with about 20 cm thickness should be inspected manually. The samples have to be weighed with documentation of gross, net mass (as gross mass subtracted the average mass of the empty bin), and the bin type by volume and fabrication model (in order to be linked with empty bin mass).

2) Sorting

If food waste is collected together with other waste, e.g. as part of the municipal mixed waste collection system of households or mixed waste collection from retail , waste bins have to be analysed by **manual sorting analysis** to determine the proportion of food waste in the total amount of waste. Regularly, mixed municipal solid waste and mixed biogenic waste with remarkable amount of garden waste have to be sorted without visual inspection.

2.3.3 Dimensioning sample number and mass for weighing and sorting

Aim of dimensioning the sample number and mass is to guarantee representativity and an adequate level of accuracy of extrapolated results. Representativeness is a property of data surveys that enables statements to be made about a much larger quantity (population) from a small sample. One important means of achieving representativeness is the drawing of stratified random samples, whereby each structure, e.g. business operators by size, should be represented equally in the sample and the population.

The number and mass of samples required is determined on the basis of, in case of sorting, the expected mass proportion mass food waste, the confidence interval to be observed for the estimated mean fraction and the heterogeneity measure used in conjunction with the calculation method. The confidence interval indicates the area around the mean in which the true value lies with a given probability (confidence level). In principle, the confidence interval must be specified with the probability. It is the area that includes the true position of the parameter (e.g. mean value) when a random experiment is repeated infinitely with a certain frequency (95%). The heterogeneity measures used for this guideline are based on numerous analyses implemented in further projects. Details on the methodology can be found in the annex.

2.3.3.1 Required sample number for weighing pure food waste bins

At how many business operators pure food waste bins, e.g. kitchen waste bins, should be drawn as sample in order to achieve a given accuracy? This question is answered on the basis of the variation of mass of collected commercial waste bins in previous studies, expressed by the coefficient of variation named VC, and the aspired accuracy CI_{rel}, where values of $CI_{rel} = 0.3$ express that the estimated waste generation per employee should be estimated in a range of $\pm 30\%$ of the true value. The required number of business operators n_{req} is then calculated with

$$n_{req} = \left(\frac{VC\ z_{1-\frac{\alpha}{2}}}{CI_{rel}} \right)^2$$

with the statistical constant $z_{1-\frac{\alpha}{2}} = 1.96$ that is based on a level of confidence of 95%. Assuming the evidence-based coefficient of variation of $VC = 2.0$ results into

$$n_{req} = \left(\frac{3.92}{CI_{rel}} \right)^2.$$

Assuming a maximum error of $\pm 30\%$, at least 41 business operators have to sampled. Alternatively, in the case of a maximum error of $\pm 20\%$, at least 92 business operators have to sampled.

It is recommended to draw 41 business operators per random selection as the higher accuracy do have low marginal improvement of the overall estimate.

2.3.3.2 Required sample mass for sorting mixed bins

Based on the fraction-specific heterogeneity u_f (see details in the annex) and the expected mass percentage of fraction 'food waste' $\hat{a}_f$ as well as the aspired accuracy as absolute confidence interval CI_{abs} the required sample mass m_{req} is calculated with

$$m_{req} = u_f * \hat{a}_f * (1 - \hat{a}_f) * \left(\frac{z_{1-\frac{\alpha}{2}}}{CI_{rel}}\right)^2,$$

whereby as in last formula the statistical constant $z_{1-\frac{\alpha}{2}} = 1.96$.

Table 13 shows the required total sample mass on basis of food waste as lead fraction, whereby it is recommended to select an aspired accuracy of 5% as shown in green. The table is valid both for food waste as part of mixed municipal waste as well as a part of mixed biogenic waste bins.

After determination of the planned sample mass, the sample number results from the net mass of each bin, whereby individual samples from bin volumes exceeding 240 litres have to be rejuvenated appropriately by coning (quartering or eighting).

Table 13: Required total sample mass

Expected mass percentage of fraction 'food waste' (a_f) and sum of other fractions		Required total sample mass m_{req} in kg ($u_f = 3{,}0$ kg) – Aspired accuracy (absolute confidence interval CI_{abs})							
		3.0%	4.0%	5.0%	6.0%	7.0%	8%	9%	10%
5%	*95%*	608	342	219	152	112	86	68	55
6%	*94%*	722	406	260	181	133	102	80	65
7%	*93%*	834	469	300	208	153	117	93	75
8%	*92%*	942	530	339	236	173	133	105	85
9%	*91%*	1 049	590	378	262	193	147	117	94
10%	*90%*	1 152	648	415	288	212	162	128	104
11%	*89%*	1 254	705	451	313	230	176	139	113
12%	*88%*	1 352	761	487	338	248	190	150	122
13%	*87%*	1 448	815	521	362	266	204	161	130
14%	*86%*	1 542	867	555	385	283	217	171	139
15%	*85%*	1 633	918	588	408	300	230	181	147
16%	*84%*	1 721	968	620	430	316	242	191	155
17%	*83%*	1 807	1 016	650	452	332	254	201	163
18%	*82%*	1 890	1 063	680	472	347	266	210	170
19%	*81%*	1 971	1 109	709	493	362	277	219	177
20%	*80%*	2 049	1 152	738	512	376	288	228	184
21%	*79%*	2 124	1 195	765	531	390	299	236	191
22%	*78%*	2 197	1 236	791	549	404	309	244	198
23%	*77%*	2 268	1 276	816	567	417	319	252	204
24%	*76%*	2 336	1 314	841	584	429	328	260	210
25%	*75%*	2 401	1 351	864	600	441	338	267	216
26%	*74%*	2 464	1 386	887	616	453	346	274	222
27%	*73%*	2 524	1 420	909	631	464	355	280	227
28%	*72%*	2 581	1 452	929	645	474	363	287	232
29%	*71%*	2 637	1 483	949	659	484	371	293	237
30%	*70%*	2 689	1 513	968	672	494	378	299	242
32%	*68%*	2 786	1 567	1 003	697	512	392	310	251
34%	*66%*	2 873	1 616	1 034	718	528	404	319	259
36%	*64%*	2 950	1 660	1 062	738	542	415	328	266
38%	*62%*	3 017	1 697	1 086	754	554	424	335	272
40%	*60%*	3 073	1 729	1 106	768	564	432	341	277
42%	*58%*	3 119	1 755	1 123	780	573	439	347	281
44%	*56%*	3 155	1 775	1 136	789	580	444	351	284
46%	*54%*	3 181	1 789	1 145	795	584	447	353	286
48%	*52%*	3 196	1 798	1 151	799	587	449	355	288
50%	*50%*	3 201	1 801	1 152	800	588	450	356	288

2.3.4 Weighing of pure food waste bins

Based on the required sample number, samples have to be representatively allocated according to the size of business operators as exemplarily shown in table 12, second column. Thus the percentage of sample number should be similar to the percentage of employees in the given sector.

The displayed accuracy of the used scale should be at least at 0.1 kg. The tara, i.e. mass of empty bins, should be checked frequently and only taken over for containers with exactly the same design and producer.

A sampling protocol should be used that contains the business name and sector of business operator, size of business according to EU SME classification, the number of employees based on official definition, the address, the bin volume and collection interval.

The net mass of each bin of a business operator has to be extrapolated from the covered period of collection interval (e.g. 7 days) to the whole year (i.e. 365 days), resulting in the extrapolated waste generation for the whole business per year. Finally, the waste generation per year and employee is calculated by division through the number of employees.

The sectoral waste generation is then resulting as unweighted mean of the final values per business.

2.3.5 Sorting of mixed bins containing food and other wastes

In order to allow better comparability within time and between regions following standards are determined in chronological order:

- Access level for sampling: The collection container provided for emptying on the property of the household or business is to be selected as the access level.
- Volume of individual sample (240 litres): The samples must have a similar volume. This should be based on the container size prevailing in the study area. In principle, the contents of a 240 litre container are recommended as a random sample, i.e. this is analysed in its entirety. For containers with a volume of more than 240 litres, corresponding partial samples should be taken. Containers with a volume of 120 litres may not be aggregated and are used as 1 random sample if they represent the predominant container size.
- Determination of the number of samples by municipality using stratified random selection: The allocation of samples by municipality must be based on stratified random selection, whereby for each group of municipalities the sample proportion corresponds to the proportion of the population.
- Sampling from large containers (>240 litres): In the case of large containers, a partial quantity corresponding to the specified sample size can be analysed. The partial quantity is to be taken by quartering or eighthing at random, whereby care must be taken to ensure that the waste is not homogenised in the process (i.e. no opening of pre-collection containers). If quartering or eighthing is not feasible, logistically very complex or unreasonable for other reasons, the partial quantity must be removed on site and emptied into sample containers.
- Sorting of waste fractions: The samples must not be sieved, as the required sortability of food waste may be significantly restricted.

- Check the control total of the sample mass for each random sample: The sum of the masses of the individual fractions of a random sample must be compared with the mass of the total sample immediately after sorting. The deviation of these two values must not exceed 3% of the mass of the total sample. Otherwise the sample may not be analysed.

2.3.6 Evaluation and reference to indicators

The evaluation covers the food waste estimate by sector and by waste collection stream whereby the food waste fraction mass is only relevant for mixed waste streams. The mass of food waste with subdivision by business size is only necessary as intermediate results, not in final results however.

Indicators to relate with food waste mass cover the number of employees, and other ones mentioned in sections, e.g. number of meals per year.

Concerning all waste streams with input from different sectors, mainly mixed municipal waste and mixed biogenic waste including yard waste, direct measurement is done with sampling only for e.g. retail and restaurant sectors. In this case, the extrapolated collected mass has to be subtracted from the total collected waste (see e.g. Table 12), second row concerning mixed municipal waste) based on the mass balance in order to get the adjusted mixed municipal waste solely from households.

Appendix

Definitions

Basic population (M), mass in kg	The population is defined as the type and quantity of waste to be assessed by means of sorting analysis, i.e. the quantity of litter collected via a specific collection system (public collection bins) or the quantity of loose litter collected by means of various cleaning activities. The population refers to a defined study area.
Subpopulation (M_t or layer M_s), mass in kg	A subpopulation is a subset of the population, e.g. a qualified sample, the quantity to be assigned to a stratum or a lump.
Total sample mass (m), mass in kg	total mass to be analysed as part of the investigation.
Individual sample (i), Mass in kg	Sample taken at a specific location at a specific time. The sample or individual sample is usually part of a qualified sample (ÖNORM S 2127).
Random sample	A random sample is defined by the fact that each subset of the population has the same probability of being drawn. When applying the stratified random principle, the number of samples to be drawn from each subpopulation is broken down on a mass basis, whereby the samples within the respective subpopulation are drawn at random.
Access level	Process/condition-related sampling point (e.g. transport containers, collected collection bags for voluntary field cleaning).
Confidence interval (KI_{abs}, KI_{rel})	The confidence interval indicates the range around the mean value in which the true value is located with a given probability (confidence level). In principle, the confidence interval must be specified with the probability. It is the range that includes the true position of the parameter (e.g. mean value) with a certain frequency (95 %) if a random experiment is repeated indefinitely. The absolute confidence interval KI_{abs} denotes the range in percentage points around the mean value (e.g. ±1 %, ±4 %). The relative confidence interval KI_{rel} denotes the ratio of the one-sided range in relation to the mean value (true value).
Sample size (n)	Number of individual samples in the analysis.
Confidence level (significance level) ($1-\propto$)	The significance level is described as 1-α, where α is defined as the probability of error. A significance level of 95 % is usually selected (i.e. α=0.05 or z=1.96). The **confidence level indicates** the probability with which the position estimate of a statistical parameter (e.g. a mean value) from a sample survey is also accurate for the population. Confidence levels must be defined - in addition to the margin of error, the necessary sample size is based on them. The probability of error is set at α=0.05.
Mass fraction of the lead fraction (a_f)	Mass fraction of a fraction f e.g. as mass fraction of the population a_f as the expected mass fraction of the population $\hat{a}_f$ or mass fraction of a fraction in the i-sample $a_{f,i}$
Fraction-specific heterogeneity measure (u_f)	Heterogeneity measure according to the binomial approach as the standard method required to determine the required total sample mass
Required total sample	Required sample mass as a function of the expected mass fraction

mass (m_{erf})	of the lead fraction $\hat{a}_f$ the desired accuracy as an absolute confidence interval KI_{abs}, the selected distribution approach (estimation statistics) and the confidence level $1{-}\propto$
Required sample mass (m_{erf})	Required sample mass as a function of the expected mass fraction of the lead fraction $\hat{a}_f$ the desired accuracy as an absolute confidence interval KI_{abs}, the selected distribution approach (estimation statistics) and the confidence level $1{-}\propto$
Mass of the individual sample (m_i)	Mass of the i-of the first individual sample in kg, which should be 15 kilograms as a guide.
Fractional mass of the sample ($m_{f,i}$)	Mass of the fraction f of the i-sample in kg
Extrapolation factor by unit of analysis (h_e)	The sum of the samples from an examination unit represents the larger mass in the population by a factor of h_e larger mass in the population.

Extrapolation of the fractional proportions of heterogeneous materials

As it is not possible in practice to analyse the entire waste generation of a study area (**population**), random samples must be taken from this population. These **individual samples** must be representative of the respective study area and describe the characteristics of the population as accurately as possible.

Waste streams are very heterogeneous in terms of their composition and particle sizes. In order to nevertheless obtain statistically acceptable results, an **appropriate sample size** (mass and number) must be determined. This is the only way to generate analysis results with an appropriate statistical accuracy. Limitations arise from the fact that the chosen procedure must be economically justifiable and technically feasible.

This chapter explains the necessary definitions and basic principles, an overview and evaluation of existing estimation methods for fraction proportions of heterogeneous materials and the calculation procedure based on the guideline.

Estimation methods

As part of the development of this guideline, existing and innovative methods for estimating the fractional share in the population were evaluated. Following the definition of quality criteria and the method overview, the evaluation using cross-validation is described in an overview.

Quality criteria

According to Zwisele (2004), essential general quality criteria for estimation methods include

- Fidelity to expectations, i.e. the expected value and the value to be estimated (fraction) are the same,
- Efficiency, i.e. that the estimation method is more effective (efficient) than other estimation methods, as it has a lower variance of the estimated value,
- Consistency, i.e. that the estimator no longer deviates from the true value for infinitely large samples, and
- Sufficiency, i.e. that the maximum possible information of the sample is utilised.

Additional criteria are media fidelity, normality and linearity.

Methods

Methods for estimating waste fractions:

1. **SWA-Tool**[6] **/ ÖNORM S 2097**[7] : The standard method currently used is to determine the estimated mass fraction of a fraction by calculating the mean value of the relative fractions of the individual samples as a percentage. It is implicitly assumed that the mass of the individual samples is the same. The confidence intervals are determined according to the t-distribution (Student distribution).
2. **ÖNORM S 2097-4 (2011) with stratification by sample mass**: As in point 1, the estimated value is determined as the mean value of the fractional proportions of the individual samples, whereby the samples are stratified by sample mass. According to ÖNORM, this alternative is to be selected if the fractional mass fraction of the individual samples (as division of the sums of the fractional masses by the sums of the sample masses) is not within the confidence interval according to point 1.
3. **Binomial approach**: Homogeneous waste fractions are modelled here with a small mass, heterogeneous ones with a large mass. The heterogeneity measure is shown in kilograms. The approach represents a refinement or further development of the ÖNORM method according to point 2, as instead of stratifying the samples into a few classes, a continuous categorisation (as metric weighting) is used. The developed method is therefore based on a heterogeneity measure that is independent of the mass of the individual samples and therefore neither distortions to the expected value nor to the variance of the estimated distribution can occur.
4. **Bootstrapping**: In this method, randomly drawn individual samples are aggregated to exactly 200 kilograms each, whereby the process is carried out 500 times per simulation run with drawing and putting back the individual samples. The standard deviation is determined on the basis of the 200 kg units. This process is repeated in 500 simulations. This computationally intensive, parameter-free method is only used here for evaluation purposes and as a reference method to determine the best possible case for estimates.

Based on validations of residual waste analyses (Beigl, 2020) and waste paper sorting analyses (Beigl et al., 2018), the binomial approach is applied below.

[6] Available at https://www.wien.gv.at/meu/fdb/pdf/swa-tool-759-ma48.pdf

[7] Available at Austrian Standards (https://www.austrian-standards.at)

Determination of fraction-specific heterogeneity

Quantification of the heterogeneity of waste fractions

Within the collection volume of separately or mixed collected waste from households, fractions with low or high heterogeneity are usually characterised by their composition, whereby fractions with high heterogeneity are characterised by one or more of the following factors, namely

- Large individual items in terms of bulk volume (e.g. tree and shrub cuttings in biogenic waste, bulky waste in residual waste, large amounts of corrugated cardboard in waste paper collection),
- High mass proportion of individual parts (e.g. bricks in residual waste) or cohesive bulk material (e.g. cat litter or ash in residual waste),
- irregular generation over time or between waste producers in the study area and
- Influence of commercial waste producers with waste generation patterns different from households.

When recording heterogeneous waste, the influence is particularly evident with small samples, although homogenisation can be observed and quantified with large samples.

Drawing samples with exactly the same sample mass would be a solution for avoiding distortions. However, it is not possible to draw samples exactly from piles of waste from collection vehicles; experience shows that a coefficient of variation of the sample mass of approx. 15 to 20 % represents the achievable lower limit. When drawing from containers, the variability is a consequence of the different waste volumes over time or between waste producers. The drawing of samples of different weights is inherent to the system and can only be partially compensated for by aggregating or tapering samples.

The mixture of these two distorting effects, namely the heterogeneity of fractions and the variability of the sample mass, can only be reduced by technical means, not avoided. Another means of reducing the distortion is weighting by sample mass. However, this results in lower efficiency compared to the binomial approach as well as methodological problems (e.g. the high number of parameters required for each stratum).

Calculation

If survey results are available for the respective region within the last 10 years, the raw data for the analysis can be used. On this data basis, the fraction-specific heterogeneity is analysed u_f on the basis of the sample mass of the samples m_i and the fractional share of the samples $a_{f,i}$ of the total n Samples by means of

$$\hat{u}_f = \frac{\sum_{i=1}^{n} m_i * (a_{f,i} - \hat{a}_{f,i})^2}{n * a_f * (1 - a_f)}, \qquad \text{(Formula 1)}$$

where the estimated fraction of the sample mass is calculated with

$$\hat{a}_{f,i} = a_f \text{ with } a_f = \frac{\sum_i^n m_{f,i}}{\sum_i^n m_i} \qquad \text{(Formula 2)}$$

is accepted.

If strata with significantly different fraction proportions are assumed on the basis of existing results, the stratum-specific fraction proportion must be determined using

$$\hat{a}_{f,i} = a_{f,s} \text{ with } a_{f,s} = \frac{\sum_i^n m_{f,i}}{\sum_i^n m_{i,s}} \text{ for } i \in s \qquad \text{(Formula 3)}$$

to determine.

The confidence interval of the estimated heterogeneity $\hat{u}_f$ of each fraction f is calculated on the basis of the chi-square distribution using

$$\hat{u}_f \frac{\chi^2_{n-1,\frac{\alpha}{2}}}{n-1} < \hat{u}_f < \hat{u}_f \frac{\chi^2_{n-1,1-\frac{\alpha}{2}}}{n-1} \qquad \text{(Formula 4)}$$

determined[8] . If the results of analyses comparing units of investigation show that $\hat{u}_f$ of relevant fractions vary so greatly that the confidence intervals do not overlap, stratification in subsequent analyses is advantageous.

[8] The bounds of the confidence interval for the fraction-specific heterogeneity uf_min or uf_max are determined using Microsoft Excel © on the basis of the corresponding input parameters uf (u_f), number of samples n (n) and,alpha ($\propto$) using

```
uf_min = =uf*CHIQU.INV(alpha/2;n-1)/(n-1)  or
uf_max = =uf*CHIQU.INV(1-alpha/2;n-1)/(n-1)  .
```

Selected reference values for heterogeneity measures

In the absence of comprehensive preliminary studies, only the guide values or estimated values in **Errore. L'origine riferimento non è stata trovata.** can be referred to.

Assumption of the expected fractional share

In order to estimate the required sample mass, an ex-ante estimate of the expected fraction content is required. For this purpose, the results of the most recent investigations (up to approx. 5 years ago) in the region concerned or in regions comparable in terms of waste management and settlement structure must be used (cf. **Errore. L'origine riferimento non è stata trovata.Errore. L'origine riferimento non è stata trovata.**).

Determination of the required total sample mass

On the basis of

- the fraction-specific heterogeneity u_f and
- the expected fractional share $\hat{a}_f$ with respect to the lead fraction f,
- the number of fractions to be compared f which are to be compared with regard to the distribution of subpopulations (e.g. layers), whereby it is customary to assume $f = 2$ is assumed for the two-fraction case, and
- of the desired accuracy as an absolute confidence interval KI_{abs}

the required sample mass is m_{erf} by means of

$$m_{erf} = \frac{u_f \cdot a_f \cdot (1-a_f) \cdot \chi^2{}_{f-1;1-\alpha}}{KI_{abs}{}^2} \qquad \text{(Formula 5)}$$

determined[9] . If a stratification is carried out, the sample mass is determined separately for each layer (possibly with different accuracy requirements).

The required sample mass can be determined using **Errore. L'origine riferimento non è stata trovata.** can be determined. If u_f deviates from 1 kilogram, the required sample mass is determined using

$$m_{erf} = m_{erf}\left(u_f = 1kg\right) * u_f \qquad \text{for } u_f \neq 1\,kg \qquad \text{(Formula 6)}$$

with u_f multiplied by . If the expected mass fraction of the lead fraction is more than 50 %, the results are identical to those from the mass fraction of the sum of the other fractions.

In the case of several test questions, the sample mass must be determined for each test question (possibly with different stratification), with the highest sample mass being selected in each case.

[9] The required sample mass `m_erf` is determined using Microsoft Excel © on the basis of the corresponding input parameters `uf` (u_f), `af` (a_f), `alpha` (∝) and `KI_abs` (KI_{abs}) by means of

```
m_erf = =uf*af*(1-af)*(NORM.S.INV(1-alpha/2)/KI_abs)^2 .
```

Table 1 Required sample mass in kilograms according to desired accuracy KI_{abs} and mass fraction $\hat{a}_f$ of the leading fraction in kilograms

Erforderliche Gesamtprobemasse m_{erf} in kg bei $u_f = 1,0$ kg

Je nach Fraktion und u_f-Wert lt. Annex 3.2.3 ergibt sich die erforderliche Gesamtprobemasse durch Multiplikation mit $m_{erf} \cdot u_f$

Erwarteter Massenanteil der Leitfraktion (a_f) bzw. Summe der übrigen Fraktionen		Angestrebte Genauigkeit (absolutes Konfidenzintervall KI_{abs})									
		0,5%	1,0%	1,5%	2,0%	2,5%	3%	4%	5%	7,5%	10%
0,5%	*99,5%*	764	191	85	48	31	21	12	8	3	2
1,0%	*99,0%*	1 521	380	169	95	61	42	24	15	7	4
1,5%	*98,5%*	2 270	568	252	142	91	63	35	23	10	6
2,0%	*98,0%*	3 012	753	335	188	120	84	47	30	13	8
2,5%	*97,5%*	3 745	936	416	234	150	104	59	37	17	9
3,0%	*97,0%*	4 471	1 118	497	279	179	124	70	45	20	11
4%	*96%*	5 900	1 475	656	369	236	164	92	59	26	15
5%	*95%*	7 299	1 825	811	456	292	203	114	73	32	18
6%	*94%*	8 666	2 167	963	542	347	241	135	87	39	22
7%	*93%*	10 003	2 501	1 111	625	400	278	156	100	44	25
8%	*92%*	11 309	2 827	1 257	707	452	314	177	113	50	28
9%	*91%*	12 585	3 146	1 398	787	503	350	197	126	56	31
10%	*90%*	13 829	3 457	1 537	864	553	384	216	138	61	35
11%	*89%*	15 043	3 761	1 671	940	602	418	235	150	67	38
12%	*88%*	16 226	4 057	1 803	1 014	649	451	254	162	72	41
13%	*87%*	17 379	4 345	1 931	1 086	695	483	272	174	77	43
14%	*86%*	18 500	4 625	2 056	1 156	740	514	289	185	82	46
15%	*85%*	19 591	4 898	2 177	1 224	784	544	306	196	87	49
16%	*84%*	20 652	5 163	2 295	1 291	826	574	323	207	92	52
17%	*83%*	21 681	5 420	2 409	1 355	867	602	339	217	96	54
18%	*82%*	22 680	5 670	2 520	1 417	907	630	354	227	101	57
19%	*81%*	23 648	5 912	2 628	1 478	946	657	370	236	105	59
20%	*80%*	24 585	6 146	2 732	1 537	983	683	384	246	109	61
21%	*79%*	25 492	6 373	2 832	1 593	1 020	708	398	255	113	64
22%	*78%*	26 368	6 592	2 930	1 648	1 055	732	412	264	117	66
23%	*77%*	27 213	6 803	3 024	1 701	1 089	756	425	272	121	68
24%	*76%*	28 027	7 007	3 114	1 752	1 121	779	438	280	125	70
25%	*75%*	28 811	7 203	3 201	1 801	1 152	800	450	288	128	72
26%	*74%*	29 564	7 391	3 285	1 848	1 183	821	462	296	131	74
27%	*73%*	30 286	7 572	3 365	1 893	1 211	841	473	303	135	76
28%	*72%*	30 978	7 744	3 442	1 936	1 239	860	484	310	138	77
29%	*71%*	31 638	7 910	3 515	1 977	1 266	879	494	316	141	79
30%	*70%*	32 268	8 067	3 585	2 017	1 291	896	504	323	143	81
32%	*68%*	33 436	8 359	3 715	2 090	1 337	929	522	334	149	84
34%	*66%*	34 481	8 620	3 831	2 155	1 379	958	539	345	153	86
36%	*64%*	35 403	8 851	3 934	2 213	1 416	983	553	354	157	89
38%	*62%*	36 202	9 050	4 022	2 263	1 448	1 006	566	362	161	91
40%	*60%*	36 878	9 220	4 098	2 305	1 475	1 024	576	369	164	92
42%	*58%*	37 431	9 358	4 159	2 339	1 497	1 040	585	374	166	94
44%	*56%*	37 861	9 465	4 207	2 366	1 514	1 052	592	379	168	95
46%	*54%*	38 169	9 542	4 241	2 386	1 527	1 060	596	382	170	95
48%	*52%*	38 353	9 588	4 261	2 397	1 534	1 065	599	384	170	96
50%	*50%*	38 415	9 604	4 268	2 401	1 537	1 067	600	384	171	96

Extrapolation to the population

The extrapolation to the population must ensure that the analysed samples are weighted aliquot to the waste generation in the respective sub-population (e.g. stratum) in order to provide a true reflection of the composition by fraction.

For each unit of analysis e and the corresponding subpopulation M_e extrapolation factors h_e must be determined, whereby on the basis of

- the definition of the study unit e (e.g. all rural communities),
- of the analysed sample mass m_e in the respective unit of analysis (e.g. 500 kg)
- the mass of the corresponding sub-population M_e (e.g. 30,000 tonnes) and
- the mass of the population M (e.g. 300,000 tonnes of biogenic waste in a federal state)

the extrapolation factor of the unit of analysis using

$$h_e = \frac{M_e}{m_e} \qquad \text{(Formula 7)}$$

is determined (e.g. with $h_e = \frac{30.000\,t}{0,5\,t} = 60.000$ as a dimensionless factor, with 1 kg of sample mass representing 60 tonnes in the population in the calculation example mentioned), and the extrapolated fractional shares of the population $a_{f,M}$ for a fraction f with

$$a_{f,M} = \frac{1}{M} \sum_e h_e * m_{f,e} \qquad \text{(Formula 8)}$$

where $m_{f,e}$ denotes the fractional mass by unit of analysis.

To determine the confidence intervals of the estimated fractional shares of any fraction f the sample masses of all test units that are more strongly represented than the weakest represented are weighted down accordingly. This means that all test units are represented exactly in equal quantities, whereby the reference sample mass is m_{ref} is reduced. The reference sample mass m_{ref} is calculated with the help of the highest extrapolation factor of all units of analysis $h_{e,max}$ by means of

$$m_{ref} = \frac{M}{h_{e,max}} \qquad \text{(Formula 9)}$$

is determined. The confidence intervals of the mean fractional proportions for any fraction f are calculated using formulae 12 and 13 in the appendix (p. 47), whereby the reference sample mass m_{ref}, fractional shares of the population $a_{f,M}$ and the respective heterogeneity measure u_f must be used.

Determination of confidence intervals for mean fraction e

Until now, the confidence intervals of estimated mean fractional proportions have been calculated in practice using the Student distribution or normal distribution assumption. In the case of small heterogeneous fractions, this sometimes resulted in confidence intervals that reached into the negative range. Based on the beta distribution used, asymmetric confidence intervals with lower bounds in the positive range were obtained.

The confidence intervals for a determined fractional share a_f with determined heterogeneity u_f for fraction f are calculated for the population and each subpopulation with mass m using the inverse cumulative distribution function of the beta distribution with the parameters

$$a = \frac{m * a_f}{u_f} + 1 \qquad \text{(Formula 10)}$$

and

$$b = \frac{m * (1 - a_f)}{u_f} \qquad \text{(Formula 11)}$$

determined[10] . The upper and lower bounds of the confidence interval $a_{f,min}$ resp. $a_{f,max}$ for the probabilities according to the confidence level for $\frac{\propto}{2}$ or $1 - \frac{\propto}{2}$ can be calculated using spreadsheet or statistical software[11] .

Determination of the fractional shares of sub-populations

On the basis of the determined fractional shares by unit of analysis (e.g. socio-economic strata, combinations of socio-economic strata and collection systems), fractional shares can be estimated for other subpopulations (e.g. districts or district groups).

The estimated fractional share $\hat{a}_{f,t}$ of a subpopulation t (e.g. district group) is determined by weighting the fractional shares of the survey units $\hat{a}_{f,e}$ is determined.

[10] Approximation to the normal distribution can be assumed if the condition $\frac{m * a_f * (1-a_f)}{u_f} > 9$ is fulfilled according to Moivre-Laplace's limit theorem. For lead fractions with very high heterogeneity ($u_f \sim 3$) and small fraction proportions ($a_f \sim 2$ %), normal distribution can only be assumed for sample masses of 1.4 tonnes or more. For large fractions ($a_f \sim 15$ %) with normal heterogeneity ($u_f \sim 1{,}5$) the condition is already fulfilled from 100 kg.

[11] *The bounds of the confidence interval of the estimated fraction af_min or af_max are determined using Microsoft Excel © on the basis of the corresponding input parameters uf (u_f),af (a_f),alpha ($\propto$) and m (m) using*

```
af_min =BETA.INV(alpha/2;(m/uf*af)+1;(m/uf)*(1-af)) or
af_max =BETA.INV(1-alpha/2;(m/uf*af)+1;(m/uf)*(1-af)) .
```

Socio-economic stratification

Consideration of socio-economic factors

If there are clear differences within the study area in terms of settlement and building density, specific commuter balance and household sizes, e.g. in terms of different urban-rural structures, a socio-economic subdivision into four classes (urban, intermediate, rural, tourist) should be carried out at municipal level (possibly collective districts within cities).

The regional subdivision in the sense of an urban-rural index has advantages in terms of the accuracy and transferability of the results and additional information regarding the waste management infrastructure. For socio-economic stratification at municipal level, a standardised national allocation key is to be applied using the indicators provided by Statistics Austria[12] :

- Settlement density (settlement area in inhabitants per hectare),
- Proportion of the resident population in apartment blocks
- Relative commuter balance (inbound commuters minus outbound commuters per inhabitant according to labour force statistics and
- average household size according to labour force statistics.

The advantages of the assignment key[13] explained below include the following

- Strong correlation with influencing factors relevant to waste management (e.g. relative number of employees or workplaces (indirectly relevant for any business street collection),
- Clear staggering of the per capita collection volume of organics and food in residual waste with increased volumes in urban municipalities (e.g. in the nationwide residual waste analysis, Beigl 2020),
- clear gradation of the organic and food content in residual waste with the highest mass proportions in urban regions (e.g. in the evaluation of residual waste composition in Austria 2018/2019, Beigl 2020),
- Traceability of the calculation using coefficients (e.g. comparison with cluster approaches),
- Good data availability via municipal surveys by Statistics Austria
- Regional selectivity at municipal level (especially compared to aggregation at district level, which in most cases is accompanied by a mixture of different structures, e.g. the district capital and rural municipalities),
- Regional comparability between federal states
- Possibility of comprehensible categorisation into three, five or another number of classes and high informative value with regard to specific collection quantity.

Another socio-economic criterion for the classification can be the tourism of a region, which is defined as the ratio of the number of overnight stays to the resident population of a region. When categorising into two classes (tourist/non-tourist), the number of 50 overnight stays per inhabitant can be used.

[12] If no spatial stratification is carried out, there is a risk that municipalities with a rural structure will be overrepresented. The use of different and incomprehensible stratification approaches also makes updatability and comparability more difficult, especially if the stratification approaches are based on different levels (e.g. municipalities, districts).

[13] The allocation key is attached to this document in the form of an MS Excel file.

The **nationwide allocation key** for the socio-economic stratification of municipalities is based on the four significant influencing factors on municipal waste generation mentioned above, which were identified as part of the evaluation and modelling of municipal collection volumes from 542 municipalities over 17 years[14] . The criteria for selecting these influencing factors are

- sufficient significance (R>0.5),
- good data availability,
- the lowest possible correlation between the indicators and
- content and logical significance for known influences on the volume of residual waste, such as
  - the consumer behaviour of private households (household size),
  - Business included in the municipal collection (commuter balance),
  - Influence of the container sizes used (proportion of apartment buildings) and
  - Rural character or tendency towards home composting (settlement density).

Based on the data for all Austrian municipalities (with the exception of Vienna) in the year currently available, a factor was determined using principal component analysis, which represents a dimensionless urban-rural index for simplicity's sake. The socio-economic stratification factor $\boldsymbol{SSF}$[15] is calculated with

$$\boldsymbol{SSF} = 1{,}255 - 0{,}044 * SD - 1{,}132 * MFH - 0{,}691 * SPS + 0{,}614$$

SD settlement density (settlement area in inhabitants per hectare)
MFH share of the residential population in apartment blocks
SPS-specific commuter balance (inbound commuters minus outbound commuters per inhabitant)
.... HHGHousehold size

The determined stratification factor **SSF** can be divided into three layers

- Predominantly urban (with $\boldsymbol{SSF} < 1{,}5$),
- Intermediary (with $1{,}5 \leq \boldsymbol{SSF} < 2{,}5$) and
- Predominantly rural (with $\boldsymbol{SSF} \geq 2{,}5$)

or in the five layers

- Urban (with $\boldsymbol{SSF} < 1$),
- Predominantly urban (with $1 \leq \boldsymbol{SSF} < 1{,}9$) and
- Intermediary (with $1{,}9 \leq \boldsymbol{SSF} < 2{,}3$) and
- Predominantly rural (with $2{,}3 \leq \boldsymbol{SSF} < 2{,}6$) and
- Rural (with $\boldsymbol{SSF} \geq 2{,}6$)

classified. An allocation list for all Austrian municipalities is available as a supplement to this document. The classification list is updated regularly (current data basis 2020). Data from the harmonised employment statistics at municipal level are available for this purpose.
The stratification factors were determined on the basis of a principal component analysis, in which the four indicators mentioned were consolidated into one factor[16] . The municipalities were grouped on the basis of these stratification factors in such a way that each stratum accounts for approximately the same proportion of the population throughout Austria (excluding Vienna).

[14] *Beigl and Lebersorger, 2010; available at* http://www.abfallwirtschaft.steiermark.at/cms/dokumente/11328747_4335176/da0191e7/Endbericht_Abfallmengenprognose_Stmk_2020.pdf

[15] *The factor corresponds to the stratification factor used in the nationwide guidelines for residual waste sorting analyses (BMNT, 2017).*

[16] *The factor determined corresponds to the first main component, which explains 55% of the total variance of the four indicators.*

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