

Analysis of Food Loss and Waste for the European Countries in the Context of Sustainable Development



Adrian Stancu 

Abstract Nowadays, in the context of green economy, wastes represent the concern of most of the world countries. Considering also the food loss and food waste, which means discarded food, and given that, at this moment, there are people suffering from hunger, this issue has become of major importance. At the beginning of the chapter, a new approach is set for the delimitation of food loss and food waste concepts. The reduction of the food loss and waste is a goal of numerous sustainable development strategies. Thus, particular measurement systems and databases of food loss and waste employed by the Eurostat, the United States Environmental Protection Agency, and the Food and Agriculture Organization of the United Nations are described. The analysis focuses on the animal and mixed food waste, vegetal wastes, and household and similar wastes generated by households and economic activities in the European countries between 2010 and 2018. The results underscore the clusters of countries with similar behavior of food loss and waste and the link between the country's economic development and the quantity of food waste generated by households and economic activities.

Keywords Food loss · Food waste · Sustainable development · European countries · Economic development

1 Introduction

The humanity has been striving against hunger since ancient Egypt (McDermott, 2001), ancient Greece (Garnsey, 2004), etc. and will be striving against hunger at least until 2030 according to the United Nations' Sustainable Development Goals (United Nations, 2021).

In 2020, on average, 768 million people around the world faced hunger with 118 million people more than in 2019 due to the COVID-19 pandemic (FAO et al., 2021). The countries from Africa South of the Sahara and those from South Asia recorded

A. Stancu (✉)
Petroleum-Gas University of Ploiesti, Ploiesti, Romania
e-mail: astancu@upg-ploiesti.ro

the highest level of Global Hunger Index (GHI) score in 2020. In countries such as Chad, Timor-Leste, Madagascar, Burundi, Central African Republic, Comoros, the Democratic Republic of the Congo, Somalia, South Sudan, Syria, and Yemen, the hunger is considered alarming (von Grebmer et al., 2020). Meanwhile, 45% of fruits and vegetables, 45% of roots and tubers, 35% of fish and seafood, 30% of cereals, 20% of dairy products, 20% of meat, and 20% of oilseeds and pulses are lost or wasted worldwide every year (Food & Agriculture Organization of the United Nations, 2015). These are average values because the food losses depend on various factors, such as for the grains: their type, their variety, the harvest method, the time of harvesting, the weather conditions, meeting or not the criteria for food, etc. (Hartikainen et al., 2017). With respect to the above-mentioned antinomic figures, measuring in depth and diminishing the food loss and waste represent a major priority.

Since 2011, the Food and Agriculture Organization of the United Nations (FAO) has underscored the difference between food loss and food waste based on the stage in the food supply chain where the wastes occur (Food & Agriculture Organization of the United Nations, 2011). Thus, both food loss and food waste consist in reductions in the quantity or quality of food resulting from decisions and actions taken by the food suppliers in the case of food loss, and by retailers, food services, and consumers for food waste (Food and Agriculture Organization of the United Nations, 2019a) (Fig. 1a).

The same outlook was shared by the World Bank (2020), the World Economic Forum (2018) and also by some researchers (Alabrese et al., 2015; Corvellec, 2013;

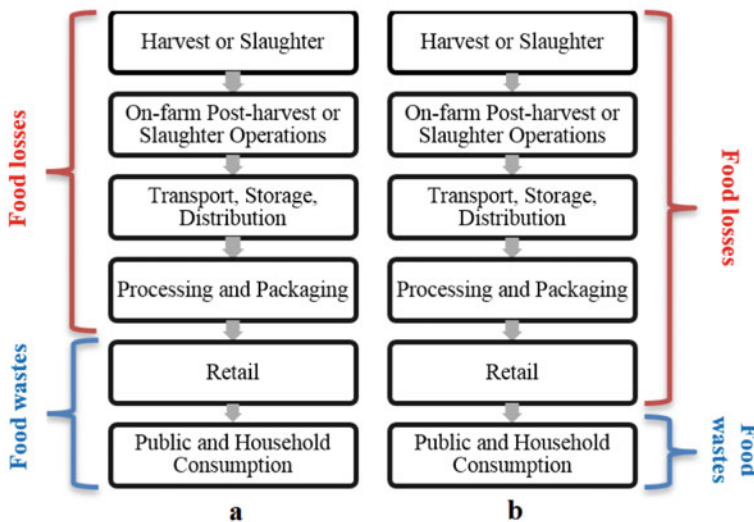


Fig. 1 Differences between food loss and food waste from FAO’s perspective (a) and author’s perspective (b) (Source Author’s development based on Food and Agriculture Organization of the United Nations [2019b])

Kummu et al., 2012; Schneider, 2013). However, the food waste generated only by households is part of the post-consumer waste (Ene, 2013).

I think that FAO's approach is not accurate because the wastes that arise from all economic activities of the food supply chain must be included in only one category, i.e., "food loss". Hence, the "food waste" category comprises the waste generated only by households, hospitals, colleges, universities, office buildings, military bases, etc., known as general "consumers" (Fig. 1b).

In a previous report, FAO asserted that food waste (which is linked with deliberate discarding) may arise at all stages of the food supply chain (Food & Agriculture Organization of the United Nations, 2017). This statement was introduced by Parfitt et al. (2010) and it is not appropriate because all the waste ranging from harvesting or slaughtering to the public and household consumption must be included in the food loss category regardless of the type of discarding. Otherwise, the grouping of food loss and food waste by the stage of the supply chain has no sense.

Similarly, from the standpoint of the food supply chain, the food loss and waste are indicators of the Food Chain Inefficiency (FCI) which emphasize the state of the process in which they arise. In addition to this, food loss is related to the unavoidable cases, independent from the human will, and the food waste is linked to the avoided issues in the supply chain (Horton et al., 2019; Pinstrup-Andersen et al., 2016).

Food loss and waste are connected only with the products for human consumption and are not applicable in the case of non-edible feeds and parts of products. If an edible product becomes non-edible at any stage of the supply chain, it is framed as food loss or waste (Food & Agriculture Organization of the United Nations, 2011), which is a suitable approach.

Human over-consumption, viewed as over-nutrition, i.e., the gap between a higher food availability in contrast to a low food need, is considered food waste (Horton et al., 2019; Smil, 2004).

The High Level Panel of Experts on Food Security and Nutrition (2014) discussed the new concept of food quality loss and waste (FQLW) which is the reduction of the food quality at any stage of the supply chain, from harvest or slaughter to consumption. Lagioia et al. (2021) brought in the notion of food wastage which is caused by both food loss and food waste.

The fact that food loss and waste are part of the sustainable development is confirmed by the 2030 Agenda for Sustainable Development (2030 ASD) which was adopted in 2015 by the member states of the United Nations. The 2030 ASD comprises 17 Sustainable Development Goals (SDGs), 169 targets, and 230 indicators. The 12th SDG (Ensure sustainable consumption and production patterns) and more precisely the Target 12.3 (By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses) emphasize the importance of food loss and waste for a sustainable development (United Nations, 2015, 2021). Thus, food waste management is essential for ensuring food safety and improving public health (Blakeney, 2019; Ene et al., 2017).

The aims of the chapters are, firstly, to describe the measurement system and the database of food loss and waste used in Europe, in the United States of America, and

by specific international organizations in order to identify the corresponding available data. Secondly, to analyze the food waste in the European countries between 2010 and 2018 to emphasize the level of each country as compared to the others. Thirdly, to highlight the cluster of countries with similar behavior of food loss and waste and to underline the interrelatedness of the country's economic development and the quantity of food waste generated by households and economic activities.

2 Food Loss and Waste Measurement

The importance of food loss and waste in the context of sustainable development generated the need for measurement by regional and international institutions. The measurement methodology used by the European Union (EU), the United States Environmental Protection Agency (EPA), and FAO will be presented in the following.

2.1 *Measurement by Eurostat*

In the EU, the Regulation No 2150 of the European Parliament and of the Council, also known as Waste Statistics Regulation (WStatR), stated that Eurostat should manage statistics of data waste by categories, including food waste (European Commission, 2002). Thus, the food waste database was established and first data was reported by both EU and non-EU countries starting with 2004 for one waste category and beginning with 2010 for the other two waste categories. Furthermore, there were adopted complementary legal acts such as Directive 2008/98/EC (Waste Framework Directive) which established the reporting obligation (European Commission, 2008) and the Decision 2011/753/EU which stipulated the rules and calculation methods (European Commission, 2011).

In 2012, Eurostat created the “food waste plug-in” initiative to increase the accuracy in collecting food waste data. Thus, this measure resulted into the following WStatR main waste categories used to measure the food waste (Eurostat, 2021a):

- Animal and mixed food waste;
- Vegetal wastes;
- Household and similar wastes.

The European Waste Classification for Statistics (EWC-Stat) divided the above-mentioned waste categories into some List of Waste (LoW) sub-categories. Thus, the animal and mixed food waste category comprises 10 waste sub-categories (such as, the animal-tissue waste, the materials unsuitable for consumption or processing, the biodegradable kitchen and canteen waste, etc.), the vegetal wastes category includes 11 waste sub-categories (for instance, the wastes from forestry, the sludge from washing and cleaning, the plant-tissue waste, etc.), and household and similar wastes

category contains 5 waste sub-categories (e.g., the mixed municipal waste, the waste from markets, the street-cleaning residues, etc.) (Eurostat, 2013, 2021a).

Each of these three waste types can be generated by numerous sectorial activities and thus grouped into 8 main categories considering the statistical classification of economic activities in the European Community (NACE Rev. 2) by Eurostat (2021b) (Fig. 2).

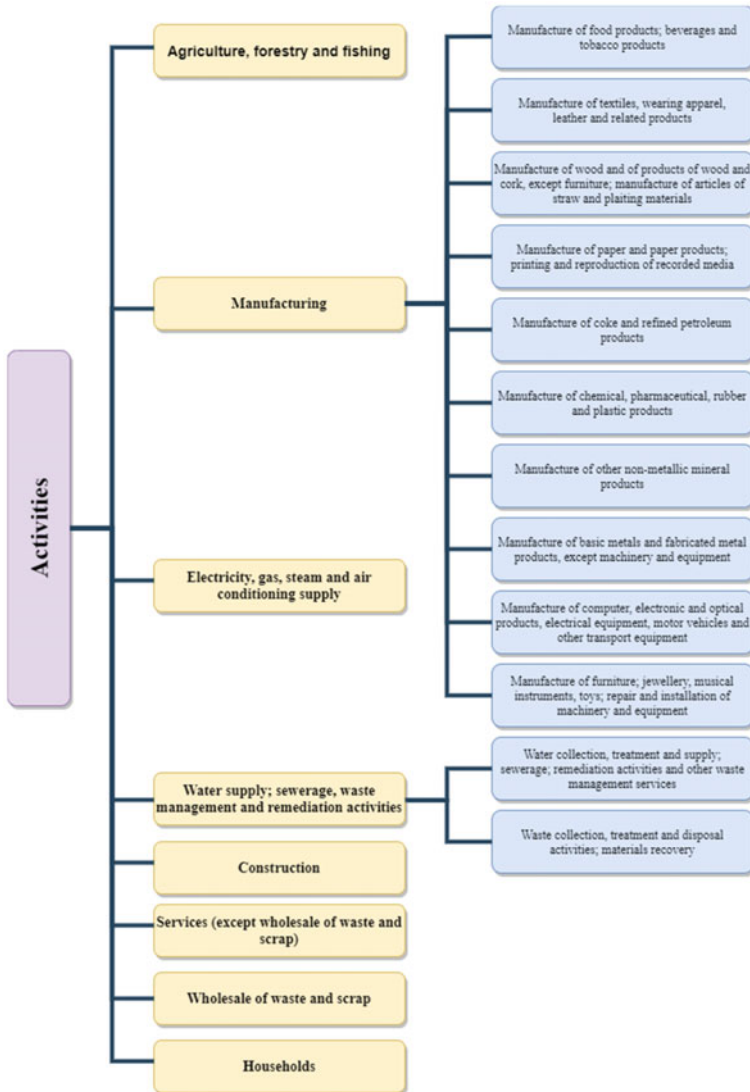


Fig. 2 Activities that generate food waste by NACE Rev. 2 (Source Author’s development based on Eurostat [2021b])

A brief analysis of the Waste Framework Directive, Eurostat's food waste database and NACE Rev. 2 highlights that, in the EU, there is not a clear delimitation between food loss and food waste data reported by the countries.

Starting with 2019, the common methodology and minimum quality requirements for the uniform measurement of levels of food waste and the format for reporting of data on food waste were adopted as an improvement of the existing methodological framework. Along with this new approach, the food waste is individually measured in the following five stages of the food supply chain: primary production (which include agriculture, forestry, and fishing), processing and manufacturing (for both foods and beverages), retail and other distribution of food, restaurants and food services, and households. The types of waste which include food waste are also specified for each of these stages and include both animal and vegetal wastes (European Commission, 2019a, 2019b).

Equally Commission Delegated Decision (EU) 2019/1597 and Commission Implementing Decision (EU) 2019/2000 still define the waste generated from primary production, processing and manufacturing, retail and other distribution of food, and restaurants and food services as "food waste" and not as "food loss" as other institutions frame these types of waste.

2.2 Measurement by EPA

In the United States of America, EPA has measured food waste, as a separate category from other waste categories, since 1960 (United States Environmental Protection Agency, 2014). In 2017, EPA enhanced its measurement methodology to have a better view of the food waste. Thus, food waste was measured according to five generating sectors, i.e., the industrial sector (food and beverage manufacturing and processing), the residential sector (family housing), the commercial sector (the food retail/wholesale and the hospitality sectors), the institutional sectors (hospitals, nursing homes, military installations, office buildings, colleges, universities, etc.), and food banks (United States Environmental Protection Agency, 2020a).

The unit of measurement of food waste depends on the generating sector and it is either in percentages, or it comprises three components, i.e., a unit of mass (lbs or tones), a waste generating unit (person, employee, student, household, etc.), and a unit of time (year), e.g., lbs/household/year (United States Environmental Protection Agency, 2020b).

The limitation of the EPA measurement methodology is that there is no breakdown of the food waste category to allow the distinction among different types of food waste, i.e., vegetal waste, animal waste, etc. Furthermore, the methodology does not measure the food loss from the agricultural sector.

So far, EPA has published only one report concerning the food waste which contains data from 2018. Hence, a comparative analysis of the values from 2018 with the previous years cannot be done.

2.3 Measurement by FAO

FAO manages a food loss and waste database (FLW Database) with some important options in contrast to Eurostat. Firstly, data collected starts with 1945 and it ends with 2017 (Food and Agriculture Organization of the United Nations, 2021a). Even if data is spread for more than 70 years, there is only one record in 1945 (from India regarding the losses in storage of wheat), and the following year with data available is 1961 for 22 countries. Secondly, data is calculated in percentages, and it relates to all world countries which can be individually selected or examined in aggregate form, e.g., there are 10 country groups, such as SDG Region, Least Developed Countries, World Bank Income Groups, etc. (Food and Agriculture Organization of the United Nations, 2021b).

Thirdly, the database contains loss and waste for 146 different types of foods which are grouped in five categories, as follows (Food and Agriculture Organization of the United Nations, 2021a):

- Cereals and pulses;
- Fruits and vegetables;
- Roots, tubers, and oil-bearing crops;
- Meat and animal products;
- Other.

Albeit there is no distinct option in the FLW Database interface to choose between food loss and food waste, the selection can be done by picking the value chain stage where the loss or waste occurred. There are 17 standard value chain stages, i.e., consumer, distribution, export, grading, harvest, market, packaging, pre-harvest, processing, producer, restaurants, retail, stacking, storage, traders, transport, and wholesale, and additional two options, namely, parameter estimate and total supply chain estimate (Food and Agriculture Organization of the United Nations, 2021a).

Fourthly, the FLW Database comprises data collected from 18 methods, for instance, case studies, census, survey, expert opinion, FAO sources, food balance sheet, national statistics yearbook, filed test and trail, etc. (Food and Agriculture Organization of the United Nations, 2021a). This option may represent an advantage if the aim is to obtain data from a unique source. However, it turns into an important disadvantage if all sources are considered, due to the data heterogeneity.

Although the FLW Database offers numerous selection options, it comprises discontinuous time series. For instance, by applying the filters to identify the waste for all 146 types of foods generated by consumers from all world countries between 2010 and 2017, collected by all methods, the output is a file with only 13 records, i.e., 8 records from the United States of America, 3 records from Finland, and one record from Norway and Kazakhstan. The year of food waste data is between 2010 and 2012 in the case of the United States of America, between 2010 and 2014 for Finland, 2014 for Kazakhstan, and 2017 for Norway (Food and Agriculture Organization of the United Nations, 2021a). Considering this state of fact, data provided by FLW Database cannot be analyzed.

Based on the Target 12.3 from 2030 ASD, FAO developed the indicator 12.3.1 (Global Food Loss and Waste) which consist of two sub-indicators, namely, 12.3.1.a—Food Loss Index and 12.3.1.b—Food Waste Index (Food and Agriculture Organization of the United Nations, 2021c).

The Global Food Loss Index (GFLI) and the Regional Food Loss Index (RFLI) are computed on the aggregation of the country-level Food Loss Indices (FLI), by commodity, on annual frequency. GFLI, RFLI, and FLI are measuring the food loss from the production to the retail stage, namely the supply side of the value chain (Food and Agriculture Organization of the United Nations, 2021d, 2021e; Gennari, 2015).

Food Waste Index is covering the food retail, households, and food services sectors, that is the demand side of the value chain. It is calculated distinctly for each of three sectors, by country, at a global level (United Nations Environment Programme, 2021).

In the latest FAO's report on Food Waste Index (United Nations Environment Programme, 2021) and other documents related to GFLI, RFLI, and FLI (Fabi, 2020, Food and Agriculture Organization of the United Nations, 2019c, 2021d, 2021f) there are no data which can be analyzed.

3 Analysis of Food Waste in the European Countries

In this section the food waste for 38 European countries is analyzed between 2010 and 2018 based on data reported every two years by each state. Thus, the term “previous year” used in this chapter means two years behind the year that is analyzed. The time-series data used was collected from Eurostat (2021b) and is limited to year 2018, even if the last table structure change was in February 2021 and the last update of data was in June 2021 (Eurostat, 2021c).

The analysis was conducted for each of the three waste types (animal and mixed food waste, vegetal wastes, and household and similar wastes) but considering one single category of hazardous and non-hazardous waste. The activities that generate waste were grouped by author into two main categories based on the NACE Rev. 2 (Fig. 2), i.e., *households* and *economic activities*. The second category was set up by the author to bound data reported by the countries and to establish the differences between food loss and food waste, and it comprises the following activities:

- Agriculture, forestry, and fishing;
- Mining and quarrying;
- Manufacturing;
- Electricity, gas, steam, and air conditioning supply;
- Water supply; sewerage, waste management, and remediation activities;
- Construction;
- Services (except wholesale of waste and scrap);
- Wholesale of waste and scrap

To ensure the intelligibility of the results, the graph of each food waste category that was analyzed excludes the countries that recorded null values or have not reported any data. But this case was mentioned for each state.

3.1 Analysis of Animal and Mixed Food Waste

3.1.1 Analysis of Animal and Mixed Food Waste Generated by Households

Concerning the animal and mixed food waste generated by households (which can be framed as food waste) in the European countries, in 2010, the highest values were for the Netherlands (76 kg per capita), Italy (42 kg per capita), Luxembourg (39 kg per capita), Norway (35 kg per capita), and Austria (20 kg per capita). By opposite, the lowest values were in the case of Denmark and Belgium (1 kg per capita), Estonia (4 kg per capita), Slovenia and the United Kingdom (5 kg per capita), Iceland (7 kg per capita), and Ireland (11 kg per capita), except the countries that recorded null values or have not reported any data (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, France, Germany, Greece, Hungary, Kosovo, Latvia, Liechtenstein, Lithuania, Malta, Montenegro, North Macedonia, Poland, Portugal, Romania, Serbia, Slovakia, and Turkey). In 2012, the countries with the highest levels were the Netherlands (78 kg per capita), Italy (52 kg per capita), Luxembourg (47 kg per capita), Austria (43 kg per capita), and Norway (35 kg per capita), while the states with the lowest level were Belgium (1 kg per capita), Denmark (3 kg per capita), Estonia (4 kg per capita), Iceland and the United Kingdom (8 kg per capita), and Slovenia (10 kg per capita). The countries that recorded null values or have not reported any data in 2010 were the same in 2012 (Fig. 3).

In 2014, the Netherlands (79 kg per capita), Italy (61 kg per capita), Luxembourg (49 kg per capita), Austria (43 kg per capita), and Finland (41 kg per capita) recorded the highest values, in contrast to Belgium, Bulgaria, Iceland, Serbia, and Slovakia (1 kg per capita), Denmark and Estonia (4 kg per capita), Montenegro and the United Kingdom (7 kg per capita), Ireland and Slovenia Slovakia (10 kg per capita), and Spain (12 kg per capita) that registered the lowest values. The states that recorded null values or have not reported any data in 2012 were the same in 2014 except for Bulgaria, Montenegro, Serbia, and Slovakia.

In 2016, the top 5 countries with the highest and lowest values were slightly different as compared to 2014, namely, the Netherlands (82 kg per capita), Italy (74 kg per capita), Finland (48 kg per capita), Austria (44 kg per capita), and Norway (36 kg per capita) for the first category, and Belgium, Croatia, Czechia, Hungary, Iceland, and Serbia (1 kg per capita), Bulgaria (2 kg per capita), Estonia (4 kg per capita), Malta and Slovakia (5 kg per capita), and Denmark and the United Kingdom (9 kg per capita) for the second category. The countries that recorded null values or have not reported any data in 2014 were the same in 2016 except for Croatia, Czechia, Hungary, and Malta. Finally, in 2018, the Netherlands (86 kg per capita),

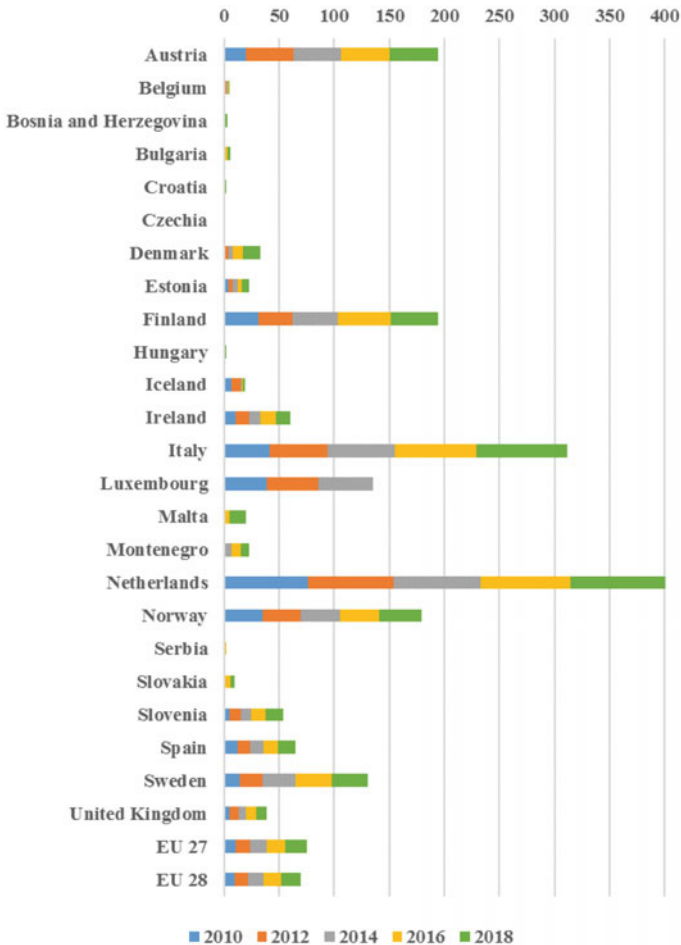


Fig. 3 Animal and mixed food waste generated by households in the European countries between 2010 and 2018 (kilograms per capita) (Source Author’s development based on Eurostat [2021b])

Italy (83 kg per capita), Austria (44 kg per capita), Finland (43 kg per capita), and Norway (38 kg per capita) recorded the highest level. On the contrary, Belgium, Croatia, and Hungary (1 kg per capita), Iceland (2 kg per capita), Bulgaria, Bosnia and Herzegovina (3 kg per capita), Slovakia (4 kg per capita), and Estonia (7 kg per capita) registered the lowest level. Czechia, Luxembourg, and Serbia recorded null values in contrast to 2016, whereas Bosnia and Herzegovina reported the data in 2018 for the first time.

The analysis of the evolution of the animal and mixed food waste generated by households in the European countries, between 2010 and 2018, underscores a different country ranking. Thus, in 2012 in contrast to 2010, the highest increases were in the case of Denmark (+200%), Austria (+115%), Slovenia (+100%), the

United Kingdom (+60%), and Sweden (+50%) and, by contrast, the lowest increases were for the Netherlands (+2.63%), Ireland (+9.09%), Iceland (+14.29%), Luxembourg (+20.51%), and Italy (+23.81%). There were no states that recorded decreases and Albania, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Estonia, Finland, France, Germany, Greece, Hungary, Kosovo, Latvia, Liechtenstein, Lithuania, Malta, Montenegro, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Spain, and Turkey maintained a constant level of their waste. In 2014 against 2012, there were only six increases, i.e., the highest rises were for Sweden (+42.86%), Denmark (+33.33%), and Finland (+32.26%), and the lowest increases were for the Netherlands (+1.28%), Luxembourg (+4.26%), and Italy (+17.31%). It is the first year when the quantity of the animal and mixed food waste generated by households declined, in the case of Iceland (−87.50%), Ireland (−16.67%), and the United Kingdom (−12.5%). Albania, Austria, Belgium, Bosnia and Herzegovina, Croatia, Cyprus, Czechia, Estonia, France, Germany, Greece, Hungary, Kosovo, Latvia, Liechtenstein, Lithuania, Malta, North Macedonia, Norway, Poland, Portugal, Romania, Slovenia, Spain, and Turkey recorded the same level.

In 2016 as compared to 2014, the highest growths were achieved by Slovakia (+400%), Denmark (+125%), Bulgaria (+100%), Ireland (+40%), and Slovenia (+30%), and the lowest increases were recorded by Austria (+2.33%), Norway (+2.86%), the Netherlands (+3.8%), Spain (+8.33%), and Sweden (+10%). In particular, Luxembourg was the only state with a reduction of food waste (−100%), and Albania, Belgium, Bosnia and Herzegovina, Cyprus, Estonia, France, Germany, Greece, Iceland, Kosovo, Latvia, Liechtenstein, Lithuania, North Macedonia, Poland, Portugal, Romania, Serbia, and Turkey registered a constant level of waste. In 2018 against 2016, Malta (+200%), Iceland (+100%), Denmark (+77.78%), Estonia (+75%), and Bulgaria (+50%) registered the highest increase and the Netherlands (+4.88%), Norway (+5.56%), Italy (+12.16%), the United Kingdom (+11.11%), and Slovenia and Spain (+23.08%) recorded the lowest rise. Czechia (+100%), Serbia (−100%), Slovakia (+20%), Finland (−10.42%), and Ireland (−7.14%) registered declines. Albania, Austria, Belgium, Croatia, Cyprus, Hungary, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Montenegro, North Macedonia, Poland, Portugal, Romania, Sweden, and Turkey generated a similar level of waste.

The analysis highlights that 2 (Austria and Finland) out of 38 countries recorded both the highest level of waste and significant increase as compared to previous year, 5 (Austria, Italy, Luxembourg, the Netherlands, and Norway) out of 38 countries recorded both the highest level of waste and irrelevant rise as compared to previous year, 2 (Finland and Luxembourg) out of 38 countries recorded both the highest level of waste and decline against previous year, 9 (Bulgaria, Denmark, Estonia, Iceland, Ireland, Malta, Slovakia, Slovenia, and the United Kingdom) out of 38 countries recorded both the lowest level of waste and a major increase versus previous year, 5 (Iceland, Ireland, Slovenia, Spain, and the United Kingdom) out of 38 countries recorded both the lowest level of waste and insignificant rise as opposed to previous

year, and 5 (Czechia, Iceland, Ireland, Serbia, and Slovakia) out of 38 countries recorded both the lowest level of waste and decrease as compared to the previous year.

3.1.2 Analysis of Animal and Mixed Food Waste Generated by Economic Activities

As regards the animal and mixed food waste generated by economic activities (which can be enclosed as food loss), firstly, in 2010, the highest levels were for Liechtenstein (533 kg per capita), Ireland (354 kg per capita), Iceland (307 kg per capita), Norway (125 kg per capita), and Belgium (108 kg per capita). North Macedonia and Turkey (1 kg per capita), Serbia (3 kg per capita), Bulgaria (4 kg per capita), Romania (6 kg per capita), and Czechia (7 kg per capita) recorded the lowest level. Albania, Bosnia and Herzegovina, Kosovo, and Montenegro recorded null values or have not reported any data. In 2012, the highest level was reached by Iceland (380 kg per capita), Ireland (193 kg per capita), Norway (116 kg per capita), Belgium and Finland (103 kg per capita), and France (63 kg per capita). On the contrary, the following cases can be highlighted with the lowest level: Turkey (1 kg per capita), Serbia (3 kg per capita), Bulgaria (4 kg per capita), Romania (6 kg per capita), and Czechia (7 kg per capita). Albania and North Macedonia recorded null values or have not reported any data (Fig. 4).

In 2014, Belgium (96 kg per capita), Ireland (73 kg per capita), Finland (70 kg per capita), Liechtenstein (65 kg per capita), and France (61 kg per capita) were the countries with the highest level. Conversely, North Macedonia (1 kg per capita), Serbia and Turkey (2 kg per capita), Italy (5 kg per capita), Czechia, Portugal, Romania (7 kg per capita), and Croatia and Hungary (8 kg per capita) recorded the lowest level. Albania and Kosovo recorded null values or have not reported any data. In 2016, the highest levels were for Ireland (183 kg per capita), Belgium (105 kg per capita), Luxembourg (83 kg per capita), Liechtenstein (77 kg per capita), and Finland (73 kg per capita), while, by contrast, the lowest levels were for Turkey (1 kg per capita), North Macedonia and Serbia (2 kg per capita), Montenegro (4 kg per capita), Italy (6 kg per capita), and Czechia (7 kg per capita).

In 2018, Ireland (187 kg per capita), Belgium (108 kg per capita), Liechtenstein (97 kg per capita), Iceland (83 kg per capita), and Luxembourg (78 kg per capita) recorded the highest levels, and Turkey (2 kg per capita), Bosnia and Herzegovina (3 kg per capita), Serbia (4 kg per capita), Bulgaria and North Macedonia (6 kg per capita), and Italy (7 kg per capita) reported the lowest levels. In both 2016 and 2018, Albania has not reported any data.

Secondly, the evolution of the animal and mixed food waste generated by economic activities emphasized that, in 2012 against 2010, Bulgaria (+275%), France (+90.91%), Finland (+33.77%), Iceland (+23.78%), Sweden (+22%), and Lithuania (+19.35%) recorded the highest rises, and Slovakia (+11.11%), Slovenia (+18.52%), and Malta (+12.5%) registered the lowest increases. The highest declines were in the case of North Macedonia (−100%), Estonia (−92.86%), Liechtenstein

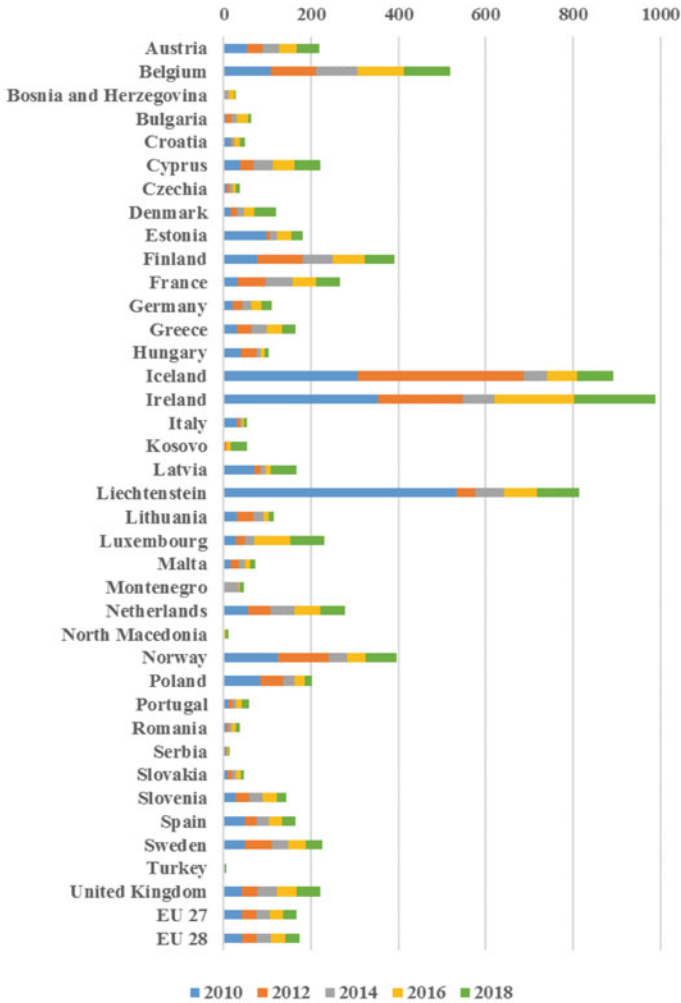


Fig. 4 Animal and mixed food waste generated by economic activities in the European countries between 2010 and 2018 (kilograms per capita) (Source Author’s development based on Eurostat [2021b])

(−91.93%), Italy (−83.87%), and Croatia (−80%), and the lowest falls were for the Netherlands (−1.82%), Denmark (−6.25%), Norway (−7.2%), Portugal (−9.09%), and Hungary (−10%). Albania, Czechia, Germany, Greece, Montenegro, Romania, Serbia, and Turkey maintained a constant level of their waste. In 2014 versus 2012, the following cases with the highest increases can be highlighted: Bosnia and Herzegovina (+400%), Croatia (+166.67%), Estonia (+157.14%), Turkey (+100%), and Liechtenstein (+54.16%). The lowest growths were for Sweden (+3.85%), Germany (+4.76%), Luxembourg (+5%), Austria (+5.71%), and Denmark (+6.67%). On

the contrary, Kosovo (−100%), Iceland (−86.05%), Hungary (−77.78%), Norway (−63.79%), and Ireland (−62.18%) recorded the highest diminutions, whereas France (−3.17%), Slovenia (−6.25%), Belgium (−6.8%), Slovakia (−10%), and Malta (−11.11%) registered the lowest decreases. Albania, Czechia, Italy, Latvia, and the Netherlands reported the same level.

In 2016 as compared to 2014, the highest increases were for Luxembourg (+295.24%), Ireland (+150.68%), Bulgaria (+145.45%), North Macedonia (+100%), and Portugal (+85.71%), and the lowest boosts were for the United Kingdom (+2.27%), Sweden (+2.63%), Finland (+4.29%), Germany (+4.55%), and Slovenia (+6.67%). Montenegro (−88.24%), Turkey (−50%), Lithuania (−47.83%), Malta (−31.25%), and Latvia (−23.08%) recorded the highest reductions, and Greece (−5.41%), Poland (−7.69%), and France (−11.48%) registered the lowest declines. Albania, Czechia, Norway, and Serbia recorded the same level of waste. In 2018 as opposed to 2016, the following countries with the highest rises can be underlined: Latvia (+490%), Kosovo (+227.27%), North Macedonia (+200%), Denmark (+117.39%), and Montenegro, Serbia, and Turkey (+100%). The lowest increases were in the case of Ireland (+2.19%), Belgium (+2.86%), France (+3.7%), Lithuania (+8.33%), and Malta (+9.09%). Bulgaria (−77.78%), Bosnia and Herzegovina (−76.92%), Slovakia (−41.67%), Poland (−33.33%), and Slovenia (−28.13%) recorded the highest cuts, and Finland (−5.48%), Luxembourg (6.02%), Spain (−6.25%), the Netherlands (−6.78%), and Greece (−11.43%) registered the lowest falls. Albania, Croatia, Germany, and Sweden supplied a similar level of waste.

The analysis underlined the following cases: 6 (Finland, France, Iceland, Ireland, Liechtenstein, and Luxembourg) out of 38 countries registered both the highest level of waste and important increase as compared to previous year, 4 (Belgium, Finland, France, and Ireland) out of 38 countries recorded both the highest level of waste and minor rise as compared to previous year, 4 (Iceland, Ireland, Liechtenstein, and Norway) out of 38 countries recorded both the highest level of waste and significant decline as against previous year, 8 (Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, North Macedonia, Portugal, Serbia, and Turkey) out of 38 countries recorded both the lowest level of waste and a significant increase versus previous year, and 9 (Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Italy, Kosovo, Montenegro, North Macedonia, and Turkey) out of 38 countries recorded both the lowest level of waste and a major decrease as opposed to previous year. There were no countries which recorded both the lowest level of waste and slight increase as opposed to previous year.

3.2 *Analysis of Vegetal Wastes*

3.2.1 **Analysis of Vegetal Waste Generated by Households**

Relating to the vegetal waste generated by households (which can be framed as food waste) in the European countries, in 2010, Belgium (109 kg per capita), Germany

(104 kg per capita), Luxembourg (95 kg per capita), Denmark (89 kg per capita), and the United Kingdom (63 kg per capita) recorded the highest values. Conversely, Romania (1 kg per capita), Poland (2 kg per capita), Estonia and Latvia (3 kg per capita), Hungary (10 kg per capita), and Malta (11 kg per capita) registered the lowest values. Countries such as Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Kosovo, Finland, Greece, Liechtenstein, Lithuania, Montenegro, North Macedonia, Portugal, Serbia, Spain, and Turkey recorded null values or have not reported any data. In 2012, the top 5 states with the highest levels were Germany (113 kg per capita), Denmark (105 kg per capita), Belgium (98 kg per capita), Luxembourg (95 kg per capita), and Austria (62 kg per capita), while the top 5 countries with the lowest level were Lithuania, Romania, and Turkey (1 kg per capita), Poland (3 kg per capita), Croatia and Cyprus (8 kg per capita), Malta (11 kg per capita), and Ireland (16 kg per capita). At the same time, Albania, Bosnia and Herzegovina, Bulgaria, Kosovo, Finland, Greece, Hungary, Liechtenstein, Montenegro, North Macedonia, Portugal, Serbia, and Spain recorded null values or have not reported any data in 2012 (Fig. 5).

In 2014, Liechtenstein (197 kg per capita), Germany (119 kg per capita), Denmark (112 kg per capita), Belgium (85 kg per capita), and Luxembourg (80 kg per capita) recorded the highest values, as opposed to Romania (1 kg per capita), Bulgaria, Estonia, and Lithuania (4 kg per capita), Latvia (8 kg per capita), Croatia (9 kg per capita), and Serbia (11 kg per capita) which registered the lowest values. The null values and no reported data were in the following cases: Albania, Bosnia and Herzegovina, Kosovo, Finland, Greece, Hungary, Portugal, Spain, and Turkey. In 2016, the highest values were for Liechtenstein (178 kg per capita), Germany (121 kg per capita), Denmark (110 kg per capita), Austria (72 kg per capita), and Belgium (70 kg per capita), and the lowest values were for Romania (2 kg per capita), Estonia (4 kg per capita), Croatia, Malta, and Serbia (5 kg per capita), Luxembourg (8 kg per capita), and Ireland (15 kg per capita). Albania, Bosnia and Herzegovina, Kosovo, Finland, Hungary, Latvia, Portugal, Spain, and Turkey recorded null values or have not reported any data.

In 2018, Liechtenstein (165 kg per capita), Germany and Denmark (118 kg per capita), Austria (74 kg per capita), Belgium (67 kg per capita), and France and the United Kingdom (61 kg per capita) recorded the highest values. By contrast, Serbia (1 kg per capita), Romania (4 kg per capita), Bosnia and Herzegovina, Latvia, and Malta (5 kg per capita), Croatia, Greece, and Spain (6 kg per capita), and Bulgaria and Estonia (9 kg per capita) registered the lowest values. The null values and no reported data were in the case of Albania, Kosovo, Hungary, and Turkey.

Secondly, the evolution of the vegetal waste generated by households highlighted that, in 2012 against 2010, Latvia (+1,000%), Estonia (+166.67%), Austria (+77.14%), Slovenia (+60%), and Poland (+50%) recorded the highest increases, while Norway (+3.03%), the Netherlands (+3.7%), Slovakia (+5.88%), the United Kingdom (+6.35%), and Germany (+8.65%) registered the lowest growths. The only decreases were in the case of Hungary (-100%), Luxembourg (-18.95%), Austria (-10.09%), and Sweden (-3.03%). Albania, Bosnia and Herzegovina, Bulgaria, Finland, Greece, Ireland, Italy, Kosovo, Liechtenstein, Malta, Montenegro, North

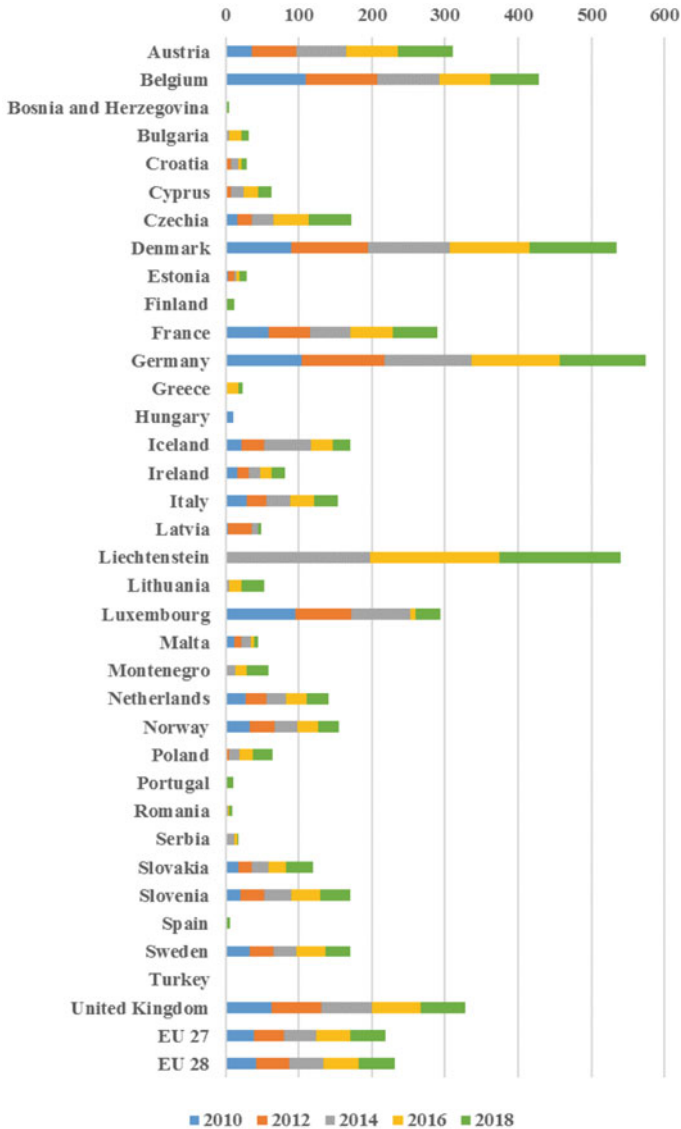


Fig. 5 Vegetal waste generated by households in the European countries between 2010 and 2018 (kilograms per capita) (Source Author’s development based on Eurostat [2021b])

Macedonia, Portugal, Romania, Serbia, and Spain maintained a constant level of their waste. In 2014 as compared to 2012, highest increases were for Poland (+333.33%), Lithuania (+300%), Cyprus (+112.5%), Iceland (+106.45%), and Czechia (+50%), and the lowest rises were for Luxembourg (+3.9%), the United Kingdom (+4.48%), Germany (+5.31%), Denmark (+6.67%), and Austria (+8.06%). There were only

seven declines in the case of Turkey (−100%), Latvia (−75.76%), Estonia (−50%), Belgium (−13.27%), Norway (−8.82%), Ireland (−6.25%), and France (−1.75%). Albania, Bosnia and Herzegovina, Finland, Greece, Hungary, Kosovo, the Netherlands, North Macedonia, Portugal, Romania, Spain, and Sweden have not changed their level of waste.

In 2016 as opposed to 2014, the following cases with the highest growths can be underscored: Bulgaria (+350%), Lithuania (+300%), Romania (+100%), Czechia (+56.67%), and Poland (+46.15%). Germany (+1.68%), France (+1.79%), Italy (+3.13%), Slovakia (+4.35%), and Austria (+7.46%) recorded the lowest increases. The highest falls were for Latvia (−100%), Luxembourg (−90%), Malta (−58.33%), Iceland (−54.69%), and Serbia (−54.55%). There were no differences among the levels from 2016 versus 2014 in the case of Albania, Bosnia and Herzegovina, Estonia, Finland, Hungary, Kosovo, Ireland, the Netherlands, North Macedonia, Portugal, Spain, and Turkey. In 2018 in contrast to 2016, Luxembourg (+312%), Estonia (+125%), Lithuania and Romania (+100%), Montenegro (+81.25%), and Slovakia (+54.17%) recorded the highest expansions and Slovenia (+2.5%), Austria (+2.78%), the Netherlands (+3.57%), France (+7.02%), and Denmark (+7.27%) registered the lowest increases. Conversely, Serbia (−80%), Greece (−64.71%), Bulgaria (−50%), Iceland (−13.79%), and Sweden (−12.82%) recorded the highest declines. The following states maintained constant their level: Albania, Cyprus, Hungary, Kosovo, Italy, Malta, North Macedonia, and Turkey.

The analysis underscored that one (Luxembourg) out of 38 countries recorded both the highest level of waste and significant increase as compared to previous year, 6 (Austria, Denmark, France, Germany, Luxembourg, and the United Kingdom) out of 38 countries recorded both the highest level of waste and irrelevant rise as compared to previous year, 7 (Belgium, Denmark, France, Germany, Liechtenstein, Luxembourg, and the United Kingdom) out of 38 countries recorded both the highest level of waste and decline against previous year, 8 (Bulgaria, Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Poland, and Romania) out of 38 countries recorded both the lowest level of waste and a major increase versus previous year, one (Luxembourg) out of 38 countries recorded both the lowest level of waste and insignificant rise as opposed to previous year, and 11 (Bulgaria, Croatia, Estonia, Greece, Hungary, Ireland, Latvia, Luxembourg, Malta, Serbia, and Turkey) out of 38 countries recorded both the lowest level of waste and decrease as compared to previous year.

3.2.2 Analysis of Vegetal Waste Generated by Economic Activities

As for to the vegetal waste generated by economic activities (which can be enclosed as food loss), in 2010, the higher levels were in the case of the Netherlands (523 kg per capita), Belgium (216 kg per capita), Lithuania (95 kg per capita), Denmark (69 kg per capita), and Cyprus (68 kg per capita), and the lowest levels were for Iceland (2 kg per capita), Turkey (5 kg per capita), Latvia and Malta (6 kg per capita), Greece (8 kg per capita), and North Macedonia (9 kg per capita). Albania, Bosnia and Herzegovina, Kosovo, Montenegro, and Norway recorded null values or have

not reported any data. In 2012, the Netherlands (517 kg per capita), Belgium (234 kg per capita), Lithuania (118 kg per capita), Austria (77 kg per capita), and Bulgaria (70 kg per capita) reported the highest levels, and Montenegro (1 kg per capita), Iceland and North Macedonia (3 kg per capita), Bosnia and Herzegovina (5 kg per capita), Croatia (6 kg per capita), and Kosovo, Malta, Norway, and Portugal (7 kg per capita) registered the lowest levels (Fig. 6).

In 2014, the following states with the highest level can be underlined: the Netherlands (503 kg per capita), Belgium (320 kg per capita), Lithuania (148 kg per capita), Finland (72 kg per capita), and Austria (67 kg per capita). At the opposite end, Kosovo (1 kg per capita), North Macedonia (2 kg per capita), Liechtenstein (5 kg per capita), Bosnia and Herzegovina, Iceland, and Turkey (6 kg per capita), and Malta and Norway (7 kg per capita) recorded the lowest levels. In 2016, the Netherlands (496 kg per capita), Belgium (407 kg per capita), Kosovo (122 kg per capita), Luxembourg (118 kg per capita), and Lithuania (113 kg per capita) registered the highest levels, and North Macedonia (1 kg per capita), Iceland (3 kg per capita), Turkey (5 kg per capita), Norway (6 kg per capita), and Bosnia and Herzegovina, Portugal, and Serbia (7 kg per capita) recorded the lowest levels.

In 2018, the highest levels were for Belgium (590 kg per capita), the Netherlands (516 kg per capita), Luxembourg (101 kg per capita), Kosovo (100 kg per capita), and Austria (83 kg per capita), and in the case of the lowest levels were Bosnia and Herzegovina (1 kg per capita), Iceland (2 kg per capita), North Macedonia (3 kg per capita), Liechtenstein (4 kg per capita), and Malta, Norway, and Serbia (6 kg per capita). Albania was the only country that has not reported any data between 2012 and 2018.

Secondly, the evolution of the vegetal waste generated by economic activities underlined that, in 2012 compared to 2010, Bulgaria (+125.81%), Hungary and Latvia (+100%), Turkey (+60%), Austria (+50.98%), and Iceland (+50%) recorded the highest rises, and Germany (+9.09%), Belgium (+12.5%), Slovenia (+3.33%), Malta (+16.67%), and Lithuania (+24.21%) registered the lowest growths. On the contrary, the highest diminutions occurred in the case of Estonia (-83.02%), Italy (-80.77%), Cyprus (-76.47%), North Macedonia (-66.67%), and Denmark (-56.52%). In 2014 against 2012, the highest increases were for Montenegro (+1,600%), Croatia (+200%), Latvia (+166.67%), Estonia (+122.22%), and Iceland (+100%), and the lowest rises were for France (+2.08%), Romania (+9.76%), Sweden (+18.52%), Bosnia and Herzegovina (+20%), and Germany (+20.83%). Kosovo (-85.71%), Liechtenstein (-82.14%), Poland (-45.31%), Bulgaria (-41.43%), and North Macedonia (-33.33%) recorded the highest drops.

In 2016 in contrast to 2014, the highest boosts were in the case of Kosovo (+12,100%), Luxembourg (+461%), Greece (+137.5%), Montenegro (+305.88%), and Latvia (+96.88%), and the lowest increases were for Denmark (+2.08%), France (+6.12%), the United Kingdom (+6.45%), Cyprus and Italy (+7.14%), and Hungary (+8.7%). Iceland, North Macedonia, and Serbia (-50%), Slovenia (-37.5%), Malta (-28.57%), Romania (-26.67%), and Bulgaria (-24.39%) registered the highest falls. In 2018 as opposed to 2016, North Macedonia (+200%), Turkey (+80%), Czechia (+72.22%), Belgium (+44.96%), and Hungary (+36%)

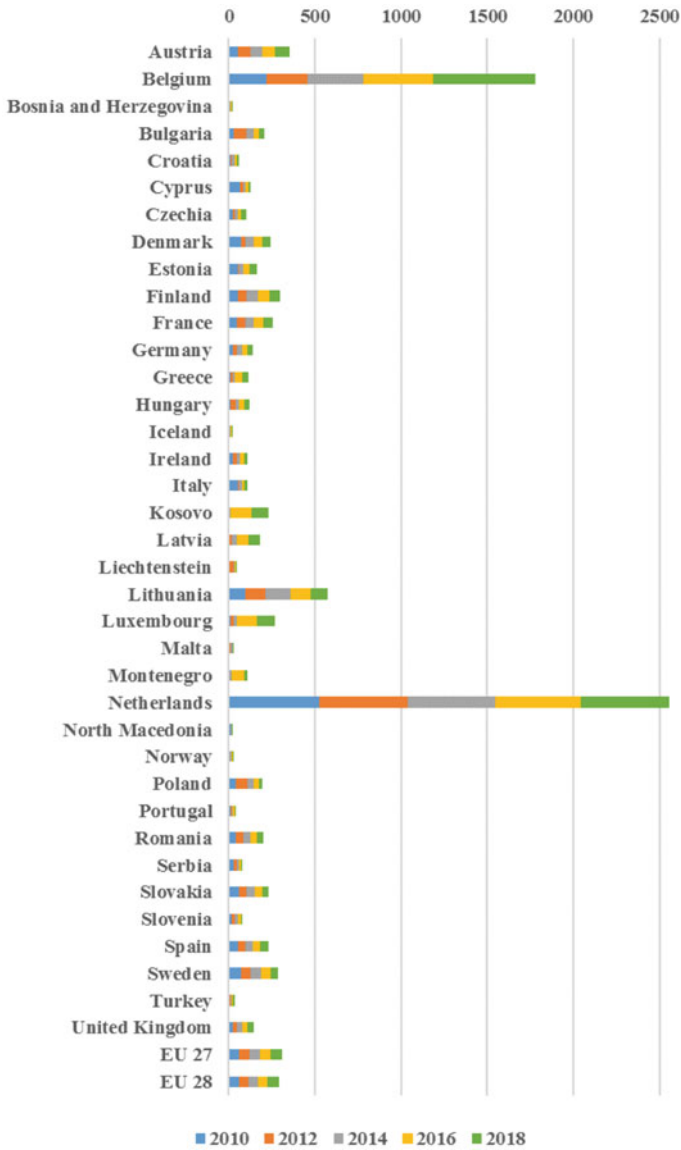


Fig. 6 Vegetal waste generated by economic activities in the European countries between 2010 and 2018 (kilograms per capita) (*Source* Author’s development based on Eurostat [2021b])

recorded the highest increase, and Greece (+2.63%), the United Kingdom (+3.03%), France (+5.77%), Italy (+6.67%), and Bulgaria (+9.68%) registered the lowest expansions. At the opposite end, the following cases with the highest reductions can be emphasized: Bosnia and Herzegovina (−85.71%), Montenegro (−68.12%), Liechtenstein (−55.56%), Ireland (−40.74%), and Slovenia (−40%). Albania (2012/2010, 2014/2012, 2016/2014, and 2018/2016), Malta (2014/2012), Norway (2014/2012 and 2018/2016), and Finland (2018/2016) maintained a constant level of their waste.

The analysis emphasized the following: 5 (Austria, Belgium, Bulgaria, Kosovo, and Luxembourg) out of 38 countries registered both the highest level of waste and important boost as compared to previous year, 5 (Belgium, Bulgaria, Cyprus, Denmark, and Lithuania) out of 38 countries recorded both the highest level of waste and minor increase as compared to previous year, 4 (Bulgaria, Cyprus, Denmark, and Kosovo) out of 38 countries recorded both the highest level of waste and significant fall as against previous year, 8 (Croatia, Greece, Iceland, Kosovo, Latvia, Montenegro, North Macedonia, and Turkey) out of 38 countries recorded both the lowest level of waste and a significant increase versus previous year, 8 (Bosnia and Herzegovina, Iceland, Kosovo, Liechtenstein, Malta, Montenegro, North Macedonia, and Serbia) out of 38 countries recorded both the lowest level of waste and a major fall as opposed to previous year, and 3 (Bosnia and Herzegovina, Greece, and Malta) out of 38 countries recorded both the lowest level of waste and slight increase as opposed to previous year.

3.3 Analysis of Household and Similar Wastes

With respect to the household and similar wastes, Eurostat (2021b) reported data every two years between 2004 and 2018. To ensure data comparison with animal and mixed food waste and vegetal waste, the analysis will be conducted for the same period of time that was used for these two types of waste, i.e., 2010–2018.

3.3.1 Analysis of Household and Similar Wastes Generated by Households

In the case of household and similar wastes generated by households (which can be framed as food waste), in 2010, Portugal (470 kg per capita), Greece and Spain (413 kg per capita), Turkey (412 kg per capita), Italy (361 kg per capita), and Denmark (334 kg per capita) recorded the highest levels, and Cyprus (2 kg per capita), Estonia (122 kg per capita), Belgium (147 kg per capita), Finland (160 kg per capita), and Iceland (165 kg per capita) registered the lowest levels. Albania, Bosnia and Herzegovina, Croatia, Kosovo, Liechtenstein, Montenegro, and Serbia recorded null values or have not reported any data. In 2012, the highest levels were in the case of Portugal (413 kg per capita), Turkey (406 kg per capita), Spain (380 kg per capita), Cyprus (378 kg per capita), and Greece (377 kg per capita). By contrast,

the countries with the lowest levels were Liechtenstein (84 kg per capita), Estonia (128 kg per capita), Belgium (132 kg per capita), Slovenia (174 kg per capita), and Finland (178 kg per capita). The following states recorded null values or have not reported any data: Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia (Fig. 7).

In 2014, Albania (425 kg per capita), Portugal (410 kg per capita), Turkey (394 kg per capita), Spain (365 kg per capita), and Greece (363 kg per capita) recorded the highest levels, and Slovenia (134 kg per capita), Finland (138 kg per capita), Estonia (153 kg per capita), Belgium (170 kg per capita), and Sweden (173 kg per capita) registered the lowest levels. There are only two states that recorded null values or have not reported any data, namely, Bosnia and Herzegovina and North Macedonia. In 2016, the top 5 countries with the highest levels included Portugal (427 kg per capita), Cyprus (404 kg per capita), Spain (388 kg per capita), Greece (381 kg per capita), and Turkey (334 kg per capita). Conversely, the states with the lowest levels were Slovenia (128 kg per capita), Estonia (147 kg per capita), Finland (162 kg per capita), Belgium (163 kg per capita), and Kosovo (170 kg per capita). Albania, Bosnia and Herzegovina, and North Macedonia recorded null values or have not reported any data.

In 2018, Portugal (435 kg per capita), Spain (391 kg per capita), Cyprus (384 kg per capita), Greece (381 kg per capita), and Montenegro (359 kg per capita) recorded the highest level, while Slovenia (129 kg per capita), Estonia (151 kg per capita), Belgium (158 kg per capita), Latvia (175 kg per capita), and Norway (174 kg per capita) registered the lowest levels. There are only two states that recorded null values or have not reported any data, i.e., Albania and North Macedonia.

Secondly, the evolution of the household and similar wastes generated by households showed that, in 2012 against 2010, Cyprus (+18,800%), Latvia (+60.96%), Norway (+16%), Finland (+11.25%), and Austria (+8.89%) recorded the highest rises, and Denmark (+0.6%), Turkey (+1%), Poland (+3.64%), Sweden (+4.78%), and Estonia (+4.92%) registered the lowest growths. The highest declines were in the case of North Macedonia (-100%), Slovenia (-29.55%), Bulgaria (-19.14%), Malta (-16.19%), and Romania (-15.45%). Albania, Bosnia and Herzegovina, Montenegro, and Serbia generated a similar level of waste. In 2014 as compared to 2012, there were only 8 states that recorded increases, Liechtenstein (+173.81%), Iceland (+98.03%), Belgium (+28.79%), Estonia (+19.53%), and Hungary (+18.18%) registered the highest increases and Austria (+0.51%), Slovakia (+1.18%), and Bulgaria (+4.58%) recorded the lowest boosts. The highest falls were for Latvia (-30.9%), Sweden (-28.22%), Slovenia (-22.99%), Finland (-22.47%), and Poland (-20.61%).

In 2016 versus 2014, the following cases with the highest increases can be underscored, namely Luxembourg (+25.89%), Montenegro (+25.61%), Cyprus (+25.08%), Finland (+17.39%), and Latvia (+16.35%), which come into contrast with the lowest increases in the United Kingdom (+0.44%), Slovakia (+0.78%), Romania (+1.14%), Serbia (+1.43%), and Sweden (+2.89%). At the opposite end, the highest drops were for Albania (-100%), Kosovo (-37.04%), Bulgaria (-17.15%), Turkey (-15.23%), and Lithuania (-9.38%). Bosnia and Herzegovina and North

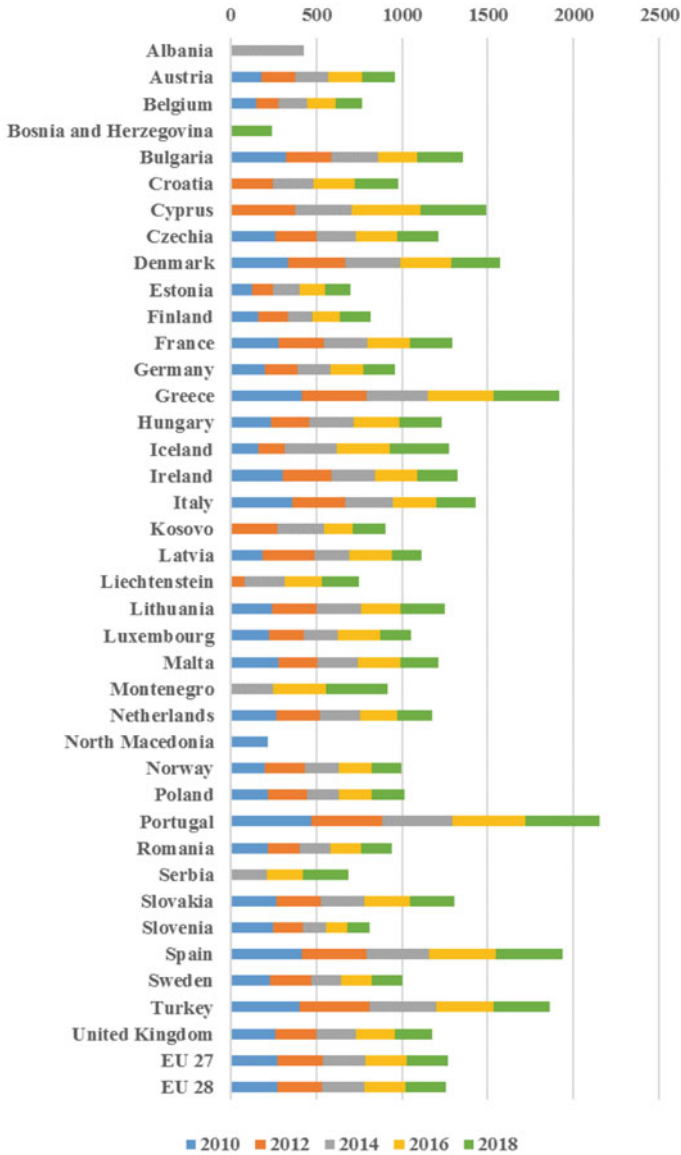


Fig. 7 Household and similar wastes generated by households in the European countries between 2010 and 2018 (kilograms per capita) (Source Author's development based on Eurostat [2021b])

Macedonia maintained a constant level of waste in 2016 and 2014 as compared to previous years. In 2018 in contrast to 2016, Serbia (+24.41%), Bulgaria (+18.06%), Montenegro (+16.18%), Finland (+11.73%), and Lithuania (+11.21%) recorded the highest booms, whereas Spain (+0.77%), Slovenia (+0.78%), Austria (+1.04%), Sweden (+1.69%), and Portugal (+1.87%) registered the lowest rises. The highest declines occurred in the case of Luxembourg (−29.03%), Latvia (−27.69%), Norway (−9.84%), Italy (−9.09%), and Malta (−8.57%). Albania and North Macedonia provided a similar level of waste.

The analysis underlined that 2 (Cyprus and Montenegro) out of 38 countries recorded both the highest level of waste and major boost as compared to previous year, 6 (Austria, Denmark, France, Germany, Luxembourg, and the United Kingdom) out of 38 countries recorded both the highest level of waste and minor increase as compared to previous year, 3 (Albania, Italy, and Turkey) out of 38 countries recorded both the highest level of waste and decline against previous year, 8 (Belgium, Cyprus, Estonia, Finland, Iceland, Latvia, Liechtenstein, and Norway) out of 38 countries recorded both the lowest level of waste and a significant increase versus previous year, 3 (Estonia, Slovenia, and Sweden) out of 38 countries recorded both the lowest level of waste and minor increase as opposed to previous year, and 6 (Finland, Kosovo, Latvia, Norway, Slovenia, and Sweden) out of 38 countries recorded both the lowest level of waste and decline as compared to the previous year.

3.3.2 Analysis of Household and Similar Wastes Generated by Economic Activities

As regards the household and similar wastes generated by economic activities (which can be enclosed as food loss), in 2010, the higher levels were for Ireland (413 kg per capita), Croatia (353 kg per capita), Austria (258 kg per capita), Malta (248 kg per capita), and the United Kingdom (235 kg per capita), while the lowest levels were for North Macedonia, Norway, and Turkey (2 kg per capita), Serbia (3 kg per capita), Poland (7 kg per capita), Portugal (10 kg per capita), and Greece (16 kg per capita). Albania, Bosnia and Herzegovina, Italy, Kosovo, Montenegro, and Slovakia recorded null values or have not reported any data (Fig. 8). In 2012, Malta (257 kg per capita), Belgium (212 kg per capita), the United Kingdom (204 kg per capita), Luxembourg (184 kg per capita), and the Netherlands (176 kg per capita) recorded the highest levels, and states such as North Macedonia (1 kg per capita), Montenegro (2 kg per capita), Poland (3 kg per capita), Bosnia and Herzegovina (4 kg per capita), and Turkey (5 kg per capita) recorded the lowest levels. The countries that recorded null values or have not reported any data were Albania, Italy, Norway, and Slovakia.

In 2014, the following cases with the highest levels can be highlighted: Bosnia and Herzegovina (315 kg per capita), Malta (244 kg per capita), the United Kingdom (203 kg per capita), Belgium (197 kg per capita), and Luxembourg (185 kg per capita). By contrast, Italy (1 kg per capita), North Macedonia (2 kg per capita), Turkey (6 kg per capita), Greece (12 kg per capita), and Serbia (15 kg per capita) registered the lowest levels. In 2016, Bosnia and Herzegovina (328 kg per capita),

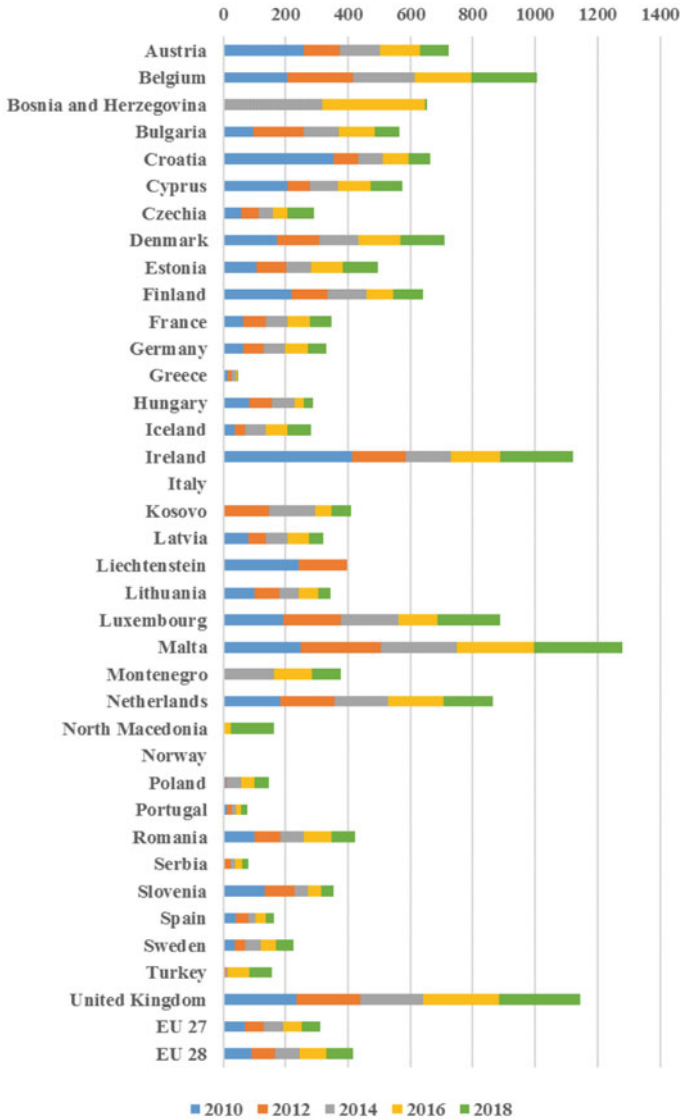


Fig. 8 Household and similar wastes generated by economic activities in the European countries between 2010 and 2018 (kilograms per capita) (Source Author’s development based on Eurostat [2021b])

Malta (246 kg per capita), the United Kingdom (243 kg per capita), Belgium (180 kg per capita), and the Netherlands (178 kg per capita) recorded the highest levels. The lowest levels were in the case of Italy (1 kg per capita), Greece (2 kg per capita), Portugal (15 kg per capita), North Macedonia (20 kg per capita), and Serbia (22 kg per capita).

In 2018, the highest levels were for Malta (283 kg per capita), the United Kingdom (261 kg per capita), Ireland (235 kg per capita), Belgium (211 kg per capita), and Luxembourg (198 kg per capita), and the lowest levels were for Italy (2 kg per capita), Greece (4 kg per capita), Bosnia and Herzegovina (8 kg per capita), Portugal and Serbia (21 kg per capita), and Spain (26 kg per capita). Nonetheless, Albania, Liechtenstein, Norway, Slovakia recorded null values or have not reported any data in 2014, 2016, and 2018.

Secondly, the evolution of the household and similar wastes generated by economic activities underlined that, in 2012 as compared to 2010, there were only 8 states that recorded increases, the highest occurred in the case of Serbia (+600%), Turkey (+150%), Bulgaria (+70.83%), Portugal (+70%), and France (+12.5%), whereas the lowest were registered by Belgium (+3.41%), Malta (+3.63%), and Germany (+4.69%). The highest declines were reported by Norway (-100%), Croatia (-77.05%), Cyprus (-64.56%), Ireland (-58.11%), and Poland (-57.14%). In 2014 against 2012, Montenegro (+8,000%), Bosnia and Herzegovina (+7,775%), Poland (+1,466.67%), North Macedonia (+100%), and Iceland (+94.12%) recorded the highest rises, while Luxembourg (+0.54%), Kosovo (+0.68%), Hungary (+2.78%), Germany (+2.99%), and Finland (+6.9%) registered the lowest boosts. The highest falls were for Liechtenstein (-100%), Slovenia (-59.18%), Spain (-33.33%), Bulgaria (-32.93%), and Lithuania (-21.52%).

In 2016 in contrast to 2014, the highest growths were in the case of Turkey (+1,100%), North Macedonia (+900%), Serbia (+46.67%), Estonia (+30%), and Cyprus (+20.45%), and the lowest increases were for Malta (+0.82%), Germany (+1.45%), Austria (+2.34%), Croatia (+2.53%), and Lithuania (+3.23%). Greece (-83.33%), Kosovo (-63.27%), Hungary (-59.46%), Luxembourg (-31.35%), and Finland (-30.65%) recorded the highest drops. Finally, in 2018 as opposed to 2016, the top 5 countries with the highest increases included: North Macedonia and Turkey (+585%), Greece and Italy (+100%), Czechia (+93.33%), Luxembourg (+55.91%), and Portugal (+40%). Countries such as Sweden (+1.92%), Denmark (+5.97%), Estonia (+6.73%), the United Kingdom (+4.1%), and Iceland (+8.7%) registered the lowest booms. The highest decreases were in the case of Bosnia and Herzegovina (-97.56%), Lithuania (-40.63%), Austria and Bulgaria (-31.3%), Latvia (-29.41%), and Montenegro (-23.14%).

Albania and Slovakia (2012/2010, 2014/2012, 2016/2014, and 2018/2016), Italy (2012/2010 and 2016/2014), Liechtenstein (2016/2014 and 2018/2016), Norway (2014/2012, 2016/2014, and 2018/2016), and Portugal (2016/2014) generated similar levels of waste.

The analysis stressed that 2 (Bosnia and Herzegovina and Luxembourg) out of 38 countries recorded both the highest level of waste and important increase as compared to previous year, 6 (Austria, Belgium, Croatia, Luxembourg, Malta, and

the United Kingdom) out of 38 countries recorded both the highest level of waste and minor rise as compared to previous year, 5 (Austria, Bosnia and Herzegovina, Croatia, Ireland, and Luxembourg) out of 38 countries recorded both the highest level of waste and drop against previous year, 5 (Bosnia and Herzegovina, Greece, Italy, Montenegro, and Turkey) out of 38 countries recorded both the lowest level of waste and a major increase versus previous year, no countries recorded both the lowest level of waste and minor boost as opposed to previous year, and 6 (Bosnia and Herzegovina, Greece, Montenegro, Norway, Poland, and Spain) out of 38 countries recorded both the lowest level of waste and major decrease as compared to previous year.

4 Conclusions

Currently, the Eurostat database is the only framework that contains food waste data which can be analyzed. But, in the following years, as FAO will collect more data and will establish a time series of FLI and FWI, the FLW Database will become more useful for researchers.

By analyzing the animal and mixed food waste, vegetal waste, and household and similar wastes generated by households, the following cluster of countries with similar behavior can be stressed (disregarding the countries that reported null values or have not reported any data). The ranking on “high” and “low” was made based on the position of each country’s food waste level against the average value of all countries’ level for each year. Thus, Italy registered high levels of all three waste categories; Bosnia and Herzegovina, Malta, and Serbia registered low levels of all three waste categories; Finland and the Netherlands recorded high levels of animal and mixed food waste and low levels of vegetal waste and household and similar wastes; Austria, Luxemburg, Norway, and Sweden recorded high levels of animal and mixed food waste and vegetal waste and low levels of household and similar wastes; Belgium and Slovenia recorded high levels of vegetal waste and low levels of animal and mixed food waste and household and similar wastes; Denmark, Iceland, and the United Kingdom recorded high levels of vegetal waste and household and similar wastes and low levels of animal and mixed food waste; Bulgaria, Croatia, Czechia, Hungary, Ireland, Montenegro, Slovakia, and Spain recorded high levels of household and similar wastes and low levels of animal and mixed food waste and vegetal waste.

Most of the countries with the highest level of the three waste categories generated by households recorded the lowest change (increase or decline) between 2010 and 2018. This is the case of Austria, Denmark, Germany, Greece, Italy, Liechtenstein, the Netherlands, Norway, Portugal, Spain, etc. with some exceptions in specific years, such as Belgium, Cyprus, Finland, and Luxembourg. The vice versa is applicable too, for instance, Bulgaria, Estonia, Latvia, Iceland, Ireland, Poland, Romania, Serbia, Slovakia, Slovenia, apart from Sweden, the United Kingdom, etc.

In the case of animal and mixed food waste, vegetal waste, and household and similar wastes generated by economic activities, the following cluster of states with similar behavior can be underscored (the states that reported null values or have not reported any data are not included): Austria, Belgium, Finland, and the Netherlands registered high levels of all three waste categories; Bosnia and Herzegovina, Croatia, Czechia, Germany, Greece, Hungary, Italy, Kosovo, Latvia, North Macedonia, Poland, Portugal, Romania, Serbia, Slovenia, Spain, and Turkey registered low levels of all three waste categories; France, Iceland, Liechtenstein, and Norway recorded high levels of animal and mixed food waste and low levels of vegetal waste and household and similar wastes; Cyprus, Ireland, and the United Kingdom recorded high levels of animal and mixed food waste and household and similar wastes and low levels of vegetal waste; Sweden recorded high levels of animal and mixed food waste and vegetal waste and low levels of household and similar wastes; Lithuania recorded high levels of vegetal waste and low levels of animal and mixed food waste and household and similar wastes; Bulgaria, Denmark, Estonia, Luxembourg, Malta, and Montenegro recorded high levels of household and similar wastes and low levels of animal and mixed food waste and vegetal waste.

The same pattern of the negative relationship between the country's waste level and the weight of the changes in the country's waste level was applicable for the animal and mixed food waste, vegetal waste, and household and similar wastes generated by economic activities for 2010–2018 period. Hence, Belgium, Norway, Lithuania, Luxembourg, Malta, the Netherlands, the United Kingdom, etc. recorded high level of waste and low changes in their level. Finland, France, Iceland, and Ireland were special cases that have disobeyed for certain years the above-mentioned pattern.

These findings substantiate a positive correlation between the country's economic development and the quantity of food waste generated by households and economic activities.

As regards the limitations of this research, one can notice from the outset that the data of the animal and mixed food waste, the vegetable wastes and the household and similar wastes contain data of other type of wastes in addition to food waste and thus, a clear distinction between them cannot be made. Secondly, the analysis was constrained by the fact that, between 2004 and 2018, particular countries have not reported any data to Eurostat for important food waste category (for instance, Albania, Cyprus, France, Germany, Greece, Kosovo, Latvia, Liechtenstein, Lithuania, North Macedonia, Poland, Portugal, Romania, and Turkey in the case of the animal and mixed food waste generated by households), individual states reported erroneous data (such as Montenegro in 2012 for household and similar waste generated by economic activities, Kosovo in 2012 and 2014 for vegetal wastes generated by economic activities, etc.), whereas certain countries stopped reporting data (for example Norway between 2012 and 2018 in the case of household and similar waste generated by economic activities).

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