

DOI: 10.15276/EJ.03.2023.9  
DOI: 10.5281/zenodo.10038788  
UDC: 502/504:349.6  
JEL: I12, D13, Q11/18, D24

## ANALYSIS OF THE CURRENT SITUATION AND MEASURES TO PREVENT FOOD LOSS AND FOOD WASTE IN UKRAINE

### АНАЛІЗ ПОТОЧНОЇ СИТУАЦІЇ ТА ЗАСОБІВ ЗАПОБІГАННЯ ПРОДОВОЛЬЧИХ ВТРАТ І ХАРЧОВИХ ВІДХОДІВ В УКРАЇНІ

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Received 12.08.2023

*Філіппов В.Ю., Сагітова Р., Волощук Л.О., Джек Л. Аналіз поточної ситуації та засобів запобігання продовольчих втрат і харчових відходів в Україні. Оглядова стаття.*

Зменшення втрат їжі та відходів набуває важливого значення в світі, де зростає кількість людей, що страждають від голоду, особливо після 2014 року. Викиди їжі призводять до екологічних проблем, включаючи викиди вуглекислого газу, що підсилюють глобальне потепління. Це може спричинити соціальні та економічні проблеми. Також важливо враховувати форс-мажорні обставини, такі як пандемія COVID-19, російське вторгнення та введення воєнного стану в Україні. Дослідження та адаптація українського досвіду управління харчовими відходами можуть бути корисними для інших країн у зменшенні та переробці харчових втрат і відходів на глобальному рівні. Дана стаття є проміжним результатом роботи проекту UUT17 (НДР №1877-01/17) «Оцінка можливостей запобігання, скорочення, переробки та повторного використання харчових втрат та відходів (ХВВ) в Україні».

*Ключові слова:* продовольчі втрати, харчові відходи, їстівна продукція, екологічна небезпека, соціальна небезпека, економічна небезпека, споживчий ланцюг, сільськогосподарська продукція, малі підприємства, форс-мажорні обставини

*Filippov V.Yu., Sagitova R., Voloshchuk L.O., Jack L. Analysis of the Current Situation and Measures to Prevent Food Loss and Food Waste in Ukraine. Review article.*

Reducing food losses and waste is of significant importance in a world where the number of people suffering from hunger is increasing, especially after 2014. Food waste leads to ecological issues, including carbon dioxide emissions that exacerbate global warming, and it can also result in social and economic problems. It is also crucial to consider force majeure circumstances such as the COVID-19 pandemic, Russian invasion, and the declaration of martial law in Ukraine. Studying and adapting the Ukrainian experience in managing food waste during force majeure situations can be beneficial for other countries in reducing and processing food losses and waste globally. This article is an interim outcome of the UUT17 project (Research Project No. 1877-01/17) "Evaluation of opportunities for prevention, reduction, recycling and reuse of FLW in Ukraine".

*Keywords:* food losses, food waste, edible products, ecological hazard, social risk, economic risk, consumption chain, agricultural production, small businesses, force majeure circumstances

**R**educing food and waste losses is important in a world where the number of people suffering from hunger is little by little growing, especially since 2014, with numerous tons of food being lost and/or consumed every day. Discarded food causes an environmental hazard due to the release of carbon dioxide, which increases the global greenhouse effect. Food waste also contributes to excessive consumption of fresh water and fossil fuels, which, together with methane emissions from food decomposition, has an undeniable impact on global climate change. In addition, there may arise social risks, since food shortages provoke hunger, and economic danger, since enterprises receive financial losses or lose profits, which in turn negatively affects the country's economy.

Unfortunately, in Ukraine, food is lost at all stages of the consumption chain: from agricultural production industry to final consumption by households. In economically developed regions, the food is mostly lost at the stage of consumption, that is, food is thrown away, even if it is still suitable for consumption. In depressed regions, most of the food is lost at the stages of production, storage and processing, mainly for two reasons: there are worse production technologies and underdeveloped storage infrastructure for storing products.

The volume of food loss and waste in Ukraine confirms the need to develop and implement specific measures to reduce food losses. Such measures vary between subjects and depending on the food chain stages. Given the fact that most of the agricultural products in Ukraine are produced by small and medium-sized business entities, it is necessary to assess the possibilities of preventing, reducing, processing and reusing food loss and waste. To achieve this goal, necessary is getting an answer to such questions in the Ukrainian context:

- what are the drivers of food loss and waste management?
- which food is mostly lost or wasted?
- at what point the food is lost or wasted?
- what businesses exist to deal with food waste effect?
- how do Ukrainian companies manage the food waste?

An additional factor that should be taken into account is force majeure, the negative consequences of which the entire Ukrainian economy, and especially agricultural producers and sellers of finished food products, have felt over the past three years. Such force majeure circumstances include the global Covid-19 pandemic, the Russian invasion to Ukraine and, as a result, the introduction of martial law, the loss of full control over some territories. All of those factors significantly changed the already existing problem to an even larger scale.

It is necessary to distinguish the factors of force majeure influence from the human factor of handling food loss and waste, because not all of them are amenable to counteraction—some of them can be used as an experience and adapted for use, for example, in peacetime. This will render possible to apply the Ukrainian practice of preventing, reducing, processing and reusing food loss and waste at the world level.

### **Analysis of recent researches and publications**

Although global research on food loss and waste has been conducted for a long time, the Ukrainian scientific community begun to pay attention to this problem relatively recently. So, some global studies have been established that evaluated the implementation of policies aimed at reducing food losses and that would be useful for use in Ukraine. For example, the Albizzati P. et al. [1] study focuses on France, where companies are required to reduce food waste by redistributing excess food to charities or animal feed. This study shows that reallocation has both environmental and economic benefits, as it has helped retailers reduce their costs. However, the causes and, as a result, methods of solving the problem in developed and developing countries differ essentially. This is described by Adam A. et al. [2], pointing out that the losses of developing countries are focused on food production and storage, while developed countries suffer from extravagance and consumer behavior.

Experts from the UK Jack L. and Hammans H. [3] conducted a study analysing the food prices and determined that it is more fair to distribute costs along the supply chain, supporting not only affordable food, but also better incomes for those working in the agricultural sector.

According to Ghosh R. and Eriksson M. [4] most research has focused on quantifying food waste through the role of retail sellers in supply chains. But in order to be able using world experience, change practices and contribute to the Ukrainian economy, it is necessary to go beyond quantitative determination.

In Ukraine, the study of food loss and waste occurrence was carried out by Sedikova I.A., Dyachenko Yu.V. [5], Kovalenko O., Yashchenko L. [6], Teodorovych L., Kiyanytsa M. [7] who determine the causes of losses in the food chain: from primary production to consumption. Kotikova O. et al. [8] do propose measures to reduce food loss and waste, and Hahula B. [9] reveals the economic aspects of the formation of innovative development of waste-free production and food waste disposal.

At the same time, the researchers agree on one point: not end users, but the business sector is one of the powerful generators of food loss and waste, although consumers also play a significantly weighting role in this matter.

As additional sources of information we consider both global and local research of world and Ukrainian organizations that care about a sustainable future. Among them are the UN as well as its programs and organizations, such as the Food and Agriculture Organization (FAO), the All-Ukrainian environmental League (aUEL), and the Bioenergy Association of Ukraine (UABIO).

The study of the best international practices and Ukrainian experience in managing food loss and waste is important, as it will contribute to identifying opportunities for the current situation improvement.

### **Unsolved aspects of the problem**

The problem posed has existed for quite a long time and despite all the counteractions developed earlier, it continues to increase. In normal peacetime, the issue of reducing food loss and spoilage should be seen as a means to achieve food security and improve nutrition, reduce greenhouse gas emissions, reduce the burden on water and land resources, and increase productivity and ensure economic growth.

Before the Russian invasion to Ukraine in 2022, the volume of national household waste was 1.5 times higher than the European average. The Ukrainian situation is special for the world, because in the conditions of martial law, military operations and annexation or temporary occupation of territories, enterprises making part of all stages of the food production chain suffer greatly. Due to the critical infrastructure destruction and, as a result, power outages, which in turn can lead to a complete blackout for several hours, or even days or weeks, sales companies may not provide decent storage conditions for food products.

However, whichever challenges being they also open up opportunities to prevent possible food loss and waste. Today, in the business environment, priority is given to initiatives to optimize business processes in order to maintain profits and reduce financial costs. Assessing the points of losses occurrence at all stages of the production and sales chain, determining their formation cause-and-effect relationships, maintaining statistics records and monitoring are complex, intersectoral and expensive processes, and their economic benefits for an individual enterprise are not obvious.

At the same time, for small and medium-sized businesses, many practices for reducing food losses remain inaccessible due to their high cost, economic instability due to the Russian invasion, or the complexity of legislative procedures. In this regard, in Ukraine, it is necessary that the state encourages business to reduce food losses on the entire production and sales chain: in agriculture, food industry, retail trade and public catering through compensation, providing benefits, subsidies, creating opportunities for cooperation with volunteer and charitable organizations.

It is the issue of reducing the food spoilage scale during force majeure that the ordinary consumers, business representatives, the government, and scientists, all of them should pay attention to today. This proves the problem urgency, especially in the Ukrainian context, since the difficult situation in which Ukraine finds itself forms a unique experience that any other country can use in the future.

### The main part

According to world-wide research (UN FAO [10, 11], DESA [12], OECD [13]), food produced but not consumed accounts for approximately 1.4 billion hectares of land, which is almost 1/3 of the planet's agricultural land. For the 7 billion inhabitants of the Earth, 1.3 billion tons of food worth more than 1 trillion are lost or unproductively spent. European and North American consumers discard almost 10 kg of food per 1 person per month to the trash. A total of 2.1 billion tons of garbage are produced annually in the world. Only 16% of this volume is recycled. According to global forecasts, by 2050 the world's population will reach 9.7 billion people, which will form up to +70% increase in food needs.

According to the United Nations, food waste production continues to grow worldwide, which is a serious problem. It is estimated that about 30% of the world's food is thrown away every year. Information on the level of food waste per capita in various regions of the world for 2017-2021 is shown in Table 1.

Table 1. Level of food waste per capita in different regions worldwide for 2017-2021

Region	Year				
	2017 (kg/person)	2018 (kg/person)	2019 (kg/person)	2020 (kg/person)	2021 (kg/person)
N. America	95.4	96.0	97.1	98.2	99.3
Europe	97.7	98.2	99.1	100.1	101.1
L. America	64.3	64.7	65.2	65.7	66.2
Asia	63.5	63.8	64.1	64.4	64.7
Africa	45.2	45.6	46.1	46.6	47.1

Source: compiled by authors on materials [11, 20]

Table 1 shows that European countries have the highest rates among others. According to the Food Sustainability Index, about a third of all food in the world is produced but not consumed, which leads to a large amount of food waste. In addition, today the world produces annually 2.5 billion tons of hard-to-decompose food packaging varieties, and only half of those packages are disposed of by "sustainable methods" – this forms a global trend for the growth of the waste processing industry and the transition to a circular economy.

According to the "Food Waste Index 2021" study of the "United Nations Environment Program" report [15] and according to Statista [16] Table 2 shows an estimate of household food waste (based on measured data points or extrapolation) for some European countries, which implies that household waste in Ukraine is 76 kg per capita, similar to the UK (77 kg per capita).

Within the framework of the UN Save Food Initiative, FAO and the United Nations Environment Programme (UNEP) (an intergovernmental program created on the initiative of the Stockholm UN conference on the environment in 1972 and the decision of the UN General Assembly in 1973) and stakeholders agreed this definition of food and waste losses [14, 15]:

— food loss is a decrease in the quantity or quality of food. Food loss in production and distribution segments in the food supply chain mainly depends on the food production and supply system or its institutional and legal framework;

— food waste (which is a component of food loss) represents any removal from the food supply chain of food suitable or potentially suitable for human consumption, but spoiled or expired, mainly due to economic behavior, poor inventory management, or neglect.

Table 2. Level of food waste per capita in different regions of Europe for 2021

Region	Country	Household food waste estimate (kg/capita/year)	Household food waste estimate (tonnes/year)	Confidence in
Eastern Europe	Bulgaria	68	478,667	Very low
	Poland	56	2 119 455	Medium
	Moldova	76	307,419	Very low
	Romania	70	1 353 077	Very low
	Slovakia	70	381,301	Very low
	Ukraine	76	3 344 904	Very low
Northern Europe	Denmark	81	469,449	High
	Norway	79	423,857	High
	Sweden	81	812,948	High
	United Kingdom	77	5 199 825	High
	Finland	65	361,937	Medium
	Lithuania	76	210,255	Low
Southern Europe	Greece	142	1 483 996	Medium
	Italy	67	4 059 806	Medium
	Spain	77	3 613 954	Medium
	Croatia	84	348,091	Low
	Portugal	84	861,838	Low
	Serbia	83	726,196	Low
Western Europe	Germany	75	6 263 775	High
	Netherlands	50	854,855	High
	Austria	39	349,249	High
	France	85	5 522 358	Medium
	Belgium	50	576,036	Medium
	Switzerland	72	616,037	Low

Source: compiled by authors on materials [15, 16]

Important components of this definition are the following:

- food waste is part of food loss, but the difference between them isn't defined;
- food redirected to non-food chains (including animal feed, compost, or waste redirected to bioenergy) is counted as food loss or waste;
- plants and animals produced for food industry contain "non-food parts" that are included as "food loss and waste" (these inedible parts are sometimes referred to as "unavoidable food waste").

To understand the situation of Ukraine on this issue, necessary is to consider a comparative table of the number of food loss and waste per capita of countries from the European Union countries that have the highest rates and Ukraine.

The data in Table 2 indicate that Eastern European countries, firstly, have very low confidence in evaluating the data provided, and secondly, even at the same time, they have quite high indicators. While the Nordic countries have a fairly high indicator of "confidence in the assessment of data provided". If we trust this data, it turns out that Ukraine generates the same amount of household food waste per capita per year as, for example, the United Kingdom.

Ukraine is one of the countries specific with a high level of food loss and waste. In terms of the amount of food waste in business activities, it ranks 6th among Eastern European countries, and in terms of the total amount of food loss and waste per capita-5th. The European Commission emphasizes that in Europe in 2021, an average of 173 kg of food loss and waste per inhabitant per year occurs. Ukraine ranks high in the overall ranking of European countries with an indicator that is above average.

Using the data in Table 2, one can build a summary graph with a separate indicator for Ukraine (fig. 1).

Figure 1 shows that Ukraine is in the middle position among other European countries, although according to FAO data for 2021, unofficially, the average Ukrainian generates 250-300 kg of food waste per year [14].

Typically, food loss is usually defined as food lost or wasted between the production enterprise/area to the retail enterprise level, while food waste includes food wasted at the retail and consumption stages.

According to FAO, about 14% of the world's nutritional products intended for human consumption are lost during business activities such as production, processing, storage and transportation. In addition, about 17% of products intended for human consumption become food waste during retail and consumption.

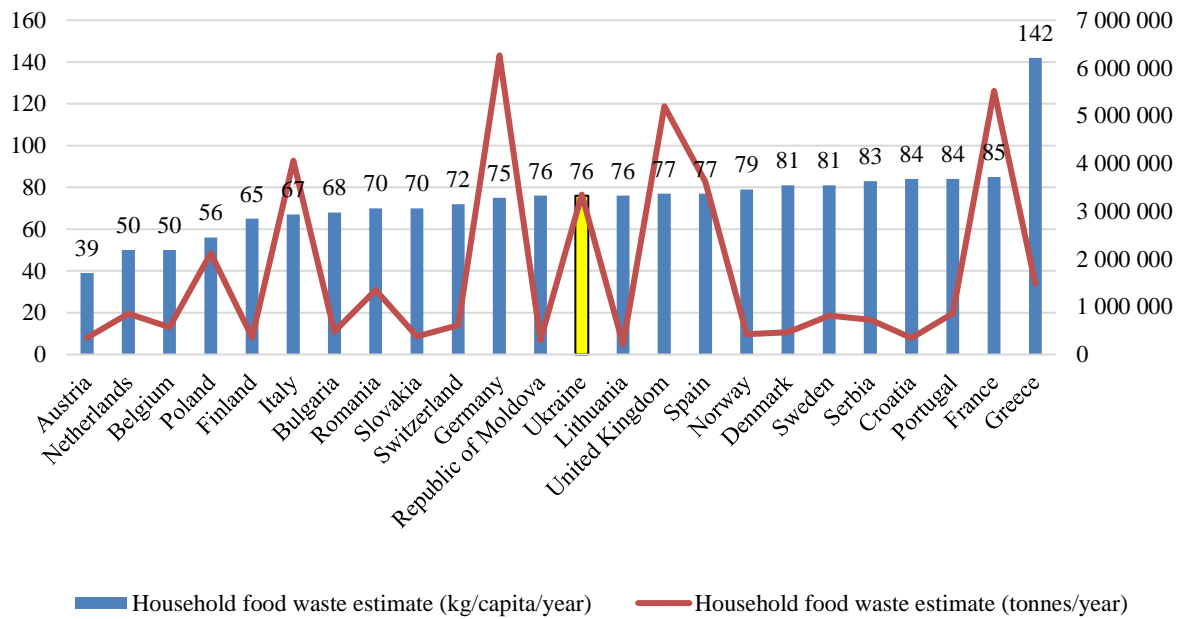


Figure 1. Per capita food waste levels in different regions of Europe in 2021

Source: compiled by authors on materials [15, 16]

The European countries and Ukraine reveal the following indicators of food loss and waste in business activities for 2020, which are shown in Figure 2 (unfortunately, there is currently no publicly available information on 2021 and 2022, since data on the amount of food loss and waste in business activities have not yet been made public by FAO and other relevant sources at the moment).

Meanwhile a number of countries and regions are beginning to take measures to reduce food waste production, particularly by promoting food processing, reducing waste during production and packaging, and consuming leftover food.

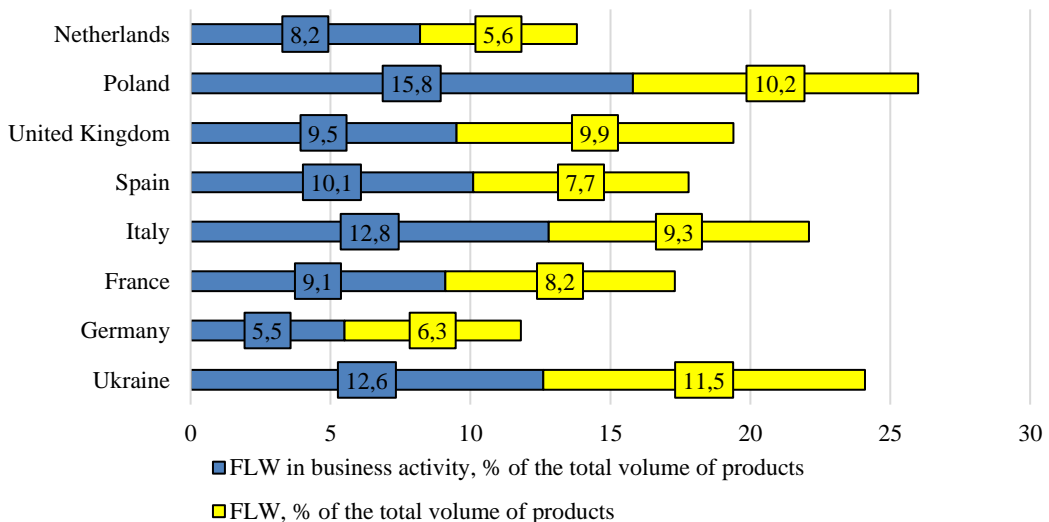


Figure 2. Number of food loss and waste in business activities in Europe and Ukraine in 2020

Source: compiled by authors on materials [12, 18]

The UN has developed an Agenda for Sustainable Development up to 2030, which deals with the problem of food loss and waste [18]. The Sustainable Development Goals (SDGs) have a direct impact on the management of food loss and waste in Ukraine (Table 3).

SDG No.2, "Ending hunger, ensuring food security and improving nutrition", identifies the need to increase access to food and reduce the loss of food resources. To this aim, it is necessary to improve infrastructure related to food storage, transportation and distribution, develop local food systems as well as to support small agricultural producers.

Table 3. Compliance of the Sustainable Development Goals and their objectives with the problem of food loss and waste

SDG	Tasks	Relationship to food loss and food waste
2	2.2	Reducing food losses at the production stage
	2.3	Reducing food losses in the supply chain
	2.4	Reducing food losses and maintaining productivity in agriculture
6	6.3	Minimization of environmental pollution due to improper disposal of food waste
8	8.4	Reducing losses at workplace by improving waste management
12	12.2	Reducing waste by optimizing production processes
	12.3	Raising consumer awareness and reducing losses at the producer level
	12.5	Reducing supplier-level waste through effective management
	12.6	Encouraging companies to adopt environmental practices
13	13.1	Minimization of the environmental impact from food waste. Improving resource efficiency

Source: compiled by authors on materials [12, 18, 19]

In particular, SDG No.6 "Clean Water and Sanitation", CSR No.8 "Decent Work", SDG No.12 "Responsible Consumption and production" provides for reducing food losses at every stage of their life cycle, from production to consumption. The UN Agenda for the period up to 2030 calls for a substantial reduction in waste through "prevention, reduction, recycling and reuse", this can be achieved through the rational use of resources, in particular water, energy and land, reducing waste and improving the processes of food storage and transportation.

Also, SDG No.13 "Measures preventing from climate change" aims to reduce greenhouse gas emissions that occur during the decomposition of food waste. This can be achieved by introducing more efficient technologies for reprocessing and recycling food waste [20].

Thus, the Sustainable Development Goals can help reduce food losses and waste in Ukraine, which will help improve food security, reduce resource losses and reduce the negative impact on the environment. To achieve these SDGs, necessary is to improve the collection and processing of data on food losses and waste, to support the development of innovative technologies and establish cross-sectoral partnerships between government, business and the public [21].

Drivers of food loss and waste management in Ukraine. Ukraine is a country where a significant level of food loss and waste creates a serious problem for ensuring the safety of food for the population and sustainable economic development. The main drivers and, at the same time, problems of food waste management and losses in Ukraine are:

- insufficient infrastructure and equipment for the collection, processing and disposal of food waste.
- low public awareness of the importance of rational food consumption and waste disposal.
- insufficient regulatory framework and the national legislation on food waste management non-compliance with EU norms and standards.
- low level of innovations introduced and low technological efficiency of food production and processing.
- lack of efficient mechanisms for food waste controlling and monitoring at different stages of its life cycle.

To overcome these challenges, required is to implement comprehensive measures, such as raising public awareness, improving infrastructure and processing technologies, developing effective systems for controlling and monitoring food waste, and establishing strict norms and standards for the management of food waste and losses.

In addition, Ukraine has been affected by the military conflicts in the Donbass since 2014 and those conflicts impact on the food security level in the region. As a result of this conflict and other economic difficulties that have occurred in Ukraine in recent years, food security problems have increased in some regions and the amount of food waste has increased.

According to the state statistics service of Ukraine [17] a clear example of undesirable food loss is the situation in 2019. That year, 64.9 million tons of grain crops were harvested in Ukraine, but only 51.3 million tons of them were suitable for consumption, that is, almost 13.6 million tons of grain (or 21%) were lost due to unsuitable storage and transportation conditions. In addition, according to the Ministry of Economic Development, Trade and Agriculture of Ukraine, at the level of retail sales and public catering, food losses account for about 30%, and food waste amounts to about 20% of the purchased products volume.

Ukrainian enterprises deal with food loss and waste under the influence of many different factors, including the following:

- economic: raw material prices and other production costs are the main factors that affect the management of enterprises with food waste and losses. For example, when raw material prices rise, businesses may try to reduce losses and waste to reduce production costs;
- regulatory: the Ukrainian government sets legislation and regulatory standards that render their effect on how businesses handle food waste and losses. For example, legislation may prohibit the disposal of food waste in landfills or set standards for their processing;

- social: social pressures, demand for sustainable development, and ethical factors can also influence businesses' handling of food loss and waste. For example, many consumers believe that businesses should be environmentally responsible and reduce waste;
- technological: using the latest technologies and innovations can help businesses reduce losses and waste. For example, using technologies to control raw material costs and reduce production losses can help reduce waste;
- market (competitive factor): can also affect how businesses handle food loss and waste. For example, if one enterprise reduces production costs, in particular waste reduction, it can lower the prices of its products and compete with other enterprises in the market;
- environmental: the growing interest in sustainable development and environmental conservation can also affect the management of food loss and waste by businesses. Both legislation and regulatory standards may impose restrictions on the disposal of food waste and require businesses to process it, which may affect the choice of waste management technologies and methods.

In general, the enterprises' policy on food loss and waste management in Ukraine depends on many factors, such as economic, regulatory, social, technological, competitive and environmental. At the same time, reducing the amount of waste and losses can be an effective means of reducing production costs and improving the enterprises' competitiveness, as well as essentially contribute to sustainable development and environmental conservation.

In 2021, SMEs account for 99.7% of the total number of entrepreneurs in Ukraine. The majority of SMEs are microenterprises (96%). This sector accounts for 64% of value added, so changes within microenterprises have a significant impact on the Ukrainian economy. In addition, it can be argued that SMEs are more vulnerable to food loss and waste compared to large companies.

So, according to general estimates, the level of food loss and waste in Ukraine, has been high in recent years and requires attention and additional measures to reduce losses and improve the efficiency of the food chain. Studying microenterprise and waste management practices can help reduce related costs and benefit SMEs and the economy as a whole.

Let's look at the main issues related to food losses and the best practices of Ukrainian companies regarding food waste management in Ukraine.

Which food is mostly lost or wasted? Unfortunately, in 2022, Ukraine faced Russia's military aggression, which led to significant loss of human lives, material damage and destruction of infrastructure. In addition, food losses as a result of the war increased, taking into account the overall damage caused to the Ukrainian economy. Unfortunately, military operations have affected food security and the availability of food products, reducing their quantity and quality, while increasing their cost.

Table 4. Food losses and food waste by regions of Ukraine in 2021, according to the State Statistics Service of Ukraine

Region	Food losses, thousand tons	Food waste, thousand tons
1. Vinnytsia	44.1	4.4
2. Volyn	70.4	4.4
3. Dnipropetrovsk	134.3	16.8
4. Donetsk	56.5	10.2
5. Zhytomyr	61.3	5.5
6. Zakarpattia	45.5	1.6
7. Zaporizhia	48.9	8.7
8. Ivano-Frankivsk	29.5	2.0
9. Kyiv	52.2	11.3
10. Kirovograd	37.3	3.3
11. Lugansk	40.2	5.9
12. Lviv	89.4	10.4
13. Mykolayiv	26.8	3.3
14. Odessa	116.8	15.5
15. Poltava	57.2	5.7
16. Rivne	54.4	3.9
17. Sumy	42.2	3.7
18. Ternopil	25.5	1.8
19. Kharkiv	84.8	8.9
20. Kherson	29.5	2.7
21. Khmelnytsk	41.9	3.8
22. Cherkasy	34.8	3.1
23. Chernivtsi	20.6	1.0
24. Chernihiv	26.6	2.2

Source: compiled by authors on materials [17]

In the retail sector, the largest losses are observed in the categories of fruits and vegetables, as well as ready dishes. Product losses can account for up to 50% of total production in some product categories. Data on food

losses and food waste by region using data from the state statistics service of Ukraine for 2021 are shown in Table 4.

Table 4 demonstrates that the conditional leaders in this problem are the Dnipropetrovsk and Odessa regions (fig. 3). However, in 2023, the situation will change, since parts of some regions of Ukraine are temporarily occupied by the russian invader.

For example, in 2022, during the vegetable harvesting season, entrepreneurs of the Zaporizhia and Kherson regions could not fully sell the harvest of vegetables and fruits that simply rotted in the fields or warehouses due to the producer's inability to export them. Tons of agricultural products ended up in the trash; these were cucumbers, tomatoes, cherries, watermelons, and other perishable crops.

Ukraine is one of the leading countries worldwide in the field of production of grain and other cereals, including oilseeds. However, russia's aggression impacted the agricultural sector in the country, in particular the production, storage and transportation of products. Because of that, the food loss and waste indicators in Ukraine in 2022 may change dramatically. Therefore, we should separate the force majeure influence on these indicators.

According to data published by the State Statistics Service of Ukraine, food losses in Ukraine in 2020 amounted to 2.6 million tons, and in 2021 – 2.8 million tons [17]. The most expensively lost products in Ukraine are bakery products, dairy and meat products, vegetables and fruits:

- meat and meat products: 260 thousand tons;
- fish and fish products: 22 thousand tons;
- milk and dairy products: 107 thousand tons;
- vegetables and fruits: 180 thousand tons;
- bakery products: 110 thousand tons;
- confectionery products: 15 thousand tons;
- other products: 38 thousand tons.

The situation in the Odessa region may be interesting for studying the problem of opportunities for preventing, reducing, processing and reusing food losses and food waste, since there were almost no military operations on its territory, but it received a large number of displaced persons (IDPs) from other regions.

The sphere of food products production and sale, the public catering enterprises is invariably associated with the accumulation of food waste, illiquid products and products with expired sale terms. Such waste is forbidden to be thrown in the trash, it is subject to disposal by specialized companies.

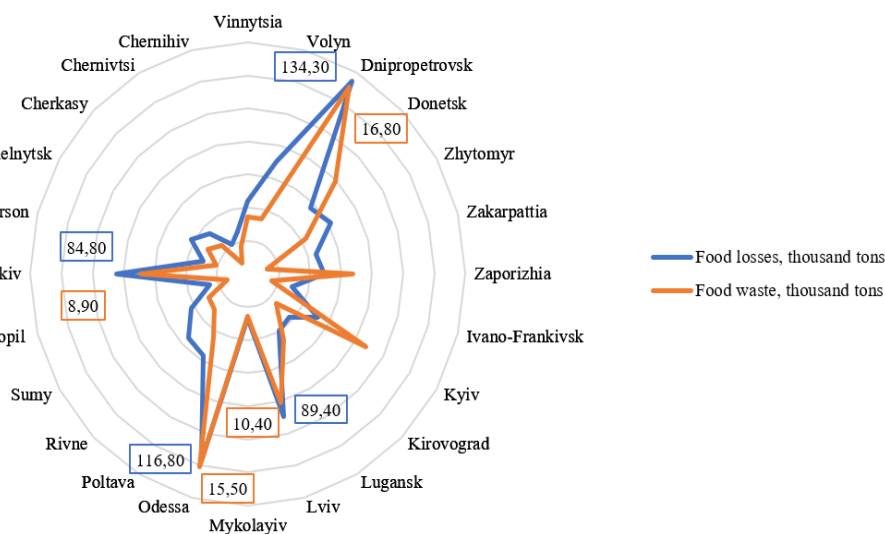


Figure 3. The largest number of food losses and food waste by the regions of Ukraine in 2021  
Source: compiled by authors on materials [17]

The HoReCa sector is one of the most powerful producers of food waste. Most restaurants, hotels, cafes and food businesses tend to overprepare/overproduce products, as this is more economically profitable and has a positive impact on the level of Service-dishes are available in large quantities and there are no delays in cooking. Some sector managers believe that producing food in large batches minimizes costs, but in reality it leads to an increase in waste compared to custom cooking or small batches. Excessive volumes of trade in food products and these goods in retail centers, wholesalers and supermarkets often lead to the loss of products, as the consumer's attention is scattered over a huge assortment and a significant part of the goods are not sold. Every year, the average Ukrainian throws into the landfill about 250 kg of household waste, half of which is food.

Fruits, vegetables, meat products, eggs, bread are the most popular items in the food list of Ukrainians. When buying goods, only a small part of the population thinks about the consequences of excessive consumption. Fruits, vegetables, root vegetables, and potatoes have the highest loss rates among edible fruits. FAO estimates



that 1 kg of discarded food causes 2 kg of carbon dioxide (CO<sub>2</sub>) emissions, which increases the global greenhouse effect.

Ukrainian enterprises can engage in various types of economic activity, and therefore, food costs may vary depending on the field of activity of the enterprise. For example, in the restaurant industry, there may be a large loss of fresh food, such as vegetables and fruits, due to insufficient demand or improper storage. In the grocery industry, there may be a large loss of ready meals and confectionery products due to the limited shelf life.

To reduce food losses, businesses can use various approaches, such as inventory planning, the use of storage and conservation technologies, inventory monitoring, and the use of resource management programs. Optimization of production processes, use of waste processing technologies, as well as improving inventory management and product quality control can also be an effective tool.

At what point the food is lost or wasted? Food may lose its freshness or become unusable at any time if the necessary storage and transportation conditions are not met. Such conditions include proper temperature, humidity, ventilation, and other factors that ensure safe food storage.

Ukraine has certain rules and standards for the storage and transportation of food products, which are regulated by the relevant state authorities. In particular, national standards provide for requirements for the storage and transportation conditions of various types of products, including meat, fish, dairy products, fruits and vegetables, etc.

Food products may lose their quality and become unsuitable for consumption due to various reasons, such as violation of storage conditions, non-compliance with hygiene and sanitation rules during processing and transportation, as well as when influenced by harmful microorganisms. Food can be lost or consumed at different stages:

- production: at this stage, losses may occur due to bad weather conditions, pests, plant diseases, and other natural factors. Also, losses may occur due to insufficient use of agricultural machinery or negligence during harvesting;
- transportation: products may be lost due to insufficient packaging, carelessness during transportation, as well as due to artificial factors such as theft, fires, and other accidents;
- storage: food loss can occur due to poor storage conditions, such as insufficient ventilation, excessive humidity, pests, rot, and other natural factors. There may also be losses due to negligence during storage or lack of appropriate equipment for storing food;
- retail stores: food products may be lost due to expiring expiration dates, insufficient inventory control, and poor staff attitude;
- consumption: products can be discarded due to unfair treatment of food, unnecessary purchases, lack of appropriate packaging or storage, and other factors.

Thus, food losses and costs can occur at any stage of the food chain. Ukraine is no exception and food can be lost at any time point, from its production to consumption. At the same time, the risk of food losses and an increase in food waste augments due to military operations on the territory of Ukraine. The latter can affect food loss due to various factors:

- first, a military conflict can disrupt transport routes and lead to a decrease in food supplies to regions affected by military operations. This can lead to an increased risk of losing products on the way to the consumer;
- secondly, war can lead to a decline in food production due to reduced availability of workers and materials, limited sales markets, reduced financial stability of enterprises, and so on. This can lead to an increased risk of losing products that cannot be sold or stored quickly;
- third, war can lead to an increase in the number of IDP and refugees who need additional food provision and assistance. This can involve an increase in demand for food and an increased risk of loss due to insufficient resources to meet the needs of the population.

However, the Ukrainian government and international organizations are developing and implementing programs to help those affected by the war in Ukraine, including food aid and other types of assistance.

What businesses exist to deal with food waste effect? In Ukraine, there are several organizations trying to counteract the problem defined by the world. One of them is the All-Ukrainian Environmental League (aUEL, a public organization whose goal is to improve the environmental situation in the state, the formation of a new environmental mentality), dealing with the problem of food waste rapid accumulation and the fact that the trends in the development of the economy worldwide have led to a conditional division of the population into two categories: some people live in conditions of overproduction, still the others experience acute food shortages [22].

As noted by the Ukrainian internet information resource "Sustainable Development for Ukraine" the food waste are any food products that are lost due to waste, neglect and our behavioral habits, but could be eaten. Approximately 30-50% of all waste is organic waste, that is, food residues: scraps of vegetables, fruits and herbs, leftovers, spoiled food, bones, sometimes wilted flowers, leaves. This is a classic set of trash cans in its organic form [23]. In Ukraine, there are enterprises that are working on the problem of reducing those wastes. Here are some of such enterprises:

"BioEnergy" is an enterprise that processes organic waste into biofuels and organic fertilizer materials. They have technologies for processing various types of waste, such as food waste, plant material, solid household waste, and others.

"EcoFruit" is a social business that collects and processes unsold fruits and vegetables from supermarkets and markets. They create fresh juices and syrups from them, which are sold in supermarkets and online stores.

"Waste no Food" is a charity organisation that collects unsold food from restaurants and cafes and processes it into ready meals distributed to the homeless and people in difficult life circumstances.

"Eco-Soft" is an enterprise that creates software for monitoring waste and its processing in organizations such as hotels, restaurants, and others.

"Kramar Eco" is a European-level customer service company. It has a wide range of operational activity: from the removal of household, large-sized and construction debris, the removal of leaves and branches, snow removal and transportation, stumps uprooting to the full disposal of food waste. It also carries a certain social mission and helps people.

"Refood" is a company that offers services for collecting and processing organic waste in various sectors, such as hotels, restaurants, grocery stores and others.

"FoodHero" is an online service dedicated to fighting food waste by helping restaurants and supermarkets sell unsold products at a reduced price through its mobile app.

"FoodCloud" is a charity organisation that collects unsold food from supermarkets and distributes it to local charities that provide food to people in need.

"Eco Food" is a company that processes food waste into electricity and heat. They also produce organic fertilizers from waste processed.

This is not a complete list of companies that deal with the problem of food waste in Ukraine, but these companies can become a source of inspiration for those who want to deal with this problem in their region.

One of the areas of these enterprises' work is the expired food disposal. Expired products to be disposed of:

- beer, wine and vodka products;
- juices, carbonated drinks;
- meat products (chicken, beef, pork, etc.);
- fish products;
- canned food;
- dairy products (cheeses, cottage cheese, milk, etc.);
- products of plant origin.

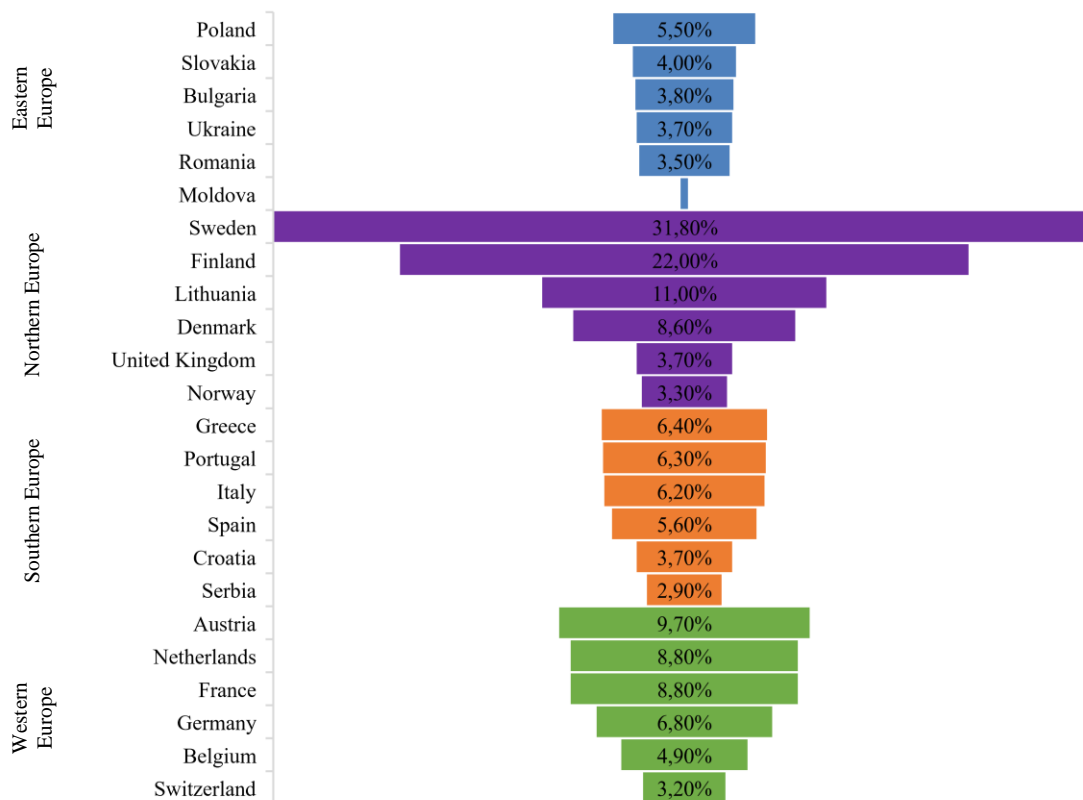


Figure 4. Percentage of biofuel use in Europe in 2021  
Source: compiled by authors on materials [26, 27]

Rotting of organic residues in landfills uncontrollably pollutes the soil and water, destroys the flora and fauna in such area. In addition, product packaging is often made of long-decomposing elements that cannot neutralize the harmful effects without recycling. Food disposal is carried out using a special technology, in accordance with regulations and requirements for Environmental Protection [24].

Here convenient will be to note the best achievements in biofuels sphere. Food waste can be used for the production of biofuels in biogas plants or in the process of processing into renewable fuels such as biodiesel. Figure 4 shows the percentage of biofuel use in Europe in 2021 according to the European Commission's Annual European Union report on biofuels and other renewable transport fuels [26].

Recycling food waste into biofuels can help reduce greenhouse gas emissions, therefore reducing the environmental pollution. This is proved by the successful global practice of microenterprises that successfully operate in various industries, including the production of biofuels, in particular:

"Biodiesel Amsterdam": this company from the Netherlands is a microenterprise that produces biodiesel using local waste such as coffee lumps and oil.

"Green Fuels Ltd.": this UK company is a leading manufacturer of equipment for the biodiesel and other types of biofuels production. This is a microenterprise with a small staff.

"PetroAlgae Inc.": this is an American microenterprise that produces biofuels from microscopic algae. They use technology that allows growing algae on waste from other industrial processes.

These companies are just a few examples of successful biofuel microenterprises in the world. In Ukraine also there are many microenterprises that produce biofuels or those fuels components. Below are some examples of microenterprises in Ukraine:

"Ukrainian Biofuel Company" is a microenterprise that produces fuel pellets using biomass and wood.

"Bionet-Eco" is a company that produces biofuels from organic waste, including food, plant residues and solid household waste.

"Eco Energy" is a microenterprise that produces biofuels from various types of biomass, including fuel pellets, boiler biomass and biodiesel.

The Ukrainian government also applies best efforts to develop a biofuel-based energy system aiming not only to reduce greenhouse gas emissions, but also to improve the national energy security. In 2018 the share of biofuels in the total volume of primary energy was 3.4%, with growth forecasts in the future, for example, in 2021 this figure was already 3.7%. The Ukrainian Association for Bioenergy (UABIO) demonstrates that most of the biomass consists of plant residues and energy crops, and not food waste. While spoiled food would be an obvious choice for biofuels, there may be even better sustainability solutions. There is potential to prevent, reduce, recycle and reuse spoiled food [27].

Ukrainian production of biofuels from food waste is developing, but it is not yet properly developed. However, over time, interest in using food waste for biofuel production increases and progresses. There are several successful examples of companies producing biofuels from food waste, although this is not yet a large-scale industry:

"Biosphere" is a company that processes biological waste into biofuels. They produce biogas, biodiesel, and other biofuel products.

"Ecodepo" is a company that specializes in processing waste from food markets into biofuels. They use biodestruction technology to produce biogas and other products.

"Euroecology" is an enterprise that produces biogas from food waste. They collect waste from restaurants, cafes and other food establishments, process it into biogas and use it to generate electricity.

"Greenway" is a company specialized in the production of biodiesel using food waste. They collect waste from fast food, recycle it, and use it to produce biodiesel that can be used in diesel engines.

"BIOPOWER Ukraine" is a company that specializes in processing plant and animal waste into biofuels. They produce biogas and biodiesel, and use waste to produce organic fertilizers.

"Green Fuel": this company is engaged in the production of biodiesel using food waste. They collect waste from restaurants and other food establishments, recycle and use it to produce biodiesel that can be used in diesel engines.

These companies are also examples of successful production of biofuels from food waste in Ukraine. However, with the development of technology and an increase in interest to the use of biofuels, we can expect that the production of biofuels from food waste in Ukraine will surely augment. Ukraine has a significant potential for biofuel production, as the country has significant biomass reserves, as well as a significant demand for environmentally friendly fuel. Therefore, we can expect further development of the biofuel production industry in Ukraine, including from biomass obtained from food waste.

How do ukrainian companies manage the food waste? The interests of consumers are related to increasing the food products availability as well as improving their quality.

For example, some companies donate excess food to service organizations or send it to animal feed, compost, or energy production. Others entities have launched waste awareness campaigns. And Unilever, Starbucks and Dairy Farmers of America have formed a strategic alliance and will process waste that cannot be eliminated for energy.

One of the possible ways to use innovative food storage technology can be Smart Packaging, or expanding the packaging functionality with its transformation into a full-fledged data carrier, changing the role from

passive packaging to active, which in turn will lead to an increase in shelf life. The UK example in this sphere is also useful for Ukraine, as in UK "hot" containers for food waste composting are being tested, and Finnish supermarkets have introduced "Happy hour" to minimize waste from shelves [25].

It is also important to address one of the "priority verticals" identified by the Ukrainian government in the direction of Food tech/Agtech; in particular, the management of food loss and waste. FoodTech (Food Technologies) is the integration of digital and biotechnologies across the entire food chain, from farms and food production to food packaging, storage, preparation and disposal. For this purpose, the Government of Ukraine has adopted the National Waste Management Strategy for the period up to 2030 aimed on switching to an integrated waste management system. In Ukraine, all garbage is sent to the landfill almost even without sorting. The Ukrainian government could reduce the amount of household waste, but it is necessary to understand at what food chain stage the majority of losses and food waste occur [16].

In Ukraine, there are various public initiatives, charitable foundations, NGOs and commercial companies dealing with this problem. For example, Food Bank "Ukraine", Institute of Food Preservation, "Zero Waste Ukraine", "Steps of Ukraine" Foodbank, European Federation of food banks in Ukraine, Association of producers and consumers "Fresh and Safe", NGO "Eco Nutrition" and others. In addition, Ukraine also has various projects and programs aimed at reducing losses and processing food waste, such as "Fresh Look", "Green Home", "Foodrezku", "Stop Waste" and others. They have different approaches to food waste management, but in general they can be said to focus on minimizing food losses, processing food waste, introducing innovative technologies, collaborating with other companies and organizations, as well as promoting a conscious consumption. The general trend is to reduce food loss and waste while maintaining product quality and increasing company profits.

However, although some Ukrainian companies pay attention to food waste management, in general, the problem with waste management in Ukraine remains high. The lack of an efficient system for waste collection and processing, the lack of knowledge and awareness about the food waste dangers among the population as well as the lack of infrastructure for waste processing are still significant problems that require attention and solutions from Ukrainian companies and the government. Current problems in a generalized form [23] such:

- the level of waste processing is 5-7%;
- more than 90% of garbage is sent to landfills and unauthorized landfills;
- presence of fictitious waste disposal;
- absence of full-fledged separate garbage collection system (processing entities are forced to buy plastic abroad).

The need for new technological solutions:

- improved mechanical, thermal and barrier properties;
- accelerated biodegradation, more complete decomposition;
- increased shelf life of products, protection from germs;
- damage indication, reaction to environmental factors, self-cleaning;
- product authenticity indicators, new tracking technologies.

In order to minimize losses and to render efficient the by-products use by business entities, it is necessary to implement:

1) Optimization of the sales cycle:

- rejection of the existing "clogged shelves" concept in retail chains,
- transfer of food suitable for consumption, to charity,
- use of by-products in secondary food production;

2) Waste recycling:

- use of food waste and the food industry and agriculture by-raw materials for the production of animal feed,
- processing of organic waste into soil and fertilizers,
- obtaining thermal energy through the incineration of organic waste,
- industrial release of associated gases (production of biofuels).

Efforts to reduce food loss should be considered in terms of resource management and getting some value from the various participants involved. Therefore, state authorities should be interested, among other things, in reducing food losses referring to the following interests:

- strengthening the country's food security;
- reducing social tension (due to increased food availability);
- reducing the environmental burden on the environment;
- preservation of land and water resources.

Using sociological tools for initial data collection from businesses can be very useful in identifying the range of problems associated with food loss and waste. For example, one can conduct a survey among employees of enterprises about their understanding and awareness of the losses and waste problem, as well as about existing practices for these problems managing in the enterprise. In addition, it is possible to analyze consumer behavior and understand the problem of loss and waste among end users of products, for example, by conducting focus groups or consumer surveys.

Such research can assist to understand the problem nature and identify the main factors that contribute to losses and waste. This can help businesses to focus on solving critical problems and implementing effective waste and loss management strategies. For example, to assess the current situation and opportunities for preventing, reducing, processing and reusing food loss and waste in Ukraine, a private entrepreneur can be asked a certain questions series.

As a result of these questions review, possible is to summarize that to date, organic waste generators do not have both economic incentives to introduce organic waste management practices, as well as infrastructure opportunities for their collection and processing.

Efforts aimed at reducing food losses should be considered from the viewpoint of resources rational use and obtaining a certain value from the various participants involved; these are producers, consumers, retailers and public authorities:

- 1) For manufacturers, the advantages may be as follows:
  - improving economic efficiency through the use of undemanded by-products, their sale by interested market participants, improving the food products quality;
  - creating reputational benefits and added value in the eyes of investors and consumers;
- 2) The interests of consumers are related to increasing the food products availability, as well as improving their quality;
- 3) State authorities are also interested in reducing food losses referring to the interests of:
  - strengthening the country's food security;
  - reducing social tension (due to increased food availability);
  - reducing the environmental burden on the environment;
  - conservation of land and water resources;
- 4) Retailers (a retailer that sells goods or services to the consumer) can use the following options to reduce the waste amount:
  - removal of damaged products with a certain frequency or by separate agreement;
  - waste removal to the territory of a specialised enterprise where processing will be carried out;
  - separation of packaging and the product itself, identification and sorting of organic and inorganic materials;
  - some products placement in compost pits, use of packaging for secondary production.

Solving these problems by the listed participants together will help the Ukrainian economy become more socially, environmentally and financially sustainable.

## Conclusions

Based on the gathered data, it is evident that the primary drivers and obstacles hindering consumers from reducing food waste include the absence of local waste processing or disposal facilities, inadequate knowledge in waste management, and the absence of an educational component in the system. Additionally, there is an imperfect legislative framework for waste management in businesses that generate the most waste.

Given the absence of a centralized authority in Ukraine responsible for collecting and recording data on food loss and waste, it is imperative to employ sociological tools for the initial data collection from enterprises. This could involve conducting semi-structured interviews with management or other surveys to assess key factors. This approach will enhance our understanding of effective waste management alternatives tailored to the Ukrainian context.

By studying and adopting successful practices from European countries, Ukraine can substantially reduce the burden on landfills, reintroduce valuable materials into the economy, and attract additional funds for waste processing technologies, potentially involving both domestic and foreign container and packaging manufacturers.

Furthermore, exploring Ukraine's experiences in waste management during exceptional circumstances such as martial law and prolonged electricity shortages resulting from significant infrastructure damage caused by Russia's missile bombardment can offer valuable insights to other nations. These insights can aid in the development of innovative methods for preventing, reducing, processing, and reusing food loss and waste in adverse conditions.

## Abstract

In a world where the number of people facing hunger has been slowly increasing, notably since 2014, it becomes evident that reducing food losses and waste is of paramount importance. Every day, sizeable quantities of edible food go to waste, leading to significant ecological consequences. Furthermore, food waste contributes to excessive consumption of fresh water and fossil fuels, in conjunction with methane emissions from decomposing food products, which unquestionably affect global climate changes. Additionally, it can lead to social issues as food scarcity leads to hunger and economic problems, as businesses suffer financial losses or fail to generate profit, ultimately negatively impacting the country's economy.

Unfortunately, in Ukraine, food is lost at every stage of the consumption chain, from the production of agricultural goods to their final consumption by households. In more economically developed regions, most food losses occur during consumption, where food is discarded even when still suitable for consumption. In less

developed regions, the majority of losses occur during production, storage, and processing, primarily due to suboptimal production technologies and underdeveloped infrastructure for food storage. To achieve this goal, the research addresses the following questions in the Ukrainian context:

- What are the driving factors behind food loss and waste?
- Which types of food experience the highest levels of loss or wastage?
- At what stages in the food supply chain do these losses occur?
- What enterprises are actively involved in combating food waste?
- How do Ukrainian companies manage their food waste?

The extent of food losses and waste in Ukraine underscores the necessity to develop and implement specific strategies for reducing them, with varying approaches among stakeholders and across different stages of the food supply chain. Considering the absence of a centralized authority responsible for collecting and recording information on food losses and waste in Ukraine, sociological tools must be used for primary data collection from enterprises. These tools can include semi-structured interviews with their management or other surveys focusing on key components. This will provide better insights into waste management alternatives that can work within the Ukrainian context.

Moreover, studying and adapting positive practices from European countries can significantly reduce the burden on landfills, reintegrate valuable components from waste into the economic cycle, and mobilize off-budget resources for implementing waste management technologies involving packaging and container producers, including foreign ones.

Furthermore, research and the use of Ukrainian experience in waste management during wartime and other force majeure conditions, including prolonged power outages due to Russian missile attacks on critical infrastructure, can offer other countries new methods for preventing, reducing, processing, and reusing food losses and waste.

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#### Визнання:

UK-Ukraine twinning grants scheme – програма подвійних грантів (<https://www.twinningukraine.com>) для партнерства між Великою Британією та Україною у сфері наукових досліджень і розвитку, що фінансується Research England за підтримки Universities UK International та UK Research and Innovation. Координується Фондом Президента України з питань освіти, науки і спорту (<https://presidentfund.gov.ua>).

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#### Acknowledgment:

The UK-Ukraine R&I twinning grants scheme (<https://www.twinningukraine.com>) is a program aimed at fostering partnerships between the United Kingdom and Ukraine in the field of scientific research and development. This initiative is funded by Research England with the support of Universities UK International and UK Research and Innovation. The program is coordinated by the President of Ukraine's Fund for Education, Science, and Sports (<https://presidentfund.gov.ua>).

#### Посилання на статтю:

Filippov V.Yu. *Analysis of the Current Situation and Measures to Prevent Food Loss and Food Waste in Ukraine* / V.Yu. Filippov, R. Sagitova, L.O. Voloshchuk, L. Jack // *Економічний журнал Одеського політехнічного університету*. – 2023. – № 3(25). – С. 71-87. – Режим доступу до журн.: <https://economics.net.ua/ejopu/2023/No3/71.pdf>. DOI: 10.15276/EJ.03.2023.9. DOI: 10.5281/zenodo.10038788.

#### Reference a Journal Article:

Filippov V.Yu. *Analysis of the Current Situation and Measures to Prevent Food Loss and Food Waste in Ukraine* / V.Yu. Filippov, R. Sagitova, L.O. Voloshchuk, L. Jack // *Economic journal Odessa polytechnic university*. – 2023. – № 3(25). – P. 71-87. – Retrieved from <https://economics.net.ua/ejopu/2023/No3/71.pdf>. DOI: 10.15276/EJ.03.2023.9. DOI: 10.5281/zenodo.10038788.

