Circular Economy Impact Assessment

Food waste in HORECA sector

Marko Danon, Danijela Bobić, Marija Suzić

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BAU	Business As Usual
CEE	Central and Eastern Europe
CEVES	Center for Advanced Economic Studies
CH_4	Methane
CO_2	Carbon - dioxide
EBITDA	Earnings before interest, taxes, depreciation, and amortization
EC	European Commission
EU	European Union
FTE	Full Time Equivalent
GHG	Greenhouse gas
GVA	Gross Value Added
HORECA	Hotels, restaurants, cafes
Kt	Kilotonne
SBRA	Serbian Business Registers Agency
SEPA	Serbian Environment Protection Agency
SORS	Statistical Office of Republic of Serbia

EXECUTIVE SUMMARY

HORECA sector – which includes hotels, restaurants and catering companies – in Serbia and in the world is a major food producer, and thus a major generator of food waste. This study has a double objective – first to estimate the actual size of this physical waste stream and the ways these streams are used, and secondly to estimate future dynamics of this stream, and social, economic and environmental implication of these trends.

CEVES team estimated that Serbian HORECA purchased cca 123 kt of raw food materials. Some 25 kt is wasted during preparation of food – in the so-called kitchen waste – which includes mostly inedible parts of raw food, such as eggshells or banana skin. While Serbian HORECA objects are estimated to serve 99 kt of food, some 15 kt is left behind by customers, and this waste seemingly includes in large part uneaten vegetable, bread, pasta or rice.

Thus, CEVES estimates that sector generates a total 40 kt of food waste – or almost 6 kg per capita annually – which is somewhat less than CEE' average. An overwhelming part of this waste – estimated at 99% – is landfilled with a very heavy environmental footprint and almost no economic impact at all. The remaining 1% is used for the most part, as it seems, in composting and biogas – fuelled electricity generation, as well as in smaller part in animal feed production and food donations.

CEVES team prepared several forecast scenarios for the period until 2030, which all assume a strong increase in food waste due to improving living standards and improving tourism, but which vary depending on the share of landfilled waste. In a scenario seeing no improvements in landfilling rate, we forecast minimal social and economic impacts, but with a very heavy environmental toll. In more favourable – Target – scenarios, we see social, economic and environmental effects increase as share of landfilled waste decreases.

INTRODUCTION

Food wastage – of which much is generated in HORECA – is an increasingly pressing issue worldwide. According to FAO (2011), some 1.3 billion tonnes of food is wasted annually – or approx. one third of total global production. The US department of agriculture reports[1] that some 60 million tonnes is wasted, or approx. 180 kg per person. In EU-28 alone, Fusions (2016) estimate that some 88 million tonnes of food are wasted each year, equalling to 170 kg per person. Households seem to generate most of it – 53%, while HORECA is another large generator of waste, with 12% of food waste made in food services, such as hotels, restaurants and similar. In this sector, the food waste is essentially generated at two points – kitchens, during preparation of food, and by customers, who leave out parts of served food.

Food wastage has numerous consequences, ranging from food safety to environment. Food wastage is a serious issue, which has numerous ethical, economic and environmental aspects. According to the European commission[2], hunger is still not rooted out, as some 43 million people in the EU alone are not able to afford a quality meal every second day. While the food is unevenly distributed, waste often ends up at landfills, and there it ultimately produces a

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[1] https://www.usda.gov/media/press-releases/2015/09/16/usda-and-epa-join-private-sector-charitable-organizations-set

[2] https://ec.europa.eu/food/safety/food_waste_en

harmful cocktail of methane and carbon-dioxide – it is estimated[3] that 7-8% of greenhouse gases produced globally are due to food waste. As most of food waste is disposed at landfills, which keep expanding, the waste harms not only the air, but also seeps in the underground water and polluting an even wider area.

Much can be done to improve the situation, but not all solutions are equally desirable. According to the Food Recovery Hierarchy, developed by the EPA, the most favourable method of reducing waste relates to the reduction of unnecessary production of food, i.e. decrease of food waste at source – often achieved through improved stock management in both households and larger objects. The next by order of preference is to feed the hungry – donation of extra food to food banks, shelters, etc. Furthermore, it is to feed the animals – i.e. to divert food scraps to animal feed. Afterwards, it is preferred to use it industrially – conversion of food into energy for instance, followed by composting of food scraps into fertilizer. The least preferred is food waste' landfilling, which is seemingly the method used the most across the globe.

Graph 1. Food recovery hierarchy model
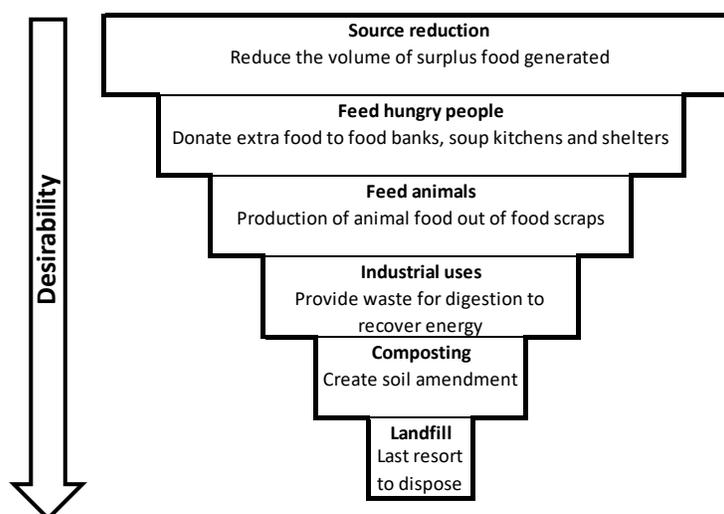
Source: United States Environmental Protection Agency

This document is an early attempt of quantifying effects of introduction of circular economy of food waste created in Serbia's HORECA industry. There is only scarce data capturing food waste in Serbia, with comparable EU countries' data being only slightly more accessible. Furthermore, a more stringent analysis is hampered by lack of a universally accepted definition of food waste and no established nor harmonised methodology on how to measure it (FUSIONS, 2016). In these circumstances, this analysis is an early attempt to quantify potential effects of introduction of circular economy in HORECA industry in Serbia, and it focuses of effects on jobs, GVA and Greenhouse gas emissions.

The analysis attempts to quantify current and future levels of food waste and to estimate its social, economic and environmental impacts. This analysis is structured as follows. In the first section, we debate on methodological issues underpinning this study. The second section attempts to shed light on Serbia's HORECA sector, the quantity of food waste it currently creates, and value chain this waste makes across the wider economy. The third section

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[3] https://changeforclimate.ca/story/the-problem-of-food-waste

provides a discussion on social (jobs), economic (GVA) and environmental impacts (GHG) expected in the period until 2030. The fourth section lists the used literature, while the final section discusses the methodological approach in detail.

PART 1: METHODOLOGICAL APPROACH

This impact assessment quantifies potential for job (social aspect), GVA creation (economic aspect) and GHG emissions (environmental aspect) which could stem from implementation of circular economy in the HORECA sector in Serbia. As we expect that the sector will keep expanding in Serbia, the anticipated rise in food production and waste may have certain positive economic and social effects, if properly harnessed. Indeed, in order to process increased waste quantities, the entire system needs to be improved, while additional workers need to be employed. These elements incur operational and capital costs, thus creating direct and indirect economic and social impacts. This methodology has been developed by CEVES team and has built on previous studies of which we draw particular attention to Tostivint et al (2016). This study contributes to existing body of research by focusing the interest solely on Serbian HORECA.

- **Scope of the study and definition of key concepts**

This research was conducted within a specific scope, focusing on the impact assessment of improved management of food waste in the period from 2019 to 2030. Further details are provided as follows:

Table 1. Scope of the study

Topic	Scope/Description
Food waste types	Waste from firm foods, and excludes beverages, alcoholic drinks, and all liquid foods, such as oils.
Players	Focus on analysis of hotels, restaurants and catering companies. Cafés are excluded since they produce marginal amount of food waste.
Timeframe	Impact assessment compares cumulative effects during 2019-2030 period compared to baseline year 2018.
Geographical scope	Focus of the study: Serbia, benchmarked against EU-28 countries
Key indicators	Economic indicators: profitability and GVA Social indicators: jobs and informal employment Environmental indicators: Greenhouse gas emissions
Value chain segments covered	Assessment covers CE VC segments from the moment food is purchased and delivered to a HORECA object, and until the waste generated is disposed to a landfill or recovered for human or industrial use.

Source: CEVES estimate

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Our model observes food waste[4] value chain starting after purchase of raw food by HORECA objects and ends it with recovery of generated food waste. It is built upon a conceptual framework visualised at the graph below. The entire food waste cycle begins with production or import of food, and ends with food waste disposal a landfill, or some kind of food waste recovery, either for human use, animal use or use in industrial or agricultural purposes, such as composting or production of electricity. However, in terms of this study, we focus on part of cycle starting with preparation of raw food by a HORECA object, and finishing with recovery (boxes marked in blue colour in the graph below), while leaving out food production and landfilling from a more detailed analysis (boxes marked in grey in graph below).

Kitchen is the first point of food waste generation in HORECA objects and generates mostly unavoidable[5] waste and slight amount of avoidable[6] waste. After raw food enters a HORECA object, it is prepared in a kitchen, and generates the so called ''kitchen'' waste. It consists mostly of unavoidable and inedible food elements, such as the banana skins, eggshells or bones. This waste may have a minor share of avoidable – or edible – waste, with share of such waste depending primarily on kitchens' production efficiency. This means that in some cases, kitchens discard edible food for a variety of reasons – such as poor planning, inadequate tools and skills of staff, or inadequate storing procedures and facilities.

Consumers are the second point of waste generation in HORECA objects and produce a mix of avoidable and unavoidable waste. After preparation in kitchens, the food is served to customers, who may leave a part of food uneaten. Regardless of type of object – be it a hotel, caterer or restaurant, all the food left behind by customers is considered as the so called ''plate waste'', which is the second point of waste generation, which consists largely of edible food waste. However, not all edible plate waste is in the same time avoidable. Our analysis assumes that most of the meals served in Serbia's HORECA objects were served in à la carte menus. Leftovers from à la carte menu cannot be served for subsequent human reuse, after having been partially consumed, due to food safety concerns. Such leftovers are in scope of this analysis deemed as unavoidable, although having been edible at one point beforehand. On the other hand, a part of (untouched) leftovers from food served in buffet menus – served mostly by hotels and caterers - can be served in subsequent human reuse, as it hasn't been directly consumed or touched by other consumers. Along this study we consider such leftovers as avoidable, and it constitute the food waste eligible for food donations. However, the part of buffet menu food which was partially consumed or touched cannot be served and is deemed unavoidable.

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[4] We rely on the definition proposed by Fusions (2016), stating that "Fractions of food and inedible parts of food removed from the food supply chain to be recovered or disposed (including - composted, crops ploughed in/not harvested, anaerobic digestion, bioenergy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)"

[5] Unavoidable food waste (Fusions, 2014), or the food that under normal circumstances humans cannot eat, such as meat bones, the shell of coconut and the skin of oranges. This part of food waste is produced in process of food preparation, and also includes the once edible food waste, but which cannot be donated to food banks, due to sanitary regulations, such as the à la carte food leftovers.

[6] Avoidable food waste (Fusions, 2014), which is thrown away because it is no longer wanted or has been allowed to go past-its-best. The vast majority of avoidable food waste is composed of material that was, at some point prior to disposal, edible - even though a proportion is not edible at the time of disposal due to deterioration (e.g. gone moldy). Such is the food that humans were at some point able to eat, such as slices of bread, a tomato or a tenderloin steak. In scope of this analysis, this category of waste refers to plate leftovers from buffet menus, which are overwhelmingly produced by hotels and catering companies.

Food waste can be recovered in a range of ways, rather than simply landfilled. As detailed in the Introduction, the Food recovery hierarchy prioritizes food donations for human use. Afterwards, it calls for production of animal feed, and only then for recovery for industrial purposes, such as composting and electricity generation. Landfilling is the least preferable method – but according to a significant body of literature – it is also currently the most common one in many countries.

Graph 2. Conceptual food waste cycle in HORECA
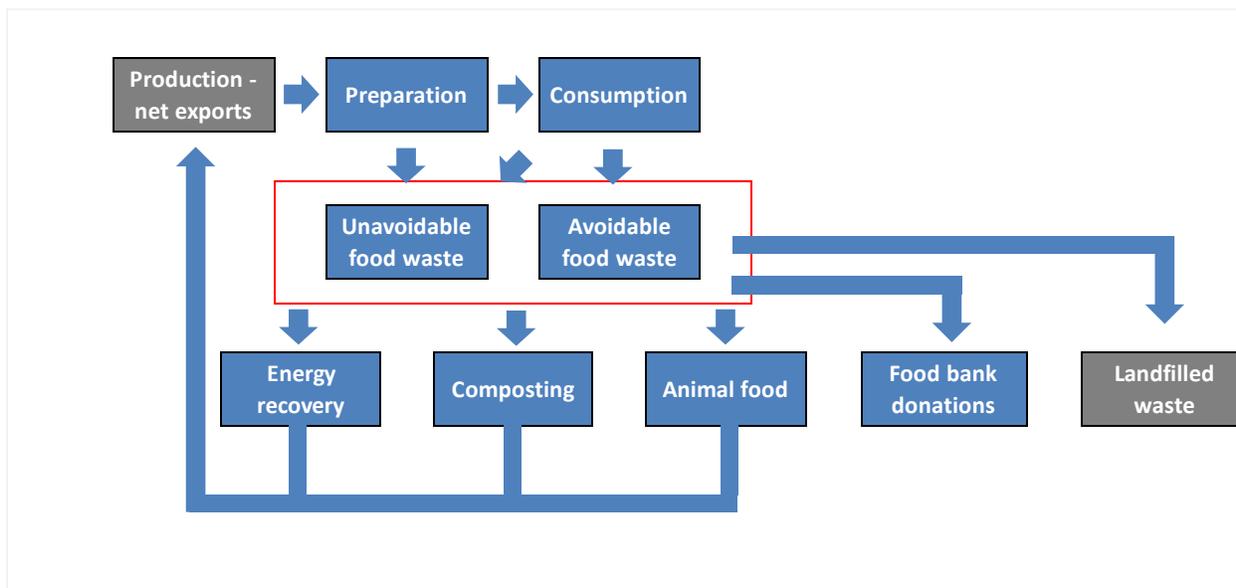
Source: CEVES estimate

- **Description of the model**

We quantify the impact of introduction of circular economy in HORECA sector on job creation, value added and greenhouse gas emissions. In the first step, our model evaluates current and future physical streams of food purchases and waste generation in Serbian HORECA sector, which in scope of this analysis refers to hotels, restaurants and catering companies, while it excludes cafes, given that they normally don't serve food. In this first step we are also trying to determine the structure of usage of waste – i.e. the extent to which the waste is landfilled or recovered. In this respect, our model focuses on recovery in composting and energy generation, and recovery in human use through food banks. In the second step, the model calculates how many additional jobs, revenues and costs and GHG emissions may be created by processing the increased quantities of waste in the period until 2030 across several scenarios, each assuming a different mix of post-disposal treatment procedures.

The model focuses both on effects of reduction of avoidable and unavoidable food waste and on better usage of waste. Circular economy implies both opportunities arising from increased material resource efficiency in production and reduction of avoidable food waste. This model assumes that HORECA objects are already running at maximum material resource efficiency in production, and thus focuses on the reduction of food waste – including also a better usage of existing waste – through increased reliance on food banks and improved food waste recovery through composting and electricity generation.

Current physical streams of food waste are estimated at basis of interviews with HORECA objects, and future ones are forecasted. Current physical streams of food waste in Serbian HORECA sector are largely estimated based on the information obtained during direct interviews with HORECA companies, and in a smaller part on official data – especially financial data. As for the period until 2030, our forecast is based on expected trends of domestic consumption and foreign tourist activity.

Associated labour, costs and revenue coefficients estimates are based on the interviews with hotels, restaurants and catering companies. We relied on interviews with companies for most of information for our model, given the overall scarcity of data sources in the area of food waste. Thus, we segmented the research in subareas of hotels, restaurants and catering companies, and conducted a series of in-depth interviews after having secured an adequate sample of interviewed companies.

The model attributes these coefficients to the estimated current and future physical quantities of food waste. The heart of the model relies to the possible reuses of food waste – and in this approach we focus on food banks, animal feed, biogas – fuelled electricity generation and composting, although more uses are possible. To this end, we conducted in-depth interviews with some of the leading companies in these sectors and retrieved the technical details – such as how much persons are required to operate a certain amount of waste, or how much electrical energy may be generated with the same amount of food waste. In order to minimize potential bias, we cross-checked these technical details with relevant literature and interviews with relevant experts in this field. This information allowed us to calculate social (jobs), economic (GVA) and environmental (GHG emissions) coefficients per tonnage of processed food waste in each of the recovery/landfilling procedures. As for effects of food banks, we opted for a simpler approach consisting of quantification of number of meals which could potentially be retrieved and number of workers needed for logistics, without entering in financial aspects of such effort. For the fully detailed description of the approach, please refer to Section IV.

- ## Scenarios

Two models branch out of the reference year 2018. Our approach posits two scenarios for the period 2019-2030, which effectively represent lower and upper boundary, depending on the level of improvements landfilling rates – or share of food waste being landfilled – against the reference year 2018. More precisely, these scenarios are:

- **First, a Business-as-usual (BAU) scenario** which implies that current state of waste management practices will not be changed along the observed period. This means that the current landfilling rate – which is estimated at 99% of total waste generated – will remain unchanged along the observed period, implying adverse environmental and social effects. The remaining 1% of waste is expected to be recovered via donations to food banks, production of animal feed, electricity generation and composting. In both scenarios, redistribution is made upon the principles of 1) equal shares of waste going to biogas and composters 2) donations to food banks capped by quantity of avoidable food waste and 3) potential quantity of food waste for animal feed being capped at approx. 5%.

- **Secondly, the three Target scenarios,** of which Target 1 (T1) sees landfilling rate dropping from the current 99% to 80%, to 60% in T2 and to 40% in T3 by 2030. These levels are clearly inspired by targets set out by the EU action plan for the Circular

Economy (2015)[7]. The remaining waste – 20% in T1, 40% in T2 and 60% in T3 – is thus expected to be recovered via donations to food banks, electricity generation and composting.

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[7] https://ec.europa.eu/environment/circular-economy/

PART 2: CURRENT STATE

CEVES' team estimates that Serbian HORECA sector wasted almost 40 kt of food (5.7 kg per capita), of which almost entire quantity is landfilled, and only a slight part reused for food donations, energy generation or composting.

1. Food waste in HORECA in the EU

Europe wastes 12 million tonnes of food in HORECA sector annually, which is close to 20 kg per capita. Fusions (2016) reports that EU-28 wasted 88 mln tonnes of food in 2012. Out of this amount, food service – including hotels, restaurants and caterers – wasted cca 12%, or close to 20 kg per capita. CEE countries are significantly below – ranging from 6 to 12 kg per capita. More developed countries, with a strong tourism sector and deeply rooted eating-out culture, record even higher levels – going to 28 in Italy or Greece, 33 in Sweden or to as much as 50 in the UK. The data for European countries presented in the graph below represent only rough estimates, compiled from various analytical material by the European Commission (2010), while the Serbian data represents CEVES' estimate.

Graph 3. Overview of food waste in food service across Europe
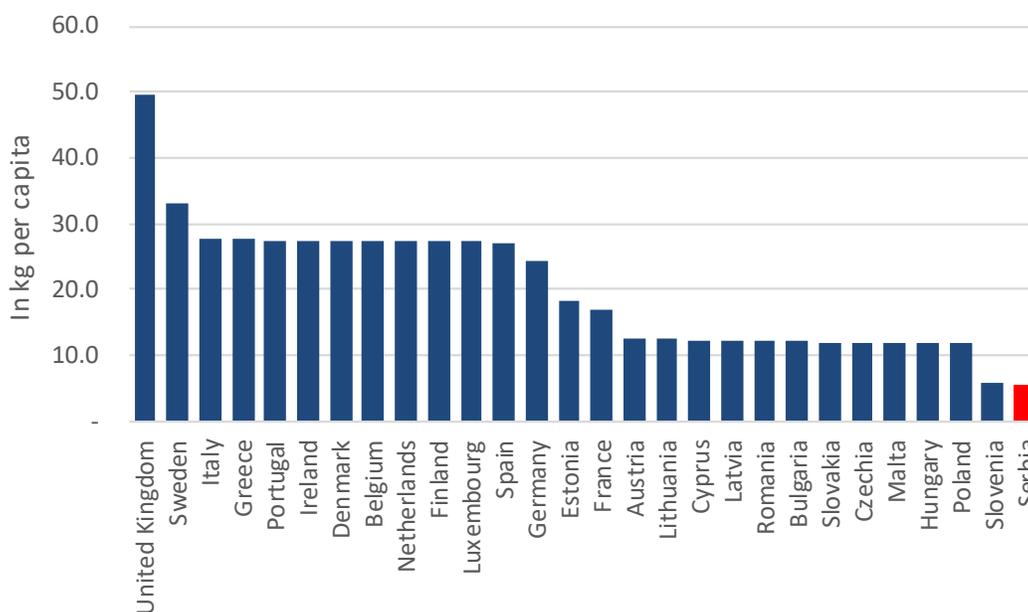
Source: For European nations - European Commission (2010), for Serbia - CEVES estimate

Food waste is a pressing concern in the EU, which has been tackling it by introduction of a new legislative framework. The need to prevent and reduce food waste, while ensuring the safety of the food and feed chain, is a subject of growing societal, economic, environmental and political interest. Food waste prevention has been singled out as a priority area in the Communication on ''Closing the loop – an EU action plan for the Circular Economy'' adopted by the European Commission in December 2015. Also, in order to support achievement of one of the UN' Sustainable development goals regarding responsible consumption and production, EU has introduced the EU platform on food losses and food waste in 2016 bringing together EU

institutions, experts from the EU countries and relevant stakeholders. The Platform aims to support all actors in defining measures needed to prevent food waste; sharing best practice; and evaluating progress made over time.

The revised legislative framework sets targets for reuse and recovery of municipal waste, including food waste. The Action plan sets out a timetable for proposed actions, and related legislative proposals on waste – including adoptions of EU guidelines to facilitate food donation and the feed use of food no longer intended for human consumption, developed food waste measurement methodology and is undertaking work to improve date marking practices. Moreover, the Revised EU Waste Legislation, adopted in 2018, calls on the EU countries to take action to reduce food waste at each stage of the food supply chain, monitor food waste levels and report back regarding progress made. This legislation also calls for increase of share of municipal waste prepared for reuse and recovery to 55% by 2025, to 60% by 2030 and to 65% by 2035.

2. Food waste quantities and value chain in Serbia

Serbian HORECA sector is estimated to waste 40 kt (6 kg per capita) yearly, while it purchases 123 kt of raw food. CEVES estimated that total costs of food purchases amounted to EUR 465 mln for 123 kt of various foods[8]. We relied on interviews with approx. 100 hotels, restaurants and caterers to determine that cca 20% or 25 kt is discarded as the ''kitchen'' waste, i.e. waste arising from preparation of food. This part of waste seemingly consists of inedible parts of food, such as bones, banana skin or eggshells, and is discarded in kitchen. Out of the 99 kt of food served to customers, 15 kt – or 15% - were seemingly left behind as the plate waste. Kitchen and plate waste put together make up 40 kt in 2018. A stylized model of the flow is provided in graph below, which represents CEVES' estimate for 2018.

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[8] Our analysis excludes the edible oils from consideration

Graph 4. Detailed overview of food cycle
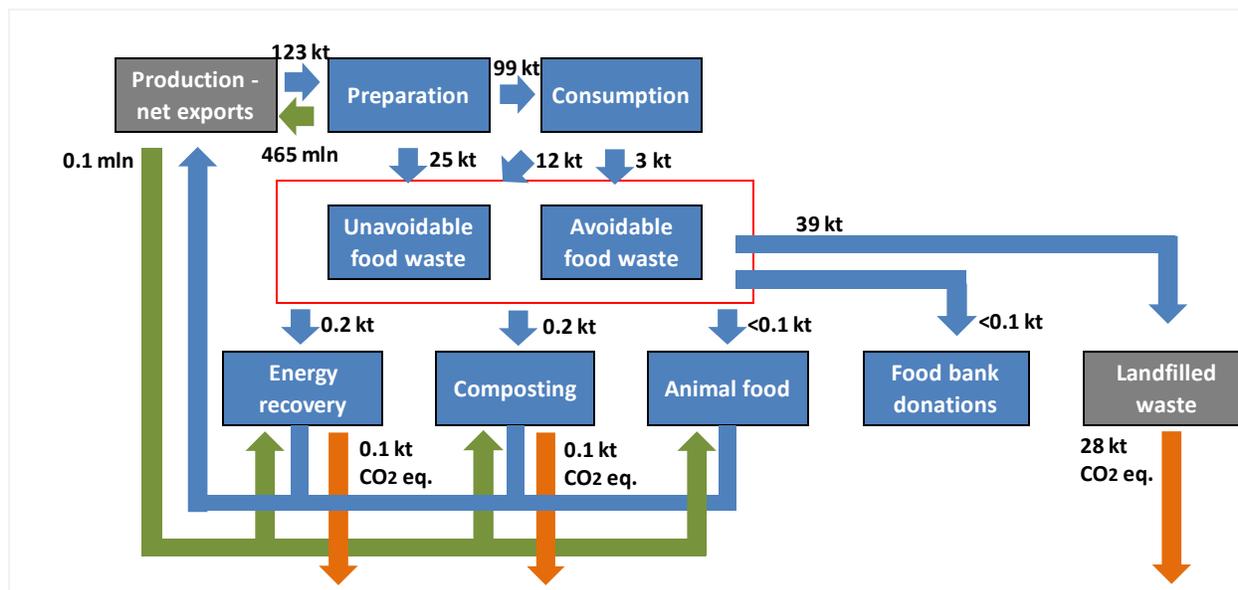
Source: CEVES estimate

An overwhelming majority of food waste is landfilled. CEVES' team assumes that a prevailing majority – or as much as 99% – of food waste is landfilled. The key issue related to the landfilling, apart from being an untapped economic potential, relates to its very heavy environmental footprint. Namely, biodegradable waste, such as food, releases powerful greenhouse gases (GHG), such as methane (CH_4) or carbon dioxide (CO_2), as it breaks down. When released in uncontrolled conditions, such as in landfills, methane and carbon dioxide trap up significant amounts of heat in the atmosphere, which leads to global warming[9]. While this analysis in this respect is an early quantifying attempt, it finds that Serbia's HORECA food waste deposited in landfills emits the GHG in total amount of 28 kt of CO_2 equivalent, which is the amount annually emitted by 6-7 thousand cars.

Only a marginal fraction is being recovered, much of it for food bank donations, animal feed, biogas electricity generation and composting. The non-landfilled share of waste can be reused by humans through donations to food banks, by animals in preparation of animal feed, of by industry, through energy generation or composting. This may include both avoidable and unavoidable food waste, and even liquid wastes, such as edible oil, recoverable through production of biodiesel. However, in the scope of this analysis, we focus on recovery through food bank donations, energy generation and composting.

Food donation has large potential social impact but still has ample room for improvement in EU-28. Food donations are a potentially effective lever in fight against poverty, but also can help in reducing the amount of surplus food sent for waste treatment or disposed at landfills. However, although food donations are a globally growing phenomenon, and food manufacturers are seemingly willing to donate their surpluses, it remains only a marginal fraction of total food waste. To put things in perspective, European Food Banks Federation reports at its web site having provided 781 kt of food in 2018, which is dwarfed by the total food waste estimated 88 million tonnes. At current moment, the potential food donors across Europe

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[9] https://www.wastewiseproductsinc.com/blog/food-waste/the-dangers-of-food-waste/

are seemingly prevented both by legal and operational barriers. Many potential donors claim that key issues which prevent donations are the fear of potential liability concerning the food safety, sometimes unclear expiration labelling, lack of adequate cold-storage facility, lack of adequate procedures or processes for donations in place, and unreliable pick-up service.

Donations to food banks in Serbia are currently scarce, while retailer chains are the dominant donors. In Serbia, the leading local food bank – "Banka Hrane" (2018) reports having collected approx. 1.2 kt of food in 2017, of which a prevailing part from retailer companies, while it reports it had only recently started collection from restaurants, albeit at low intensity at current moment. In this analysis we have assumed that in line with this report food donation is currently very limited at approx. 34 tonnes annually – and this includes both food donations in strict sense and food leftovers collected by the HORECA object's staff.

Feeding food waste to animals is a long-term practice across the world, but may have detrimental effects if not compliant to strict phytosanitary requirements. Feeding food waste to domestic animals is a common practice in many parts of the world, and there is a growing interest in its potential use as a replacement for conventional, high-cost feed. However, if such food waste contains meat wastes and is not heat-treated, it can transmit diseases, such as foot-and-mouth disease and African swine fever. Al-Tabbaa et al (2017) state that in 2001, a UK farmer illegally fed uncooked food waste to pigs, precipitating the foot-and-mouth disease epidemic, which cost the UK economy GBP 8 bln. As a result, recycling of most food waste as animal feed is generally prohibited in the European Union (EC, 1774/2002). Feeding food waste to animals is possible only after all meat particles are eliminated, food waste is heat treated and dehydrated and mixed with dry feed. Upon discussions with local experts, CEVES team estimated that total food waste eligible for such reuse is capped at 5%. It has also been estimated that currently a total output of animal feed produced from food waste under correct phytosanitary standards reaches a total of 20 tonnes. **Biogas produces electric energy with a relatively low environmental footprint, but with a significant room to develop in Serbia.** Biogas – fuelled plants use food waste to provoke anaerobic digestion, a process in which the microorganisms break down biodegradable material in absence of oxygen. This process produces biogas – or a mixture of gases such as methane (CH_4) and carbon dioxide (CO_2) – used in gas engines to convert it into electricity, which is sold with a feed-in premium to the national electric utility company EPS. Upon discussion with a leading local company, CEVES team estimated that cca 180 tons of food waste were consumed by local plants in 2018. This amount is then combined with other forms of waste, such as manure or garden waste, and it creates some 22.000 m^3, a volume convertible in approx. 60 MWh of electricity.

Composting produces nutrient-rich fertilizer, with a somewhat heavier environmental footprint than biogas, but much lighter than landfilling. Composting is a process of aerobic digestion of organic matter, in which it is decomposed in compost, a good and nutrient-rich fertilizer for plants. Besides its fertilizer function, it can also, among other things, be used to control temperature and moisture of the soil or to serve as a weed barrier. It is widely used, for example, in gardening, landscaping, horticulture, or organic agriculture. However, the process of decomposition frees up more GHGs in the atmosphere than in the case of biogas production, but substantially less than in case of landfilling. Upon discussion with a leading local company, CEVES team estimated that cca 180 tons of food waste is consumed by composters. This amount is estimated to lose 25% of its mass in the process, and that the remaining 135 tons of compost is sold nationwide. A specific issue with both composting and biogas is the composition of the input. Both processes require stable structure of input, which is hard to obtain given the diversity of number of different HORECA objects and wastes they could produce, and this may constitute the key technical challenge for a quicker expansion of these forms of food waste recovery.

3. Key players within the HORECA sector

HORECA sector – dominated by restaurants – purchased 123 kt of food in 2018, of which it has wasted 40 kt. The restaurants dominate the HORECA sector in terms of number of companies, with more than 6.000 units scattered across Serbia, against less than 400 food-serving hotels, and approx. 800 caterers. These companies purchase a total of 123 kt of food in 2018 according to CEVES' estimate. During preparation of food, their kitchens wasted approx. 25 kt of food. Some 99 kt is served to customers, who leave 15 kt behind. Total waste attains 40 kt, and its overwhelming majority – or 99% - is assumed to be landfilled, and remainder is recovered in an array of purposes.

Out of 40 kt of food waste, 3 kt may be potentially donated to food banks – equalling 6 million meals. The entire kitchen waste of 25 kt is assumed in this study to be unavoidable, as we assume it is completely composed of inedible foodstuffs, i.e. kitchens run at maximum efficiency for the sake of modelling simplicity. Plate waste, which attains 15 kt, can be divided on avoidable – 3 kt – and unavoidable part – 12 kt, of which the former was served as buffet menu by the hotels and caterers, and the latter served as à la carte menu by hotels and restaurants. This means that the avoidable part can be donated to food banks, while the unavailable part – although still possibly edible – cannot be recovered through human consumption due to food safety concerns. All in, out of total 40 kt of food waste, we assume that a maximum of 3 kt of food – or 6 million meals – may be potentially donated to food banks at annual basis.

Table 2. Food waste stream estimate for 2018 (in tonnes)

	HORECA - total	TOTAL	Restaurants	Hotels	Catering
(1)	**Input**	**123,422**	**90,868**	**19,765**	**12,789**
(2)	-Kitchen waste	24,684	18,174	3,953	2,558
	of what avoidable	*0*	*0*	*0*	*0*
(3=1-2)	=Served food	98,738	72,695	15,812	10,231
(4)	-Plate waste	14,811	10,904	2,372	1,535
	of what avoidable	*2,934*	*0*	*1,399*	*1,535*
(5=2+4)	**=Total waste**	**39,495**	**29,078**	**6,325**	**4,092**
	of what avoidable	*2,934*	*0*	*1,399*	*1,535*
(6)	- Landfilled	39,100	28,787	6,262	4,051
(7=5-6)	**=Recovered waste**	**395**	**291**	**63**	**41**
(8)	Animal feed	20	15	3	2
(9)	Biogas	171	138	20	13
(10)	Composting	171	138	20	13
(11)	Food banks	33	0	20	13

Source: CEVES estimate

More than 6,000 restaurants used cca 91 kt in food purchases and wasted 29 kt. According to the SBRS database, that there are somewhat more than 6,100 active restaurants in Serbia. Based on the analysis of 2014 cost structure for sample of 1,615 restaurants – CEVES team estimated that the entire restaurant sector purchased 91 kt of food, equivalent to an estimated cost of EUR 342 mln. All meals in restaurants are served as à la carte, meaning that no waste can be reused in human use due to stringent sanitary standards. However, as most of the waste is composed of vegetables, bread and cereals, as indicate in-depth interviews with 13 restaurants, prevailing part of waste can be used for biogas or composting.

There are almost 400 star-classified hotels which serve food. Out of 1,000 hotels or other accommodation structures in Serbia, some almost 400 is under the star rating system. This

largely includes hotels, garni hotels and motels, which serve some amount of food, however in varying frequencies – for instance while garni hotels serve only breakfast, many hotels also have half or full boards, i.e. 2 or 3 meals. As opposed to these structures, the remaining cca 600 structures as general rule don't serve food, and thus are excluded from our analysis. Out of the cca 400 hotel-alike structures, CEVES conducted telephone interviews with 70 hotels and with another 17 conducted in-depth discussions, as presented at table below.

Table 3. Overview of interviewed hotels

Type of object	Classified hotels (1)	Telephone interviews (2)	In-depth interviews (3)	Total interviewed (2+3)
Total	**397**	**70**	**17**	**87**
Garni hotels	125	24	4	28
Hotels	252	40	13	53
Motels	8	2	0	2
Pansions	3	3	0	3
Tourist settlements	6	1	0	1
Other not classified above	3	0	0	0

Source: CEVES estimate

Hotels use cca 20 kt of food and waste 6 kt, across three different streams. The observed hotels have three streams of food waste generation: 1) hotel visitors, 2) visitors of a hotel's restaurant and 3) attendees at conferences or other events organized at hotel's premises. Based on in-depth and telephone interviews, we estimated that hotels purchase a total of 20 kt of food, of which 16 kt – or 32 million meals – is served to customers. Most of it – 15 million meals – are consumed by hotel guests. The interviews also show that visitors of restaurants consume another 13 mln meals, given that more than 85% of hotels also have an active restaurant open for wide public. The rest of 4 mln meals is prepared for attendees at conferences, weddings or similar events. This assumes that each hotel can organize two or three such events per week, and the size of event facilities is proportional to hotel size, as proxied by number of beds.

Out of 6 kt of food waste, 1.4 kt can potentially be donated to food banks, which is an equivalent of 2.8 mln meals. Out of the 20 kt purchased by hotels, some 4 kt is discarded as kitchen waste, which can only be recovered in industrial reuse. On top of this, the hotels serve 16 kt of food to customers, of which they leave app 2.3 kt behind as plate waste. Most of this plate waste – 1.4 kt – was served in buffet menu, whose leftovers can potentially yield 2.8 mln meals for human use annually[10].

Almost 800 caterers use cca 13 kt of food and waste 4 kt, of which a relatively large chunk can be donated to food banks. The catering industry is relatively small in terms of employment and food consumption but includes almost 800 entities. Based on the analysis of cost structure of cca 150 caterers, and in-depth interviews with 10 such companies, we conclude they prepare 21 million meals. We assume that it is entirely prepared as buffet, which means that the entire plate waste of 1.5 kt or 3 million meals can be potentially used for subsequent human use.

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[10] If each meal contains 0.5 kg of food

PART 3: CIRCULAR ECONOMY IMPACT ASSESSMENT

The impact assessment attempts to quantify social (jobs), economic (GVA) and environmental (GHG emissions) of introduction of circular economy in the local HORECA sector.

The model is based upon two distinct scenarios. The key difference between scenarios is the expected landfilling rate in 2030. While the first, Business as usual scenario foresees the landfilling rate unchanged until 2030, the Target scenario expects the rate to sharply drop. The Target scenario than develops three distinct sub-scenarios, with a differing level of intensity of decrease of the landfilling rate. A more detailed overview of the scenarios is provided as follows:

Business as usual (BAU) scenario implies no improvements in the current system – the landfilling rate would remain near current levels of 99% of food waste by 2030. This said, almost entire quantity of food waste fill keep being landfilled with other municipal waste, thus generating the poorest developmental effect on wider economy. Only 1% will be used in food banks, animal food, biogas fuel or as raw material for composting.

Target scenario(s) imply improvements in the current system with landfilling rate gradually dropping to:

- 80% in our T1 scenario,
- 60% in our T2 scenario and to
- 40% in our T3 scenario.

It is noteworthy that the EU legislative framework[11] sets the target for landfilling rate of municipal waste to 40% by 2030 and 35% by 2035, which roughly matches our T3 sub scenario. This means that EU legislation calls for a gradual decrease of share of municipal waste which is landfilled, and gradual increase of share of processed and reused waste.

1. Impact on recovered quantities

BAU scenario foresees only a marginal increase of reuse, causing minimal social and economic impacts, and heavy negative environmental impact. All scenarios imply increase of food waste from actual cca 40 kt to approx. 77 kt in 2030. However, BAU scenario foresees that landfilling rate would remain at 99%. This means that overwhelming majority of increase in food waste would end up on environmentally unfriendly landfills, while reused waste would only marginally increase. Thus, the associated additional employment would be very modest, while the environmental footprint would be especially heavy.

Target scenarios imply decrease in landfilling rate, for more tangible social, economic and environmental impacts. While all scenarios expect increase of food waste from the actual 40 kt to 77 kt in 2030, Target scenario expects that the landfilling rate would drop down from the current 99%. Target sub-scenarios differ one from another by intensity of decrease of landfilling rate. In our T1 sub-scenario, where landfilling rate drops to 80%, recovered quantities rise from current 0.4 kt to 15 kt. T2 sub-scenario sees landfilling rate dropping to 60%, with recovered quantities rising to 31 kt. The optimal sub-scenario – T3, landfilling rate drops to 40%, pushing the recovered quantities to 46 kt. However, in order for any of the Target sub-scenarios to materialize, it is seemingly needed to adopt a number of accompanying measures, going from a

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[11] https://ec.europa.eu/info/news/commission-reviews-implementation-eu-waste-rules-proposes-actions-help-14-member-states-meet-recycling-targets-2018-sep-24_en

more developed network of collecting bins, to an improved system of sorting and to an increased awareness of general public on the importance of the subject.

An ample rise of food donations is possible under Target scenarios, but they require substantial improvements in collection, legislation and awareness. Donations to food banks are limited by the amount of avoidable waste – or the edible plate waste stemming from buffet menus served in hotels and caterers. However, in none of the scenarios, this potential is fully used. It is curbed by the high landfilling rate and the general reluctance of potential donors, resulting from food safety concerns and often inadequate logistic network. This said, while some 6 million meals may be donated at current moment, we estimate that only 69 thousand meals are currently donated by HORECA objects, and this including the leftovers consumed by HORECA object's staff. All the scenarios foresee the same amount of avoidable waste, which means that the potential for food donations across all scenarios is the same and it amounts to approx. 15 million meals in 2030. However, BAU scenario sees the number of donated meals rising to only 200 thousand by 2030. In our T1 sub-scenario, it rises to 4.1 million, 8.1 million in T2 and 12.2 million in T3 sub-scenario. However, for this to materialize, there are numerous requirements, including among other an improved collection network, more enticing legislative environment, even more clearly defined labelling guidance and raised public awareness.

Graph 5. BAU vs Target: Total reused quantities (in kt)
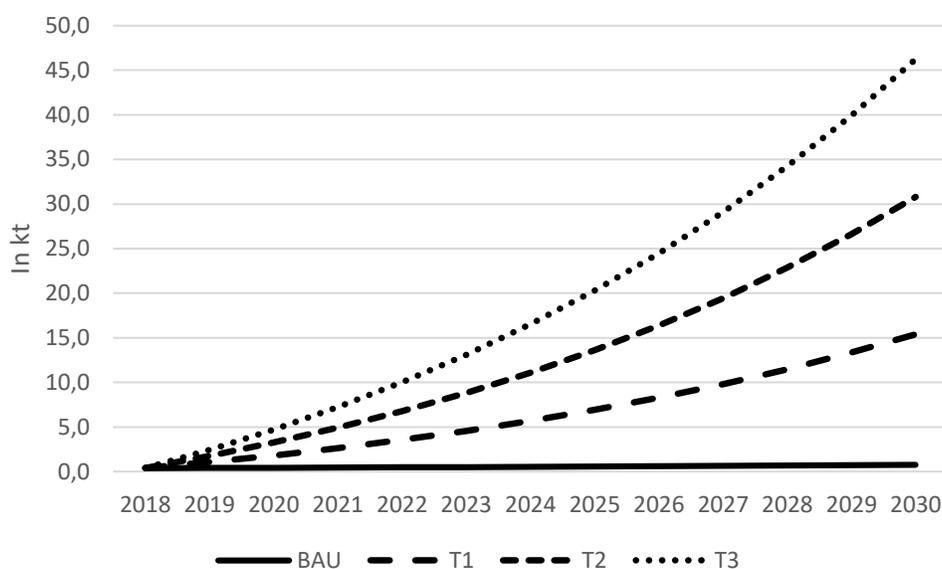
Source: CEVES estimate

2. Impact on job creation

If the sector continues to landfill most of the waste, the employment effects would be very modest. If HORECA sector continue with their current practice of landfilling an overwhelming majority of food waste, then the recovered quantity of food waste would rise to merely 0.8 kt a year until 2030, from the today's 0.4 kt. This increase would leave no room for a meaningful increase in employment and that the total number of workers would increase by merely 9.

It is possible to create 356 to 1,068 new jobs, but only if extent of food waste processing is increased. If the landfilling rate drops from the current 99% to 80%, the processed quantity

would increase towards 15 kt, which would require additional 356 workers. Out of this, 154 are needed for transport – as an increased quantity of food waste inputs needs a more substantial logistic network between the food banks, animal food, biogas and composting plants and the HORECA objects. The remainder – or 202 workers – would be needed for processing and administration. Further decrease of landfilling rate – to 60% in T2 and to 40% in T3 – provokes proportional improvements in job creation. Namely, our T2 model forecasts additional 712 workers for a total of 31 kt of processed food waste, and 1,063 new jobs for 46 kt of processed food waste.

Table 4. Overview of impacts on job creation (in FTEs if not otherwise stated)

Indicators	Baseline 2018	Value in 2030				Change 2030 vs 2018			
		BAU	T1	T2	T3	BAU	T1	T2	T3
Total food waste (kt)	39.5	77.0	77.0	77.0	77.0	37.5	37.5	37.5	37.5
Total food waste reuse (kt)	0.4	0.8	15.4	30.8	46.2	0.4	15.0	30.4	45.8
Total	9	18	356	712	1,068	8	347	703	1,059
Transport	4	8	154	308	462	4	150	304	458
Animal feed	0	0	8	15	23	0	8	15	23
Food banks	0	1	19	39	58	1	19	39	58
Biogas	2	3	63	127	190	1	62	125	189
Composting	2	3	63	127	190	1	62	125	189
Processing	5	10	202	404	606	5	197	398	600
Animal feed	0	1	12	23	35	0	11	23	34
Biogas	3	5	95	190	286	2	93	188	283
Composting	3	5	95	190	286	2	93	188	283

Source: CEVES estimate

3. Impact on GVA creation

If no changes were made, in the period between 2019 and 2030, only EUR 1.5 mln of GVA would be created, while if circular economy was implemented GVA would be increased by somewhere between EUR 18 and 53 mln. If the current system of work – where most of food waste is landfilled –protracts, then there would be no tangible benefits for the broader economy. However, should the landfilling rate falls to 80%, as predicts the T1 scenario, the entire value chain would create additional EUR 18 mln, of which EUR 8 mln in biogas plants and EUR 10 mln in composting facilities. Further drops in landfilling rate provoke more GVA: almost EUR 35 mln in additional GVA is expected to be created in T2 scenario, and EUR 53 mln in T3 scenario, over what could have been created should no changes are made. However, potential benefits, not calculated under this model, are even higher – this model doesn't measure capital investments needed for setting up an adequate collection network, nor does it calculate the indirect and induced effects of workers' wages on broader economy.

Table 5. Overview of impacts on GVA creation (in EUR 000 unless otherwise stated)

Indicators	Baseline 2018	Value in 2030				Cumulative 2019 - 2030*			
		BAU	T1	T2	T3	BAU	T1	T2	T3
Total food waste (kt)	**39.5**	**77.0**	**77.0**	**77.0**	**77.0**	**37.5**	**37.5**	**37.5**	**37.5**
Total food waste reuse (kt)	**0.4**	**0.8**	**15.4**	**30.8**	**46.2**	**0.4**	**15.0**	**30.4**	**45.8**
Revenues (1)	105	0.2	3.9	7.8	11.7	21.8	21.8	42.9	63.9
Costs (2)	93	0.2	3.5	6.9	10.4	19.3	19.3	37.9	56.5
Wages gross (3)	64	0.1	2.4	4.8	7.1	13.3	13.3	26.1	38.9
Fuel (4)	18	0.0	0.7	1.4	2.0	3.8	3.8	7.4	11.0
Amortization (5)	11	0.0	0.4	0.8	1.2	2.2	2.2	4.4	6.5
Operative result (6=1-2)	12	0.0	0.5	0.9	1.4	2.5	2.5	5.0	7.5
EBITDA (7=6+5)	23	0.0	0.9	1.7	2.6	4.8	4.8	9.4	14.0
GVA (8=7+3)	**87**	**0.2**	**3.2**	**6.5**	**9.7**	**18.0**	**18.0**	**35.5**	**52.9**

Source: CEVES estimate

4. Impact on GHG emissions

Continuation of current landfilling practices will create massive environmental challenges, should HORECA sector keeps steady growth until 2030. If the landfilling rate remains at 99%, as predicts BAU scenario, then the strong increase in food waste expected until 2030, going from 40 kt to 77 kt, will be almost fully absorbed by the environmentally harmful landfills. This chain of events would, apart from producing only slim social and economic benefits, create significant environmental issues in the years to come. Namely, the GHG emissions would increase from the current – estimated – level of 28.4 kt of CO_2 equivalent to 55.4 kt in BAU-2030, which is equal to annual GHG emissions of 12 thousand passenger vehicles[12].

Reuse of food waste would have particularly beneficial effects for environment, with significant reduction of GHGs being possible if the landfill rate is decreased. Target scenarios foresee less GHG emissions for the same amount of food waste as in BAU. Namely, as much more of the waste is expected to be processed in biogas or composting facilities, which have a much lighter environmental footprint, T1 sees GHG emissions reaching 52.6 kt of CO_2 equivalent, 49.6 kt in T2 and 46.6 kt in T3[13]. It is noteworthy that Target scenarios also expect an increasing share of food donations – which generate no GHG emission, this being another reason why less emissions are generated under Target scenarios. Finally, we have modelled that a part of food waste is processed into animal feed – and without any more concrete inputs from experts, we had to assume that this production doesn't generate any GHG emissions directly.

[12] https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

[13] Please refer to Stevanovic et al (2017) for an overview of GHG emissions from Serbia's largest landfill in Vinča, which estimates that total municipal waste disposal currently equals 500-600 kt annually, while the annual GHG emission from the landfill is estimated at 1.3 mln tonnes of CO_2 equivalent.

Table 6. Overview of impacts on GHG emissions (in 000 tonnes of CO2 equivalent if not otherwise stated)

Indicators	Baseline 2018	Value in 2030				Change 2030 vs 2018			
		BAU	T1	T2	T3	BAU	T1	T2	T3
Total food waste (kt)	**39.5**	**77.0**	**77.0**	**77.0**	**77.0**	**37.5**	**37.5**	**37.5**	**37.5**
Total food waste reuse (kt)	**0.4**	**0.8**	**15.4**	**30.8**	**46.2**	**0.4**	**15.0**	**30.4**	**45.8**
Total	**28.4**	**55.4**	**52.6**	**49.6**	**46.6**	**27.0**	**24.1**	**21.2**	**18.2**
Landfilling	28.2	55.0	44.4	33.3	22.2	26.8	16.2	5.1	-6.0
Biogas	0.1	0.2	3.6	7.1	10.7	0.1	3.5	7.0	10.6
Composting	0.1	0.2	4.6	9.1	13.7	0.1	4.4	9.0	13.5

Source: CEVES estimate

Graph 6. Baseline vs BAU and Target scenarios – GHG emissions by source in absolute terms (above) and share in total (below)
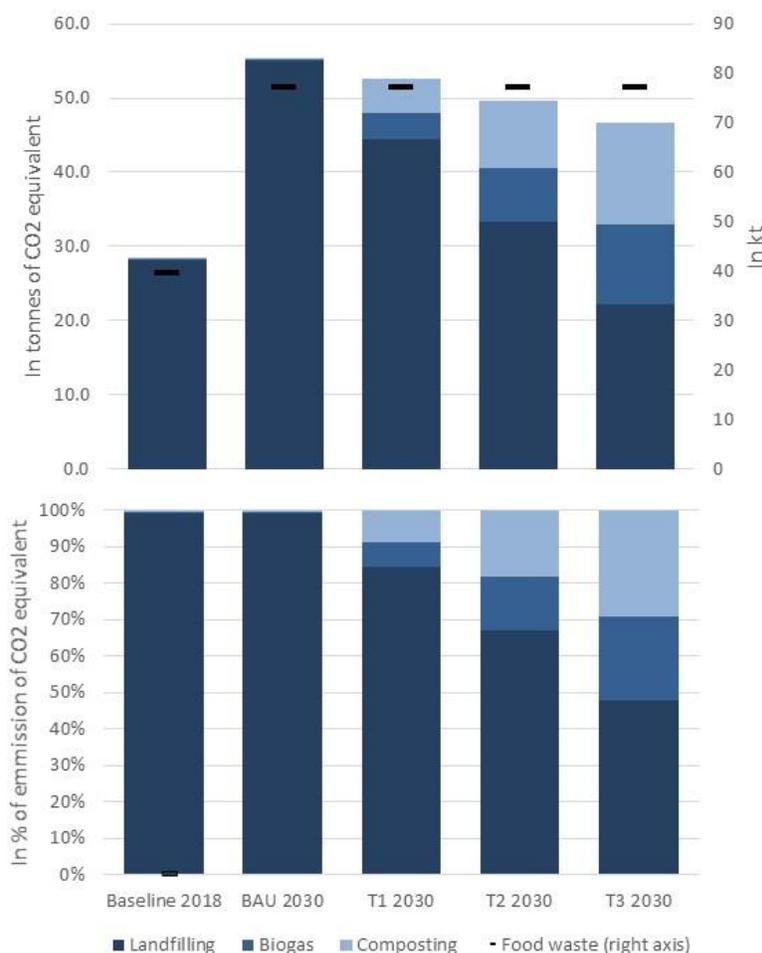
Source: CEVES estimate

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APPENDIX - METHODOLOGY DETAILS

The subject of food waste is still poorly documented by the official statistical sources, while the literature is still in early development phase. Thus, this model is only partially based on official statistical sources, such as SEPA, SBRS, SORS or Eurostat, while CEVES team had to rely on assumptions and expert opinion provided through interviews with HORECA companies, firms which reuse food waste, as well as from relevant literature.

Construction of the model required two distinct phases. In the first phase, we estimated the physical flows of food waste in HORECA companies – including the amounts of food purchases by hospitality objects and food wastage at different points of value chain. In this same phase, we also attempt to quantify potential increase in these physical quantities by 2030.

Based on this data, the second phase attempts to estimate current impact of food waste arising, and to quantify how the expected increase in food waste may affect the broader society and economy.

1. Phase 1: quantification of physical streams

As HORECA objects may vary greatly in size and type, the quantification of physical streams of waste relies on two distinct sub-models. In the first one, we quantify the food waste made in hotels, and in the second one in restaurants and catering companies. At the end of the process, we consolidated the obtained data in the main model.

i. Quantity of food waste in hotels

Out of cca 400 hotels ranked under the star system by the Ministry of Tourism, we have conducted telephone interviews with 70 hotels and accommodation structures and conducted in-depth interviews and site visits to another 17 hotels. Based on these interviews, we determined that there are basically three food waste streams within the Hotel sub-sector: 1) visitor overnight related stays, 2) conference/event – related stays and 3) visitors in in-house restaurants. We have separately estimated the three streams within this subsector, and eventually merged the estimate in the single Hotel food waste estimate.

The idea for the most part of the Hotel sub-sector was to determine the number of meal prepared in each of the streams, and to divide it by 2, in order to obtain the weight of food expressed in kg, as we assume that an average meal weight 0.5 kg.

As for the visitor overnight related stays stream, we concluded that the total number of meals prepared equals:

$$MV_t = NB_t * NM_t * OR_t * 365$$

Where:

    MV_t – Meals for visitors in year t

    NB_t – Number of beds in the cca 400 star-rated hotels - data provided by the Ministry of Tourism

    NM_t – Average number of meals in the cca 400 star-rated hotels – data obtained from telephone and in-depth interviews (1.5) and applied to entire list of observed hotels

    OR_t – Average occupancy rate in year t, assumed to be at 90%

    365 – Number of working days per year in hotels

As for the conference related stays stream, we concluded that the total number of meals prepared equals:

$$MC_t = NB_t * WD_t * SC_t$$

Where:

MCt – Meals for visitors of conferences in year t

WDt – Average number of working days for conferences in the cca 400 star-rated hotels – assumed to be organized 3 times a week

SCt – Share of hotel capacities in hotels which organize conferences, weddings or other events – data obtained from telephone and in-depth interviews (84%) and applied to entire list of observed hotels

As for the in-house restaurant related stays stream, we concluded that the total number of meals prepared equals:

$$MR_t = MV_t * SR_t$$

Where:

MRt – Meals for visitors of in-house restaurants in year n (assuming that each hotel with a restaurant serves the same amount of food to guests of the hotel and to visitors of the restaurant)

SRt – Share of hotel capacities in hotels which have restaurants open for public – data obtained from telephone and in-depth interviews (85%) and applied to entire list of observed hotels

The total amount of food prepared in the three streams are combined as follows:

$$FPH_t = \frac{(MV_t + MC_t + MR_t)}{2}$$

Where:

FPHt – Amount of prepared food in year t,

''Plate'' waste – or the waste of food served to customers and left behind – is calculated as follows:

$$PWR_t = FPH_t * PW$$

Where:

PWRt – Amount of waste generated by customers

PW – plate waste ratio, obtained in interviews with hotels

Annual food purchase is calculated as follows:

$$FPRH_t = \frac{FPH_t}{(1 - KW)}$$

Where:

FPRHt – Food purchases by hotels in year t

KW – kitchen waste ratio – or the ratio of food waste arising from process of preparation of food – obtained in interviews with hotels

Total food waste is calculated as follows:

$$FWH_t = PWR_t + FPH_t * KW$$

Where:

FWHt – Food waste by hotels in year t

Future waste flows were calculated by applying the average growth rate of 12%, which is a level attained in foreign tourist overnight stays between 2010 and 2017, in order to account for the ongoing tourism boom in Serbia, which is seemingly driven by foreign tourist arrivals.

ii. Quantity of food waste in restaurants and catering companies

The restaurants are the core of the Serbia's HORECA industry. As in the hotel subsector, our departure point was also to determine the number of meals prepared by the restaurants and to divide it by 2 – in order to obtain quantity in kilograms. While there are more than 6000 restaurants in Serbia, the number of meals prepared was calculated based on financial statements of the 1615 restaurants from the SBRS database from 2014, as follows:

$$NMR_t = \frac{MCS_t * SF}{FC_t} * 2$$

Where:

NMRt – Quantity of meals prepared by observed 1615 restaurants in year t

MCSt – purchases of materials by restaurants in year t

SF – assumed share of food in restaurants' material costs (90%), according to the interviews

FCt – average food costs per kilogram in year t (held constant and set accordingly to interviews with restaurants at 3.77 EUR / kg)

In order to obtain quantity of food purchased in entire sector, we applied the obtained quantity in 1615 restaurants and applied it entire scope of 6000+ restaurants by assuming that the latter are the average representatives, or:

$$FPR_t = NMR_t * \frac{Total\ number\ of\ restaurants}{Observed\ number\ of\ restaurants}$$

Where:

FPRt – Quantity of food purchased by entire restaurant industry in year t

Furthermore, **we determined the amount of "kitchen" waste** as follows:

$$KW_t = FPR_t * KW$$

Where:

KWt – Quantity of kitchen waste in year t

KW – Kitchen waste ratio, provided by the restaurants in interviews

Finally, **we determined the amount of ''plate'' waste** as follows:

$$PW_t = (FPR_t - KW_t) * PW$$

Where:

PWt – Quantity of plate waste in year t

PW – Plate waste ratio, provided by the restaurants in interviews

At basis of the previous point, **we determined the amount of avoidable waste** as follows:

$$AW_t = PW * (awh + awc)$$

Where:

AWt – Avoidable food waste in year t

awh – ratio of avoidable food waste in plate waste in hotels

awc – ratio of avoidable food waste in plate waste in caterers

In this respect, **total amount of food waste** in restaurants equals the sum of kitchen waste and plate waste, as follows:

$$FWR_t = PWR_t + KWR_t$$

As for the **Catering companies**, the entire method used for restaurants is reused in this exercise, with the difference that we have observed the 2014 financial data for 98 such companies and applied at the total scope of such companies which amounted to 798, while the rest of the methodology is unchanged in principle. This said, the formula for calculation of Catering companies waste equals:

$$FWC_t = PWC_t + KWC_t$$

After having obtained the quantities for all three groups of HORECA companies, and for their key categories: food purchases, kitchen and plate waste and food waste, we consolidate the data in order to obtain the quantities at level of HORECA sector. This means that total food waste equals:

$$FW_t = FWH_t + FWR_t + FWC_t$$

Future waste flows were calculated by applying the average growth rate of 4%, which is a level of economic growth expected for the period until 2030. Unlike hotel industry, we assumed that restaurants and catering companies are in larger part driven by local demand, where a double-digit growth is unlikely.

Table 7. Overview of variables used in the Phase 1 of the model

Variable	Name of variable	Value	Unit of measure	Source
NBt	Number of beds in the star-rated hotels	29,913	Abs. number	Ministry of Tourism
NMt	Average number of meals in the star-rated hotels	1.5	Abs. number	Telephone interviews w hotels
ORt	Average occupancy rate	90%	% of occupied rooms	CEVES estimate
WDt	Average number of working days for conferences in the star-rated hotels	365		
SCt	Share of hotel capacities in hotels which organize conferences, weddings or other events	84%	% of all hotels	Telephone interviews w hotels
SRt	Share of hotel capacities in hotels which have restaurants open for publi	85%		Telephone interviews w hotels
PW	Plate waste ratio	15%	% of food left over by customer	In-depth interviews w hotels / restaurants
awh	Avoidable food waste in plate waste in hotels	59%		
ahc	Avoidable food waste in plate waste in caterers	100%		
KW	Kitchen waste ratio	20%	% of food thrown in preparatior	In-depth interviews w hotels / restaurants
SF	Assumed share of food in restaurants' material costs	90%	% of material costs referring to	In-depth interviews w restaurants
FCt	Average food purchase costs	3.77	EUR per kg	CEVES estimate

Source: CEVES

2. Phase 2: quantification of social, economic and environmental impacts

In the second phase we combined the previously obtained data, and at that basis we calculated the potential social impacts (jobs), economic impacts (GVA) and environmental impacts (GHG emissions).

The departure point – and a crucial spot – in this phase was to estimate the current level of landfilling rate, or the share of food waste which is deposed in an open-air landfill. According to the interviews, we estimated that the current landfilling rate (LR_t) is currently 99%, meaning that 99% of the waste is deposed at a landfill, while the remaining 1% is split in parts between biogas – fuelled electricity production and composting, as well as animal food and donations to food banks.

In our scenarios, landfilling rate is the pivotal variable, which can be either dynamic or static. This means that in our Business as usual scenario, we hold it constant along the observed period, while in Target sub-scenarios, it drops to 80% (T1), to 60% (T2) and to 40% (T3). The decrease in landfilling rate provokes increases in reused quantities of food waste, and thus very significant increases in activity of biogas and compost producers, as fell as producers of animal feed and donations to food banks.

Jobs in biogas sector were estimated as product of quantities of collected waste (excluding the waste directed to animal and human reuse), divided by 2, and workers required to process these quantities, as outline the following formula:

$$JB_t = \frac{FW_t * (1 - LR_t)}{2} * (C_{adm} + C_{trans} + C_{oper}) = \frac{WC_t}{2} * (C_{adm} + C_{trans} + C_{oper})$$

Where:

JBt – Jobs in Biogas in year t

WCt – Waste collected for reuse in year t, or the total amount of food waste multiplied by (1 - Landfilling rate), in order to estimate the food waste not landfilled; divided by 2 in order to reflect the assumption that entire reused food waste quantity is equally split between biogas and composting

Cadm – Coefficient of tonnage which can be administered by 1 worker in administration annually

Crec – Coefficient of tonnage which can be recycled by 1 worker in operations annually

Coper – Coefficient of tonnage which can be stored and transported by 1 worker in transport and logistics annually

Jobs in composting sector were estimated as product of quantities of collected waste and workers required to process these quantities, and are practically obtained in the same fashion as the biogas workers, as outline the following formula:

$$JC_t = \frac{WC_t}{2} * (C_{adm} + C_{trans} + C_{oper})$$

Where:

JCt – Jobs in composting in year t

Jobs in animal food and food bank donations are practically obtained as product of total waste which is eligible for these purposes, and technical coefficients of workers in administration, transport and operations[14], which are identical to those in sector of biogas and composting.

Food waste quantities which are eligible for **food bank donations** are equal to:

$$W_{fd} = \frac{1}{3} * (FW_h + FW_c); \; W_{fd} < (AFW_h + AFW_c)$$

This means that this quantity is equal to a third of total food waste in hotels and restaurants, but it is always capped by quantity of avoidable waste, i.e. by that waste which is edible in theory

Food waste quantities which are eligible for **animal feed** are equal to:

$$W_{fd} = 0,05 * (RCFW_h + RCFW_c + RCFW_r)$$

This means that this quantity equals to 5% of total recovered food waste, or said differently, it is fixed at 5% of all non-landfilled waste under this model. This market is not fully developed, and food waste for animal use don't always have a single and clear price at entire market. It is why we estimate the incomes to be fixed at RSD 50 for a kg of such material, and this represents the key part of GVA in this sector.

GVA in biogas sector was estimated as sum of EBITDA and wages in recycling sector, as specifies the following formula:

$$GVAB_t = \frac{WC_t}{2} * (DISP + VOL_b * ENER * FEED) - (FC * FP * V_n)$$

Where:

GVABn – GVA in composting plants in year t

DISP – Disposal cost, paid by hospitality objects to plants, EUR per tonne

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[14] It is assumed that operations (processing) exists in animal food, while it doesn't in food bank donations – the latter only includes logistics, trasnport and administration

VOLb – Weight to volume ratio – used to calculate the volume of biogas in m^3 based on its weight in tonnes

ENER – Energy obtained from one m^3 of biogas in kWh

FEED – Feed in tariff, paid by electricity utility company to electricity producers, in EUR per kWh

FC – Fuel consumption per vehicle, litres per 100 km

FP – Fuel price per litre, EUR

Vn – Number of vehicles

GVA in composting sector was estimated as sum of EBITDA and wages in recycling sector, as specifies the following formula:

$$GVAB_t = \frac{WC_t}{2} * (DISP + P) - (FC * FP * V_n)$$

Where:

GVABn – GVA in composting plants in year t

DISP – Disposal cost, paid by hospitality objects to plants, EUR per tonne

P – price of compost

GHG emissions in landfilling was estimated in the following way:

$$GHGL_t = (FW_t * LR_t) * GHG_l$$

Where:

GHGl – quantity of GHG per one tonne of food waste disposed at landfill, in CO2 ton-equivalents

GHG emissions in biogas was estimated in the following way:

$$GHGB_t = \frac{WC_t}{2} * GHG_b$$

Where:

GHGb – quantity of GHG per one tonne of food waste disposed at biogas plant, in CO2 ton-equivalents

GHG emissions in composters was estimated in the following way:

$$GHGB_t = \frac{WC_t}{2} * GHG_c$$

Where:

GHGc – quantity of GHG per one tonne of food waste disposed at composter plant, in CO2 ton-equivalents

Table 8. Overview of variables used in the Phase 2 of the model

Variable	Name of variable	Value	Unit of measure	Source
LRt (2018)	Landfilling rate in 2018	99%	% of waste landfilled	CEVES estimate
LRt (2030 - BAU)	Landfilling rate in 2030 (BAU)	99%	% of waste landfilled	CEVES estimate
LRt (2030 - T1)	Landfilling rate in 2030 (T1)	80%	% of waste landfilled	CEVES estimate
LRt (2030 - T2)	Landfilling rate in 2030 (T2)	60%	% of waste landfilled	CEVES estimate
LRt (2030 - T3)	Landfilling rate in 2030 (T3)	40%	% of waste landfilled	https://ec.europa.eu/environment/circular-economy/
Cadm	Tonnage which can be administered by 1 worker in administration	200	Tonnes per worker annually	Expert opinion
Ctrans	Tonnage which can be administered by 1 worker in transport	100	Tonnes per worker annually	Expert opinion
Coper	Tonnage which can be administered by 1 worker in operations	100	Tonnes per worker annually	Expert opinion
DISP	Disposal cost, paid by hospitality objects to plants	203	EUR per tonne	Expert opinion
VOLb	Weight to volume ratio (biogas)	0.13	m3 of gas in 1 kg of waste	Expert opinion
VOLc	Weight to volume ratio (compost)	0.75	amount kg of compost per 1 kg of food waste input	Expert opinion
ENER	Energy obtained from biogas	2.85	KWh per 1 m3 of gas	Expert opinion
FEED	Feed in tariff	0.15	EUR per 1 KWh	https://www.energetskiportal.rs/ministarstvo/fid-in-tarife/
FC	Fuel consumption per vehicle	20	Litres per 100 km	CEVES estimate
FP	Fuel price per litre	1.0	EUR per litre	Market research
P	Price of compost	175	EUR per tonne	Market research
GHGl	Quantity of GHG per one tonne of food waste disposed at landfill	0.72	Tonnes of CO_2 equivalent	Mihajlović (2015)
GHGb	Quantity of GHG per one tonne of food waste disposed at biogas plant	0.54	Tonnes of CO_2 equivalent	Mihajlović (2015)
GHGc	Quantity of GHG per one tonne of food waste disposed at composter plant	0.68	Tonnes of CO_2 equivalent	Mihajlović (2015)

Source: CEVES