FUNDAMENTAL ELEMENTS OF THE FOOD WASTE REDUCTION PROCESS. THE CASE OF AGRITOURISM PENSIONS IN ROMANIA

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Abstract

Food waste is a generalized process that affects both the environment and resources (natural, financial, sanitary, etc.). The negative effects are felt both at the individual level (household budget) and at the society level, and they are, as a rule, difficult to combat. From the existing quantitative and qualitative analyses, it was observed that food waste at household level represents over 50% of its total volume, even if food waste is produced throughout the supply chain. It is also noted that some economic sectors, by the nature of their activities, have a greater predilection to waste food (eg HoReCa or large retail stores). The case study carried out concerning the agro-tourist guesthouses in the mountainous area of Romania showed that, at their level, food waste has a reduce dimension. This is due to the household spirit and the ethical and spiritual values passed down from generation to generation, to which is added the love and respect for Romania's mountains. Solutions to reduce this phenomenon take different forms of manifestation, from awareness of the phenomenon itself to rethinking portions, promoting good practices, innovative packaging, etc. Considering the above, the article aims to contribute to a better knowledge of the phenomenon of food waste and to the identification of viable solutions by which this phenomenon can be tackled. In order to contribute to the achievement of this objective, the article presents a series of theoretical approaches aimed at the most used methods and techniques for reducing food waste at the global level, and, at the same time, evaluates the dimension of this phenomenon in tourist structures in the mountain area of Romania. The evaluation of the waste in mountain guesthouses represents a new element of the study carried out within the ADER 18.1.2[1] project, carried out within the Center of Mountain Economy of the Romanian Academy, the methods and results obtained can be multiplied at the level of other categories of territories.

Keywords: food waste; sustainable development; smart packaging; food behaviour; Mountain Area; agro-mountain tourist pensions

JEL CLassification: 053, 058, R10

INTRODUCTION

Along with the multiple challenges that exist globally (population growth, pandemic crisis, geo-political crisis, climate change, land use pressures, etc.), there is a worrying phenomenon that is worsening and increasing: food waste. At the same time, the reduction of food waste determines a series of positive effects for society: reducing costs with natural resources, making food consumption more efficient, combating environmental pollution, etc. According to estimates by the FAO, the annual cost of food waste is estimated to be 2.6

[1] Project title: Methods for reducing food waste in the agri-food chain, at national level, in order to prevent and reduce the socio-economic impact, by 2030, ADER 18.1.2, https://bioresurse.ro/en/blogs/proiecte/metode-de-reducere-a-risipei-alimentare-pe-lan%C8%9Bul-agroalimentar-la-nivel-na%C8%9Bional-in-vederea-prevenirii-%C8%99i-reducerii-impactului-socio-economic-pana-in-anul-2031

trillion USD (or 3.3% of global GDP), and benefits include the economy of some resources (water, for example, can reach 250 billion tons annually), the reduction or avoidance of the application of some fertilizers, and a reduction in the strain on arable land.

Over 80 million tons of CO2 equivalent are attributed to food waste produced in households, which accounts for over 170 million tons of CO2 equivalent annually (or about 3% of the total greenhouse gas emissions in the European Union).

In this context, reducing food waste becomes a legitimate target and a key priority of public, local, regional, national and global policies, but also a wish for every assumed inhabitant of the planet. This aspect is even more relevant in the context of the sustainable development goals established by the United Nations Organization, which advocates a "responsible consumption/production, which leads to a 50% reduction in food waste per capita globally, by the year 2030" (ONU, 2015).

In the European Union, under the auspices of the cohesion policy, food waste is addressed within the program called *zero waste*, launched in 2018, which supports active collaboration in order to monitor and reduce food waste throughout the supply chain (EC, 2018).

In Romania, annual food waste amounts to 2.5 million tons, each citizen wasting, on average, 70 kilograms annually, a figure that places Romania in the middle of the European ranking. The Ministry of Agriculture and Rural Development estimates that the food industry sector generates 37% of the waste, public food about 5%, and the agricultural sector 2%. Thus, food is thrown away even if there is a number of over 4.6 million Romanians threatened by poverty (November, 2021) and an important percentage of the population is below the poverty line (low work intensity, in conditions of severe material deprivation).

Taking into account the above, the article aims to inventory the main ways of general assessment of food waste and to analyse it for the agro-pensions in the mountain area. Following the analyzes carried out, a series of measures and actions have been identified that can contribute to supporting public or private interventions in their fight against this global phenomenon.

1. METODOLOGY

1. The research for this article was conducted in mountain regions in Romania. The focus was given to food waste of tourism infrastructure in the mountain areas. The information on characteristics of food waste was collected from the National Institute of Statistics in Romania site, which provides independent information on the mountain tourism.

2.The documents produced at national level were studied; some major documents include different study reports of Food and Agriculture Organization of the United Nations (FAO), UNEP or Euro-Montana Forum.Literature Review and Analysis: The author conducted a thorough literature review focusing on keywords related to ‘food waste’. This review involved identifying and analyzing existing studies, reports, and articles that discussed food waste in various contexts.

3. Synthesis and Interpretations: Based on the literature review, the author synthesized the information gathered and offered their interpretations. This process involved analyzing the data to identify patterns, trends, and key insights regarding ‘food waste’.

4. Evaluation Methodology: In the specialized literature, it was found that the most commonly used method for evaluating waste, including food waste, is the cost-benefit analysis. The author decided to adapt this methodology specifically for assessing 'food waste' in this study.

5. National-level Effects Analysis: Understanding the effects of 'food waste' at the national level requires a comprehensive examination of its sources. This analysis aims to determine where food waste originates, as well as the areas and aspects of waste management that need improvement. Such examination includes assessing the associated costs involved in addressing these issues. In Romania, food waste is managed separately, despite existing legislation governing this aspect.

However, evaluating the extent of food waste in the country poses challenges due to various factors, including the complexity of waste management systems and the effectiveness of implementation.

The study were carried out in the mountain regions in Romania and try to evaluated the total amount of food waste in toruristic infrastructure (hotels, touristic pension, agro-turistic pension etc.).

In Romania, mountain regions have around 71,340 km 2 , representing 29.93% out of the total national surface and 20.14% from UAA (Utilised Agricultural Area) of total national. The mountain territory has around 3.2 million Inhabitants (20% of the national population).

Mountain Areas is overlapping almost 100% with the Carpathian Mountains. The average elevation value of the Carpathian Mountains is 1,136 m, and the highest values of altitude are over 2,500 meters. Agricultural area present in Mountain region is around 2,802,000 ha. Out of this area, in 2007, only 1,290,000 ha (46%) was under commitment, but is estimated that in 2013 will be under commitment around 2,520,000 ha (90%) and this threshold is unlikely to be higher because of eligibility criteria that are referring to plots and farm sizes. Due to natural restrictive condition (slope and altitude), Carpathian Mountains encounter obstacles in farming, with a negative consequence (a shorter period of vegetation period and supplementary costs). Also, the mountain regions are characterized by a low productivity and depopulation. Mountain regions in Romania differ from other regions due to natural disadvantages (i.e., elevation, clime, slope, low soil fertility, reduced access to the communication routes and markets), and structural disadvantages (i.e., ageing active population, migration trends, restricted jobs, distances from decisional centers, and insufficiently developed infrastructure).

2. STATE OF THE ART

Academic literature, as well as some practical approaches, reflect the recognition of the significance of reducing food waste. Relevant objectives include examining the causes and sources of production (Schanes et al., 2018), monitoring (Corrado and Sala, 2018), methods of control and mitigation (Cristobal et al., 2018), etc.

The economic literature in this area primarily focuses on short-term (Campoy-Munoz et al., 2017) but also medium-term (Rutten et al., 2013a) effects, demonstrating that the quantitative impact of reducing food waste is typically analyzed through a system-wide macroeconomic simulation, an approach that explicitly recognizes the direct impact on different stages of the production and supply chain. The conclusions of the studies mentioned

are frequently based on the phenomenon is ignored or reduced in terms of labelling, packaging and logistics within the food chain.

Nevertheless, it is still difficult to estimate the amounts and values of food waste (Bellemare et al., 2017), primarily due to a lack of statistics and statistical information. The lack of an agreed-upon evaluation technique at the level of member states as well as the fact that multiple definitions of food waste exist contribute to the problem's unpredictability (Scherhaufer et al., 2018; Schneider, 2013).

We mention here the findings of a study conducted by Corrado and Sala (2018) as evidence for the aforementioned. It demonstrates that the measurement of food waste flows on a European and even global scale can vary significantly depending on the choice of assessment methodologies, the inconsistent use of definitions, and the fact that food waste can be "avoidable or unavoidable" (Lebersorger şi Schneider, 2011).

At the EU level, food waste per person ranged from 158 kg to 298 kg annually. Estimates of 76 kg per capita per year (Monier et al., 2010 based on 2006 data for the EU27) or 92 kg per capita per year (Stenmarck et al., 2016 based on 2012 data for the EU28), including edible and inedible scraps, are added to these figures. In 2023, over 58 million tonnes of food waste (131 kg/inhabitant) are generated annually, with an value estimated at 132 billion euros (Eurostat, 2023). Eurostat roughly estimates that around 10% of food made available to EU consumers (at retail, food services and households) may be wasted. At the same time, over 37 million people cannot afford a quality meal every second day (Eurostat, 2023).

According to the UNEP Food Waste Index 2024, around 1.05 billion tonnes of food waste were generated in 2022 – 60% of which came from households, 28% from food services and 12% from retail. This amount (19%) of food available to consumers being wasted at the retail, food service and household level. The equivalent of at least one billion meals of edible food is being wasted in households worldwide every single day (UNEP, 2024[2]). Similarly, in the EU, households generate more than half of the total food waste (54%) and 70% of food waste arising at food service and retail (Eurostat, 2023).

The evaluation of the advantages and disadvantages brought on by the decrease in food waste raises a concern (FAO, 2014; Schanes et al., 2018). Microeconomic theory, it is argued, frequently falls short of capturing "real" consumption behavior, which results from non-value (non-price) factors such as poor planning, aesthetic perceptions, and social factors like prestige, as well as the relationship between purchasing power and food options or those related to nutritional value.

It can be challenging to evaluate cultural aspects as well as lifestyle factors (influenced by cuisine, nutritional knowledge, food management, storage, etc.), as well as ethical, ecological, and financial attitudes toward food waste in civilizations where food is plentiful and relatively inexpensive. A survey shows that in the US, over 37% of consumers always or usually throw away food that is near the date mentioned on the container under the name "best before" (Neff et al. 2019). Food labeling and packaging also fall under this category of criteria.

According to some experts (Williams et al. 2012), 20–25% of food is lost during packaging, proving that bulk packaging and date marking are significant contributors to food waste. Therefore, it follows logically that improvements in food labeling and packaging

[2] https://www.unep.org/resources/publication/food-waste-index-report-2024

(such as resealable, smaller, and divided packages, more detailed label instructions, time-temperature indications, and control) are essential for lowering household waste. There is even a perception that clearer indications on packaging can limit the additional cost for the retailer (Verghese et al. 2015) or increase the benefits associated with incentive taxation (Schanes et al. 2018).

The benefits of reducing food waste are not confined to a specific sector or area, but cover both upstream markets (e.g. feed, fertilizer use, land and labour) and food security benefits from reducing food imports.

Food waste assessment models are diverse. In an attempt to standardize them, a group of FAO experts (2014) specialized in food security propose a general equilibrium framework model that should be followed in case of food waste. They start from the theory of general equilibrium, in which market exchanges are based on the price system. The concept of "equilibrium" refers to the fact that such exchanges take place in such a way that all actors are satisfied and can produce new exchanges. The theory of general equilibrium is based on perfect competition (Arrow and Debreu, 1954) and certain working assumptions: there must be at least one price system, which equalizes the (global) offers and demands of economic agents (agents who behave as "participants at the price").

Other instances in the pertinent literature require the use of macroeconomic simulation models (such as the fixed-price social accounting matrix; Campoy-Munoz et al., 2017) or computable general equilibrium representations under flexible prices (Britz et al., 2014; Rutten et al., 2013a; Rutten and Verma, 2014; Rutten et al., 2015; Rutten şi Kavallari, 2016).

Other methods by which food waste can be assessed are identified in the table below.

Table 1. General methods for evaluating food waste in each economic sector

<table>
<tr><th>Economic Sector</th><th colspan="6">Evluation methods</th></tr>
<tr><td>Production</td><td rowspan="4">Direct Measurement</td><td rowspan="4">Waste composition analysis</td><td rowspan="4">Volume assessement</td><td rowspan="2">Quality asessement</td><td></td><td></td></tr>
<tr><td>Comerce</td><td rowspan="2">Numbering, scanning</td><td></td></tr>
<tr><td>Food services</td><td></td><td rowspan="2">Food Journal</td></tr>
<tr><td>Households</td><td></td><td></td></tr>
</table>

Source: No time de waste. Why the EU needs to adopt ambitious legally binding food waste reduction target?

Each EU member state has created unique tools targeted at managing, minimizing, and preventing food waste. Others take the form of various trash prevention techniques or programs, including National trash Plans.

In conclusion, it is challenging to estimate how much food is wasted in each nation because it is frequently gathered alongside other waste and cannot be tracked independently. The majority of home garbage falls into this category, but it also applies to other industries where food waste may be gathered and processed as biowaste. Calculating the amount of avoidable food waste is much more challenging. The most common approaches call for separate sorting, which is frequently challenging to accomplish, to determine the generation of preventable and time-consuming food waste.

3. A POSSIBLE MODEL OF COST–BENEFIT ANALYSIS APPLICABLE TO THE PHENOMENON OF FOOD WASTE

According to the most recent data published by the National Institute of Public Health (year 2019), in Romania, food waste is estimated at 6,000 tons per day, 50% coming from households, 37% from the food industry, 7% from retail, 5% from public food and 2% from the agricultural sector.

To combat this phenomenon, the Food Waste Prevention Law no. 217/2016 (corroborated with the provisions of Law no. 227/2015 on the Fiscal Code) covers the following measures:

1. responsibility for reducing food waste in the agri-food chain;
2. sale at a reduced price of products close to the expiry of the minimum durability date;
3. transfer of food by donation, for human consumption;
4. disposal and use of animal by-products and derived products;
5. directing agro-food products that have become unfit for human or animal consumption by turning them into compost;
6. directing agro-food products that have become unfit for human or animal consumption in order to capitalize on them by transforming them into biogas;
7. directing to an authorized waste neutralization unit.

The measures presented above carry additional costs, generated by changes in the production process that can be partially or fully recovered through a reduction in food waste.

An analysis of the effects of such measures at the national level requires examining the basis of food waste formation, in order to determine the places and directions for improvement, including their cost.

Given the fact that food waste generates different costs considered disproportionate at the level of production sources, we believe that a Cost-Benefit Analysis model applicable to the evaluation of this global phenomenon can be considered.

From this perspective, we propose a food waste evaluation model, based on cost-benefit analysis (CBA), with the following stages:

- strategic approach and definition of objectives;
- identifying and selecting the most suitable alternative;
- plan of measures (financial estimate);
- economic analysis;
- performance indicators;
- sensitivity and risk analysis.

The strategic approach considers the establishment of the following possible *objectives*:

- developing an annual plan to reduce food waste,
- carrying out internal communications with employees from different sectors on this topic,
- adapting production to certain existing market situations (demand-offer, ensuring traceability),
- waste reduction plan depending on the market and the place where it is produced,
- plan of education and information measures regarding the prevention of food waste,
- ways to quantify food waste,
- measures to redistribute/use benefits (where possible).

Cost-Benefit Analysis (CBA) seeks to compare costs now and future benefits. Typically, either the net present value (NPV) or the internal rate of return (IRR) is calculated. Proposed waste reduction projects are accepted if the NPV is positive or the IRR is greater than the average interest rate.

The purpose of CBA is to compare the economic costs of the plan of measures to reduce waste with the economic benefits that will be obtained at an updated social rate (usually 5%). In practical terms, this is expressed by the CBA's economic performance indicators: a). Net Economic Present Value (NEPV), b). The benefit / cost ratio (B / C) and c). ERR (economic rate of return).

Economic costs (as opposed to financial ones) are measured in terms of "resources" or "opportunity costs" (the benefit that must be given up by the alternative use of a resource).

Similarly, benefits can be measured in terms of the amounts that people are prepared to pay (willingness to pay) or, alternatively, in the costs of avoiding an environmental problem as a result of implementing a plan to measure. Also, the external benefits that result from the implementation of the plan of measures to reduce waste and that are not captured by the analysis carried out in financial terms must be identified.

There are a number of costs that must be taken into account when doing economic-financial analyses. Thus, economic costs represent the broadest category that includes: financial costs, resource costs, environmental costs etc.

The *identification of the economic costs* has three phases (Table 2):

- Phase 1 – corrections related to taxes, subsidies, other transfers;
- Phase 2 – corrections related to externalities;
- Phase 3 – conversion of market prices into accounting prices to include social costs and benefits (determination of conversion factors).

Table 2. Costs – calculation phases

Phase 1 – fiscal corrections	In this phase, two components for the economic analysis are determined: the fiscal correction value and the conversion factor for market prices impacted by the fiscal policy. It is challenging to estimate net values since market prices include taxes, subsidies, and some transfer payments. Therefore, generic methods will be applied to rectify these distortions: VAT and other indirect taxes will not be included in the costs of inputs and outputs for the cost-benefit analysis. Direct taxes must be included in the price of raw materials. Transfer payments to individuals, such as social insurance payments, must be excluded from the calculation; when environmental taxes are incorporated into the cost of energy and fuel, for example, indirect taxes/subsidies may be justified in being included in project costs as long as double accounting is avoided; standardized factors may be used for some classes of inputs and outputs (financial flows).
Phase 2 – externalities correction	Included in this category are the costs and benefits derived from environmental impact assessment, CO2 emission estimation, etc. In this sense, a list of quantifiable externalities can be used. When calculating the economic rate of return, quantifiable aspects can be taken into account.
Phase 3 – conversion of market prices into accounting prices	In this case, the conversion factors for the transformation of market prices into economic values are determined. Apart from fiscal influences and externalities, the real prices of raw materials and final production can be distorted by the imperfections of market mechanisms.

Source: own interpretations.

Distortions related to the wages of those involved must be taken into account when calculating the costs of waste sorting activities, especially those working with environmental protection infrastructures. Due to flaws in the labor market, current salaries might be a misleading societal measure of the opportunity costs of labor.

The calculation of the economic performance indicators is done after the correction of price distortions. After choosing the social discount rate, the net discounted value (NDV) and the benefit/cost ratio can be calculated. The economic rate differs from the financial rate in that it incorporates social and environmental externalities to the greatest extent possible and employs opportunity costs rather than prices from unreliable markets. Many projects may have a low or negative financial rate of return and a high economic rate of return due to favorable externalities. As recommended (European Commission Guide, 2014), the economic discount rate that can be used is 5%.

Calculation of CBA indicators

I. Net Economic Present Value (NEPV)

Based on the data and the net income flow, the net present value can be calculated:

$$VNAE = \sum_{t=0}^{n} a_t S_t = \frac{S_0}{(1+r_a)^0} + \frac{S_1}{(1+r_a)^1} + \dots \frac{S_t}{(1+r_a)^t} \dots + \frac{S_n}{(1+r_a)^n}$$

Where: S_n is the balance of net income flows (cash flow) over time ***n***

$\boldsymbol{a}_t$ is the balance of net income flows (cash flow) over time

$\boldsymbol{r_a}$ is the discount rate (5%).

II. Internal Rate of Return

Internal Rate of Return (IRR) is defined as the interest rate for which the net present value of the investment is equal to zero.

$$VNAE = \sum_{t=0}^{n} (S_t / (1+RIRE)^t) = 0$$

$$RIRE > 5\%$$

The value of the two financial indicators can be calculated relatively easily with the help of financial functions from the EXCEL program, or based on other specialized financial management programs, by applying appropriate functions.

III. Benefit/Cost Ratio (Profitability Index – PI)

It is calculated as a ratio between the updated value of benefits and costs. The report must be supra-unitary.

PI = Present benefits/presents costs

The benefits of reducing food waste

When estimating the benefits resulting from the reduction of food waste, three methods of analysis can be taken into account: qualitative, quantitative and monetary.

Qualitative estimation investigates the types of benefits that should result. For this, each category of food waste can be examined, although in some cases the benefits increase from combined measures to combat waste.

The main resulting benefits can be the following:

- health benefits (reduction of illnesses, avoidance of premature mortality, etc.);
- benefits regarding resources (economies of resources from forestry, agriculture and fishing);
- ecosystem benefits (benefits on some parts of the environment without commercial interest);
- social benefits (food bank, donations, etc.);
- extended economic benefits: local and regional development (attracting investments), eco-efficient gains, development of new sectors (eco-packaging);
- the economic benefits resulting from the more efficient use of some resources.

Where possible, these benefits should be quantified and, furthermore, monetary estimates of them should be presented (noting at each level the assumptions and interpreting the results).

As a result of the difficulty of assigning monetary values to benefits (in some cases it is relatively difficult: for example, how much does the peel of an apple, egg, etc. cost), economic estimates cover fewer benefits. That is why it is important that each level of analysis is seen as providing value by itself, and that the qualitative assessment is not seen only as a step towards the quantitative one. Focusing only on monetary analysis would result in missing out on some of the benefits. With each step – from qualitative to quantitative analysis, to certain monetary values – the volume of benefits changes in the sense of diminishing them.

4. RESULTS AND DISCUTIONS

4.1. Evaluation of food waste from mountain agro-pensions in Romania

An important place in the entire food chain is occupied by food waste in the HoReCa sector, given that in order to increase its turnover, the sector forces the sale through large portions of food that remain unfinished and through an oversupply in order to increase attractiveness. Part of food waste is caused by products that are cooked and left uneaten due to the lack of proper facilities.

In Romania, per capita estimates of food waste are 70 kg/year, with urban areas producing more food waste, while in rural areas there is a tradition of consumption without much loss as a result of a high ethical sense, but also relatively low incomes and the use of traditional methods of valorizing household food scraps.

The estimation of food waste took into account the interviews carried out in 2021 with the owners of agri-pensiones in the mountain area in Romania, from which it was found that this percentage reaches about 15 kg of waste per tourist (about 21.4% of the national average of 70 kg per per capita, annually).

Given that this was a maximum value, and taking into account the trends identified at national level (food waste decreased in 2020, compared to 2016, in all product categories, with significant percentages in bakery products: decrease of 63, 8% compared to 2016, as with meals prepared at home – decrease of 61.11% compared to 2016), the following analysis hypotheses existing in national studies were selected:

1. in restaurants, food waste is estimated at 15 kg per tourist per year;
2. n catering companies – 6 kg per tourist per year.

The estimation of food losses in mountain tourist in Romania structures was carried out on the basis of the following work options and took into account that not all mountain tourist structures have their own restaurants:

1. *10 kg per tourist annually* food waste produced in the average mountain areas;
2. *15 kg per tourist per year,* maximum option;
3. *6 kg. per capita annually* minimum variant of waste produced in tourist accommodation structures.

4.2. The situation of tourist structures in mountain areas in Romania

The tourist capacity of the mountain areas (year 2021) was 2,492 tourist accommodation structures, which represents 27.25% of the total at the national level. About 52.85% of the total are agro-tourist guesthouses, followed by tourist guesthouses (17.47%), tourist villas (8.47%) and hotels (7.95%). Most are 3 stars and are agro-tourist guesthouses (Figure 1).

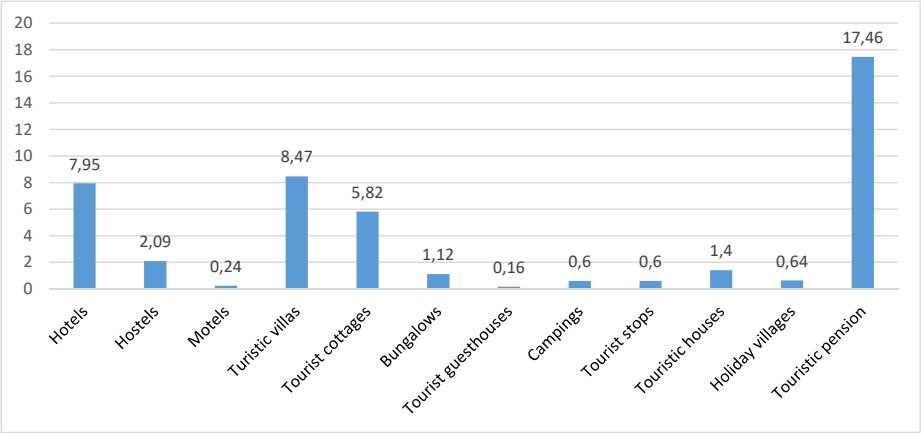

Figure 1. Turistic structure by types of accommodation, Romania, 2021 (%)

Source: own processing of INS data

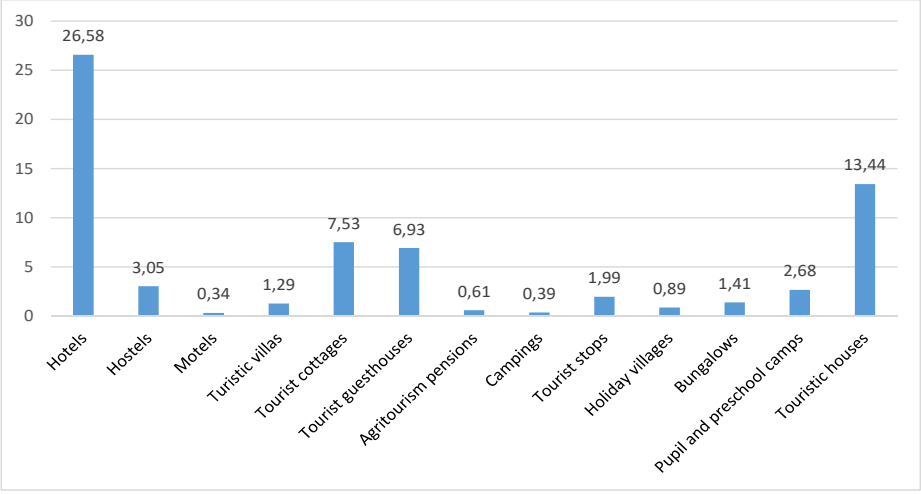

Figure 2. The structure of accommodation places in tourist units in the mountain area, Romania country, 2021 (%)

Source: own processing of NIS data

There are 66,374 accommodation places in the tourist accommodation structures in the mountain area (with an average of 27 places per tourist unit). About 32% of places are in agritourism guesthouses, followed by hotels (26.58%) (Figure 2).

Figure 3 shows the arrivals (number of people) in the tourist reception units in the mountain area. It can be seen that there were 1,866,402 people in 2021, 44.6% more than in 2014.

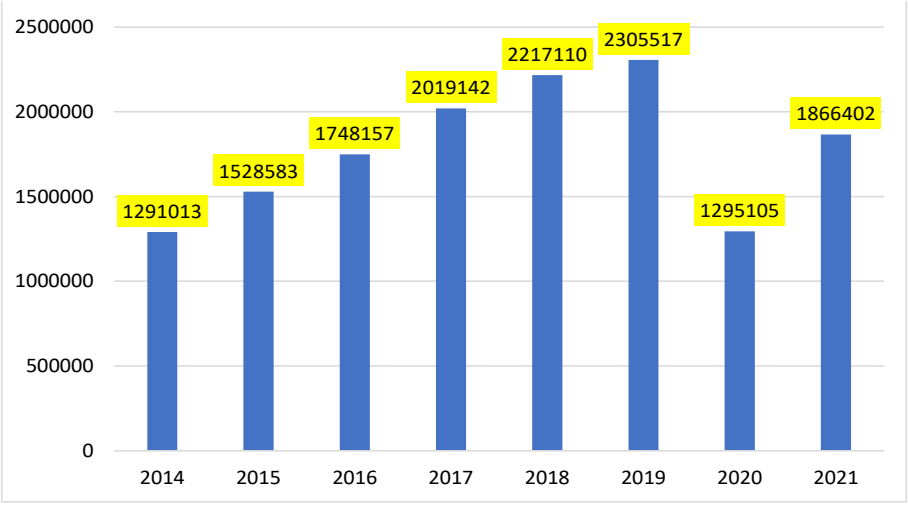

Figure 3. Arrivals of tourists in tourist reception structures in the mountain area, Romania, 2021 (no.)

Source: own processing of INS data.

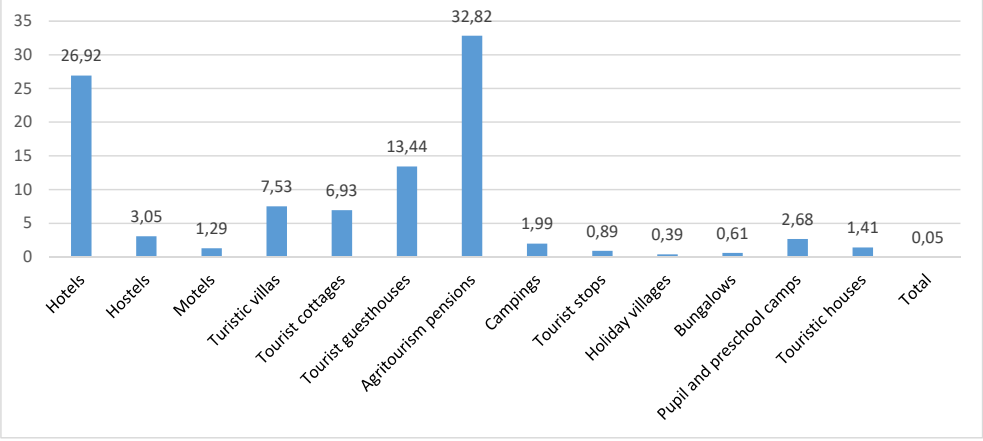

Figure 4. Places-bed in tourist structures in the mountain area, Romania, 2021 (%)

Source: own processing of NIS data.

As can be seen in Figure 5, mountain tourist structures had an average degree of occupancy in 2021 of 42.5%, the most occupied being hotels (52.8%), followed by tourist

villas (36.5%). Mountain agro-tourist guesthouses had an occupancy rate of 23.1%, while tourist guesthouses were occupied at a rate of 26.2%.

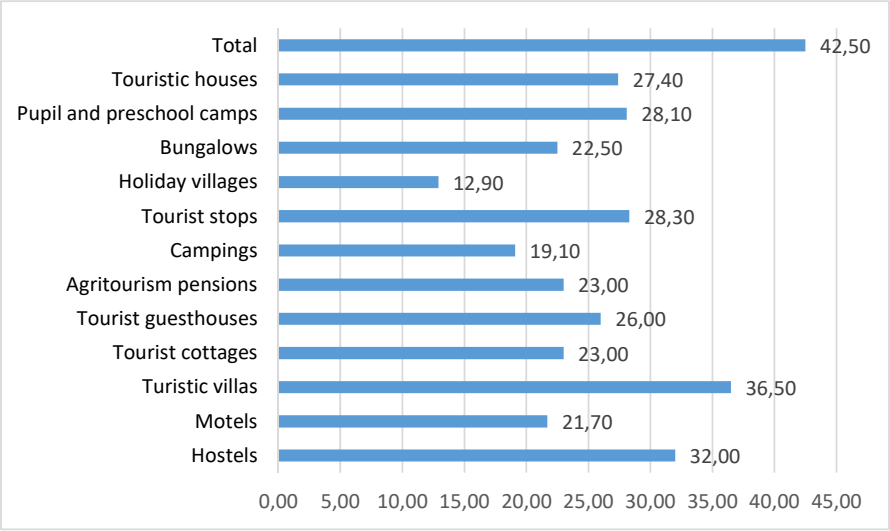

Figure 5. The degree of occupancy in mountain tourist structures, Romnaia, 2021 (%)

Source: own processing of NIS data

Taking into account the previously presented elements, Table 3 presents the estimates regarding the amounts of food waste in the analyzed mountain areas in Romania, within the tourist structures. Thus, the most estimated waste is produced in hotels in the mountain area (95.8 tons annually maximum and 57 tons minimum), followed by agro-tourist guesthouses (36 tons maximum and 21 tons minimum.

According to estimates, the units in the HoReCa sector register over 250,000 tons of food waste thrown to the landfill annually (12%-15% of the total food waste). Compared to the total value estimated for the HoReCa sector, the food waste in the mountain area has a small size, it represents 0.0144% of the estimated 250,000 tons (the maximum value of the waste in the mountain area).

In conclusion, starting from these global estimates, we believe that a more accurate assessment of the quantities of food waste is necessary, which takes into account each activity sector separately.

Moreover, it is necessary to standardize the amount of waste for each sector, so that the estimate is as close as possible to the real situation (Table 3).

Table 3: Estimates of waste quantities (annual), Mountain Area, Romania Country

Accomodation type	Total beds	Effectively occupied beds taking into account the degree of occupancy	TOTAL estimated food waste per year		
			10 kg per capita	15 kg per capita	6 kg. per capita
Hotels	18.159	9.588	95.879,52	143.820	57.527,7
Hostels	1.463	468	4.681,6	7.022,4	2.809,0

Accomodation type	Total beds	Effectively occupied beds taking into account the degree of occupancy	TOTAL estimated food waste per year		
			10 kg per capita	15 kg per capita	6 kg. per capita
Motels	1.150	250	2.495,5	3.743,25	1.497,3
Turistic villas	4.341	1.584	15.844,65	23.766,98	9.506,8
Tourist cottages	4.037	929	9.285,1	13.927,65	5.571,1
Tourist guesthouses	8.137	2.132	21.318,94	31.978,41	12.791,4
Agritourism pensions	15.549	3.592	35.918,19	53.877,29	21.550,9
Campings	1.152	220	2.200,32	3.300,48	1.320,2
Tourist stops	491	139	1.389,53	2.084,295	833,7
Holiday villages	310	40	399,9	599,85	239,9
Bungalows	369	83	830,25	1.245,375	498,2
Pupil and preschool camps	1.673	470	4.701,13	7.051,695	2.8+20,7
Touristic houses	420	115	1.150,8	1.726,2	690,5
Total	39.092	16.614	166.141	249.211,5	99.684,6

Source: own processing of NIS data

Moving forward with the analysis, it is found that not all structures in the mountain areas are equipped with restaurants or shops, the most important are hotels (34%), agro-tourist guesthouses (22%) and tourist guesthouses (20.13%).

This aspect complements the previous conclusion, in the sense that food waste is produced, in particular, in tourist structures that also have restaurants or shops.

4.3. A scenario with high potential impact on reducing food waste. Innovative packaging

The packaging process is vital in maintaining the quality and safety of food, but also in extending the shelf life of the stored product, thus reducing food waste. However, packaging is, in turn, a product with a short life cycle, therefore its incorrect management can lead to negative effects on the economy and the environment.

Packaging has a direct link to the circular economy, which promotes closing the loops in industrial systems, minimizing waste and reducing the input of raw materials and energy. From the perspective of the circular economy, the food chain includes three important stages: food production, consumption and food waste generation, including food surplus management.

Currently, the food journey "from farm to consumer" shows the need for packaging systems that facilitate the protection, transport and storage of food products. In this context, packaging could significantly contribute to reducing food waste. Therefore, it is recommended to continue the development of new forms of distribution packaging for food products, which minimize handling along the supply chain.

Reusable boxes and pallets are two examples of packaging that reduces the amount of product handling. Food and packaging have a special connection. Correct food packaging utilization can reduce family food waste and the negative environmental implications of

overproduction. That's why it's important to recognize the potential trade-off between packaging consumption and food waste. In this sense, it is well known that packaging contributes to sustainable development by maintaining the quality of products in the supply chain.

There are studies showing that packaging can be an interesting and attractive topic because people have become more aware of packaging waste than food waste (they usually underestimate the amount of food waste).

Packaging is one of the most studied methods of reducing food waste, an important concern being the impact on the environment versus the generation of waste. For instance, although the likelihood of food waste generation is low, the switch to single-serving sizes in some food categories may result in a high amount of packing per unit mass of food. To achieve the optimum environmental result, it becomes crucial to understand and research the trade-off between packaging usage and food waste. Packaging can be classified as follows:

- Primary packaging for retail (plastic, glass, metal, etc.).
- Secondary/tertiary packaging: additional layers that contain and protect the primary packaging during distribution (examples: corrugated cardboard boxes, plastic or wooden pallets, plastic crates for processed foods or stretch films).

The most used materials are polymeric (37% – in the flexible version 10% and rigid 27%) due to the properties that can ensure the quality of the packaged products throughout their lifetime until consumption. The types of polymer packaging are: trays, boxes, casseroles, bags, films, sealable foil, cups, vacuum bags etc.

These types of packaging must comply with certain specific quality conditions for the entire duration of both transport and the life of the food products.

The phases of the packaged food supply chain must be identified in order to calculate food loss due to packaging. There are various phases and causes of food waste along the supply chain: A product may lose some of its contents after being packaged for sale or transportation. The packaging must present a series of characteristics, for example they must be easy to open and empty. If these characteristics are not met, food waste occurs quickly (by spillage).

An estimate based on studies showed that food loss and food waste caused by packaging contributes with 20–25% of the total amount of household food waste (Table 4).

Table 4. Types of food waste caused by packaging damage

Phase	Types of food waste caused by packaging damage	
On the supply chain	Post-harvest handling and storage	Damage caused by various contaminants, sharp edges, chips from storage containers.
	Processing and packaging	Problems in the filling process; Packaging failures during sealing; Changes to packaging for marketing reasons.
	Distribution	Inadequate packaging material, poor stability; damage to barcodes
In households		Packaging difficult to open or empty; Incorrect size.

Source: https://iba-riscuriambalaje.ro/wp-content/uploads/2020/09/Strategie_risipa_final.pdf

According to European Regulation 450/2009, the main design criteria that an ideal package must fulfill are: zero toxicity, easy handling, adequate mechanical strength, firm closing characteristics (such as resealing), moisture control, appropriate labeling.

The main benefits of reducing food waste by using innovative packaging are:

- Save money by reducing overbuying and disposal costs;
- Reduces the impact on the environment;
- Supporting efforts to eliminate hunger;
- Reduction of health-related problems; elimination of odors;
- Supporting community efforts to reduce waste;
- Increasing fiscal benefits through food donation;
- Energy conservation and reduction of greenhouse gases.

Food safety is also taken into account. So, the primary cause of food-borne illnesses is still microbial contamination of food products. Market globalization, which calls for items with longer shelf lives, and the rise in popularity of minimally processed foods present further difficulties.

As a result, new food packaging materials that ensure safety and retain quality over extended periods of time are required. Food packaging technology is continually changing to meet these difficulties. Table 5 lists several potential technological advancements for packaging-related food waste reduction.

Table 5. Innovative food packaging technologies to reduce food waste

• Improved mechanical, thermal, and barrier qualities of packaging • Increased biodegradation due to biodegradability • Shelf life extension, oxygen scavenger, and antimicrobial active packaging • Environmental interaction, self-cleaning, self-healing, and damage signaling are all features of smart packaging. • Controlled distribution and release: bioactive substances (like essential oils) and nutraceuticals • Monitoring of the state of the product: gas detector, freshness indicator, leak indicator, and temperature time indicator (TTI) • Nanosensors: monitoring microbial growth and food quality • Nanocoatings • Nano-barcode and product authentication information.

Source: Love Food Hate Waste (2018) A-Z of food storage.

In order to extend shelf life by interacting with the product (e.g., by releasing anti-oxidants, antimicrobials, or oxygen scavengers), food packaging must transition from a passive one (a simple container that protects its contents from moisture, air, microbes, and mechanical damage such as vibrations and shocks) to an active one.

"Smart" or "interactive" packaging solutions can help with collaboration and data sharing in the supply chain. For better demand feedback for different supply chain actors, smart food packaging can offer real-time expiration data, product tracking, and temperature indicators that are either time-based or triggered by specific chemicals, determined by radio frequency identification (RFID) data, or have thermal sensors. By relaying information to suppliers about quality, safety, shelf life, and logistical effectiveness, these smart packaging solutions have the potential to decrease food waste in the supply chain.

By minimizing the amount of time products spend in the supply chain, you may increase shelf life and lessen the chance that they will spoil while being transported or stored.

Under these circumstances, nanotechnology is being investigated more and more as a tool for the creation of active food packaging. The result is that NanoPack is an active packaging film with antimicrobial properties that gradually releases tiny amounts of antimicrobial essential oils in the form of vapors into the so-called "headspace" of the package, sanitizing both the food product and the headspace and extending the shelf life of the product. By adding three weeks to the shelf life of bread without additions, NanoPack films show the potential of active packaging technologies to cut down on food waste.

Plastics and metallized films that provide a high mechanical barrier and are impervious to water, oxygen, and microorganisms are in high demand because they can extend shelf life while using fewer preservatives. Some materials are not biodegradable and are frequently made from non-renewable fossil fuel sources.

Materials with numerous functional layers frequently have limited options for recycling or disposal. Additionally, there is widespread worry across the globe regarding the environmental effects of packaging trash made of persistent plastic in particular. As a result, there is a growing trend towards environmentally friendly choices that are more sustainable.

Because they are more readily biodegradable or compostable than typical plastic packaging, bio-based materials are being investigated as environmentally friendly alternatives. However, due to their characteristics (such as greater permeability to air or water), their industrial use and application are still restricted. If conventional plastic is to be replaced and the waste issue is to be solved, these qualities must be considerably enhanced.

An example of good practice is the RefuCoat project, financed by EU funds, which proposes the development of two new types of bio-food packaging. The first is an active packaging alternative that is totally recyclable to the metallized foils typically used to package cereal, crisps, and salty snacks. A completely biodegradable container for chicken products is the second option.

Active packaging technologies extend the time that food may be carried, reducing the loss and waste caused by food spoilage, while other cutting-edge concepts enable waste to be eliminated or turned into useful resources. These technical advancements may prove to be a vital weapon in the worldwide struggle against food waste.

Making food packaging a by-product of the food business is another ground-breaking suggestion for enhancing the sustainability of food packaging. By employing byproducts that would typically be lost, such as unpurified cheese whey and almond shells, the community initiative YPACK (2017) is creating a 100% recyclable packaging film and a fully biodegradable packing tray. The tray includes active antibacterial qualities that can increase the shelf life of food goods, while the related flow pack material serves as a passive barrier.

Taking into account the fact that plastic packaging is found everywhere in nature around the world (in ocean waters, rivers, mountains, forests, cities, etc.) and the fact that much waste can no longer be sorted or recycled, we believe that the impact of a smart packaging would be great.

To stop this waste from expanding on a large scale, it is important that certain laws are passed to protect the sale of bags and other packaging made of plastic or non-renewable materials.

In Romania, Law no. 87/2018 promulgated on January 1, 2019 regarding the management of packaging and packaging waste prohibits the sale of plastic bags (thin plastic bags with handles, 50 microns thick).

In order to reduce the presence of these bags and to interfere with the illegal system of buying surplus bags in other countries, it is important to change the green tax. As a result, plastic bags have been partially removed from the commercial system and replaced with biodegradable and compostable bags, which are more environmentally friendly. The costs vary starting from 0.10 lei/bag and reaching 0.15 lei/bag. The problem is the incorporation of natural safeguards, which are intended to include thin plastic bags without handles.

The SR EN 13432: 2002 standard applies to products that meet certain standards in the field of biodegradable and compostable objects. Therefore, to be approved, the packaging must meet certain criteria: aa have a shelf life of 12 weeks until the product degrades almost completely. Except for carbon dioxide, a biodegradable bag emits no harmful substances into the atmosphere.

There is a difference between biodegradable products and compostable products: biodegradable items are not entirely beneficial to the environment. They also have plastic components and microorganisms that help break it down. Compostable items are made from organic materials such as cornstarch. Therefore, if such objects or packages, including bags, are used more and more, nature has many benefits.

CONCLUSIONS

In conclusion, the specialized literature in the field emphasizes the short-term (Campoy-Munoz et al., 2017) as well as the medium-term (Rutten et al., 2013a) effects, demonstrating that the quantitative impact of reducing food waste is typically analyzed through a system-wide macroeconomic simulation, an approach that explicitly recognizes the direct impact on various stages of the production and supply chain. The conclusions of the studies mentioned are frequently based on estimates of the occurrence due to the absence of statistical data. Thus, most of the time, the supply perspective of the phenomenon is ignored or reduced in terms of labelling, packaging and logistics within the food chain.

Each EU member state has created unique tools targeted at managing, minimizing, and preventing food waste. Others take the form of various trash prevention techniques or programs, including National trash Plans. Additionally, it is challenging to estimate the amount of food waste generated by each nation because it is frequently collected alongside other debris and cannot be tracked independently. The majority of home garbage falls into this category, but it also applies to other industries where food waste may be gathered and processed as biowaste. Calculating the amount of avoidable food waste is much more challenging. The most common approaches call for separate sorting, which is frequently challenging to accomplish, to determine the generation of preventable and time-consuming food waste.

Taking into account the presented elements in Chapetr 4, the most estimated food waste is produced in hotels in the mountain area in Romania (95.8 tons annually maximum and 57 tons minimum), followed by agro-tourist guesthouses (36 tons maximum and 21 tons minimum. According to estimates, the units in the HoReCa sector register over 250,000 tons of food waste thrown to the landfill annually (12%-15% of the total food waste).

Compared to the total value estimated for the HoReCa sector, the food waste in the mountain area in Romania has a small size, it represents 0.0144% of the estimated 250,000 tons (the maximum value of the waste in the mountain area). Starting from these global estimates, we believe that a more accurate assessment of the quantities of food waste is necessary, which takes into account each activity sector separately.

Moreover, it is necessary to standardize the amount of waste for each sector, so that the estimate is as close as possible to the real situation.

The present article tried to give a brief picture of what the phenomenon of food waste means and the importance of actions that address, directly or indirectly, its reduction. Thus, academic research as well as certain practical techniques indicate the acknowledgement of the significance of decreasing food waste, with the pertinent objectives being the analysis of the primary causes and sources, ongoing monitoring, and promotion of control and reduction strategies.

By reducing food waste, many benefits can be obtained: for health (reduction of diseases, avoidance of premature mortality etc.), resource savings (resource savings from forestry, agriculture and fishing), ecosystem benefits, social benefits (food bank, donations) etc.

It has also been found that the use of certain packaging that uses different innovative materials can lead to a number of benefits, such as: saving money by reducing overbuying and disposal costs, reducing environmental impact, supporting efforts to eliminate hunger , reducing health-related problems; eliminating odors, supporting community efforts to reduce waste, increasing tax benefits through food donation, conserving energy and reducing greenhouse gases.

In conclusion, regardless of the means or tools to reduce food risk, it is necessary, first of all, to be aware of the size and intensity of the phenomenon and must be acted upon as such. Decision-makers, together with individual consumers, production or marketing units, must work together to identify the best solutions and measures, which ensure the achievement of the goal of reducing food waste per capita by 50% globally, at the level of the year 2030" (ONU, 2015).

The main challenge regarding food waste is determined by the lack of data and statistical indicators to help stakeholders understand the true dimension of this phenomenon. Moreover, this data must exist throughout the food chain, in order to accurately identify where the most is wasted. Currently, there is a proposal at the level of the Ministry of Agriculture and Rural Development to develop a national online platform for reporting food waste data by economic operators. It is also intended that the Ministry publishes on its own website, annually, certain relevant data regarding the progress made in the prevention and reduction of food waste. Last but not least, we can also mention the prospect of developing a national strategy for food waste, which will be updated once every five years.

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