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Research Paper

An assessment of food loss and waste in the Hungarian agri-food supply chain: Encouraging sustainable and conscious consumption

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Abstract: All through the entire supply chain, the agri-food sector has been negatively affected by significant shortages of resources, food loss, and waste. Managing the supply chain and pursuing sustainable lifestyles can be made easier through the assessment of food loss and waste. This study examines seven staple crops in the Hungarian food supply chain. The following food items were selected for analysis: wheat, maize (corn), rice, sorghum, barley, rye, and oats. Secondary data were compiled from the FAO (Food and Agriculture Organization of the United Nations) between 2009 and 2017. A PAST program was used to analyse the data, generate descriptive statistics, and pairwise comparisons with the Mann-Whitney tests were used to measure all seven crops' performance. Cluster analysis and multidimensional scaling were used to classify similarities between variables and, through the comparison of the amount of crop loss and waste, data in a two-dimensional space is depicted. This study provides two key findings. First, food loss and waste (FL&W) translate into resource shortages and unsustainable practices. Second, surplus food donation by corporations and conscious consumption at the consumer level is a solution to FL&W reduction. Furthermore, the use of five sustainable consumption guidelines is strongly suggested at the consumer level. To stabilize food security and sustainability, food producers, distributors, stakeholders, and policy planners must work together to improve food systems.

Keywords: food loss; measurement of food loss; food waste; supply chain; SDG 12; sustainability

1. Introduction

Globally, it is estimated that approximately one-third of the food produced does not reach consumers, i.e. 1.3 billion tons of food goes to waste each year (FAO, 2011). In the food chain, food waste and food loss generate negative externalities. In producing food, loss and waste degrade the environment and consume excessive energy and other natural resources. This also endangers human health, the world economic system, and food security (Fabi & English, 2018). An environmental protection organization in Budapest, WWF Hungary (2019), conducted a representative survey and found that the urban population in Hungary sees nature protection as the third most topical and fifth most important issue. Food waste is also listed as the seventh most critical concern. In Hungary, 62% of food waste occurs during the processing and production stages, and 38% occurs during household consumption and retail business activities (Bori, 2018). However, it has been discovered that the most perishable foods are thrown away in the highest quantities in Hungary. A variety of circumstances trigger food loss and waste (FL&W) in the supply chain, including a lack of field labour to support full harvests, insufficient storage and care during transportation, and an excessive focus on making food look good at retail (Lipinski et al., 2016). Previous research in Hungary discovered that the most common items wasted at the household level were cooked meals, bakery items, fresh vegetables, dairy foods, and fruits (Bori, 2018; Szabó-Bódi et al., 2018; Szakos et al., 2021).

Food systems have struggled to adjust to unforeseen shifts in consumer demands and labour constraints. Also decreases in disposable incomes resulting from the COVID-19 epidemic over the past year added to the urgency to prevent FL&W at scale. Certain food

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losses can be used to feed the hungry, and other parts are valuable biological materials that could significantly contribute to the agro-food industry (Lipisinski, 2020).

Food loss and waste are quantified in a few countries, but countries' ability to monitor trends and draw conclusions from the data is sluggish. However, most of the EU countries are more prepared than others. Additionally, there is a lack of strategic discussions or comparisons of different forms of tackling FL&W globally in alignment with existing agreements like the sustainable development goals (SDGs) described in the literature (Agarwal, 2018; Gil et al., 2019).

Furthermore, FL&W are also substantial contributors to food insecurity and degraded sustainability. This phenomenon is of utmost importance to many organizations, and many have already started to address the issue. Governmental and non-governmental organizations are intensifying their efforts to reduce FL&W at the national, regional, and international levels.

The Food and Agricultural Organization (FAO) of the United Nations will reduce food losses and food waste by 2030, a target of sustainable development goals. The United Nations' 193 member states set 17 Sustainable Development Goals (SDGs) as part of the 2030 Agenda for Sustainable Development. Only eight years are left to achieve Sustainable Development Goal 12.3, which specifies that global food waste should be cut by half at the consumer and retail levels by 2030. Food losses are also expected to be reduced in the supply and production chain, including post-harvest losses.

Furthermore, the EU's CAP (Common Agricultural Policy) includes goals of reducing food losses and food waste (European Commision, 2018). Among the European Green Deal's goals are the prevention of food losses and improved utilization of wasted foods (European Commission, 2019). However, there is finally a global awareness of food loss and waste, and a great many new initiatives have been launched to address the issue at various levels of the food supply chain (FSC). Nonetheless, quantifying food loss and waste at the national level remains a challenge due to data gaps.

Accordingly, attaining the objectives of CAP and the European Green Deal requires an accurate estimate of losses and information regarding the attitudes and behaviours of the various actors throughout the food chain. The purpose of this article is to depict the barriers to achieving SDG 12.3 and sustainability, as well as to provide policymakers with helpful information for FL&W policy reform, by analyzing the 7 staple crops associated with FL&W in Hungary. This research also focuses on the processing industry, and it studies stakeholders' capability to share data on food losses and their attitudes regarding the problem.

A quantitative approach has been selected for the following four research questions: 1. How much FL&W is generated in Hungary per year? 2. What are the most common types of crops lost and wasted in Hungary? 3. How does FL&W affect the food supply chain and consumers? 4. How does this FL&W impact the sustainability of the SDG 12.3 target?

The research was conducted in an exploratory manner, so no preliminary hypotheses were formed, but the following main research concerns were identified: consumer attitudes toward food losses; the severity of the problem from the perspectives of both the supply chain and consumers; the leading causes of food loss at the levels of the supply chain and consumers; constructive suggestions for loss prevention and better utilization; and the significant factors currently hindering food loss prevention in Hungary.

2. Literature Review

FAO (2009) stated, *"food security exists when all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food to meet dietary needs and food preferences for an active and healthy life"*. Food security pertains to three aspects: the availability of food (always available and specific), the accessibility of food (economic access to nutritious and safe food), and the utilization of food (safe, good quality, and nutritious food). Moreover, the stability aspect of food reflects sustainability (FAO, 2008; Rabbi et al., 2021). The United Nations Brundtland Commission (1987) defined sustainability as "Meeting the needs of the present without compromising the ability of future generations to meet their own needs." Climate change, pandemics, and resource constraints have all increased the importance of building a sustainable future. Today's consumption patterns lead to resource exhaustion and a disparity in quality of life across countries. It is critical to discover the aspects that primarily influence customers' relevant decisions to incorporate sustainability standards

into food purchasing patterns because food poverty can emerge from unconscious consumption.

However, food poverty has gotten less attention in developed countries like Hungary, and it is only loosely connected to issues of well-being (Baglioni et al., 2017). This paper investigates the problem related to unconscious consumption, food loss and waste, and food insecurity from the perspective of FL&W mitigation, and offers solutions designed to contribute to the Sustainable Development Goals (SDG 12.3) by reducing FL&W and facilitating conscious consumption.

FL&W refers to those edible plant and animal components harvested and accumulated for human use that is not eaten or consumed at the appropriate time. The term "Food loss (FL)" refers specifically to foods that spill, rot, have an unusual quality drop (such as discolouration or wilted), or are lost before consumers consume them. Unintentional food loss occurs due to agricultural processes, as well as to infrastructure, packaging, or marketing limitations. Food waste (FW) refers to good quality and the ideal food for human consumption that has been thrown away before or after it is consumed and either before it has been rotten. Whether intentional or not, food waste occurs because of negligence (Lipinski et al., 2016).

According to the FAO (2014), food waste occurs when food intended for human consumption is lost, discarded, damaged, or diverted away from the supply chain for other purposes. The complexity of synchronizing stakeholders in the food supply chain (FSC) has resulted in a significant increase in overall waste (Govindan, 2018). As a result, food is wasted from the beginning of the FSC until the end. During the early stages of food production, post-harvest, and food processing, adequate infrastructure and technologies are lacking. (FAO, 2011). Food waste occurs in the FSC's last stages via retail, hospitality, and consumption (Parfitt et al., 2010). Food waste has economic, environmental, and societal consequences due to the loss of one-third of edible food produced for human use (FAO, 2011; Papargyropoulou et al., 2014).

According to the Hungarian Food Bank Association (2022), Hungary generates 1.8 million tons of food waste each year. "If we put this amount on trucks, the line would extend from Budapest to Paris." This amount of FL&W equates to 180 kg of wasted food per person in a population of approximately 10 million people. This figure is comparable to the EU average per capita income (Bori, 2018).

Hungarian food waste is below the EU average; however, this issue pertains to resource efficiency and waste management and has a social impact (UNECE, 2016). The EU Circular Economy Program and Sustainable Development Goals stated that Hungary commits itself to expand its food waste management. However, studies on the FL&W issue have been extensively studied at regional and national levels worldwide. The primary objective is to quantify the precise amount of food loss and food waste generated.

As there are numerous available estimations, it is vital to establish a unified methodology and data collection system to provide policymakers and actors with the necessary information for taking appropriate measures in the future. Girotto et al. (2015) point out that there is no uniform understanding of food waste or any standard methodology to measure it; furthermore, studies are based on non-concordant data sources. Interestingly, Dou et al. (2016) also noted that several different terms are used among researchers, depending on the researcher's personal preference. In a systematic literature review, Corrado & Sala (2018) combined several studies on food waste estimates and compared different definitions, data collection years, geographical borders, and analyses of the parts of the food chain. Their studies' key finding was that current food waste estimates in European countries varied between 158 and 298 kilograms per capita per year.

Food waste was investigated by the European Commission (EC) using Eurostat data and all components in the food chain including processing, wholesale and retail, the catering sector, and households. Both edible and non-edible parts were deemed food waste in their estimation. FAO estimates FL&W in developed European and North American countries to be about 280–300 kilograms per year, which is almost twofold compared to sub-Saharan African and South/Southeast Asian countries. It must also be remembered that this method does not take into account non-edible waste (FAO, 2011).

Canali et al. (2016) assert that there is substantial literature and research on food waste. However, most of these papers emphasize quantitative measures and are mainly concerned with household food waste. In a study by Schanes et al. (2018), sixty peer-reviewed articles were analysed as part of a literature review that found that households are given

increased attention. However, this research focused on food distribution and conscious consumption as a solution to the problems of food waste and sustainability. The voluntary contribution of suitable food to food donation organizations for redistribution to needy persons is known as food distribution. However, it is common for governments, the commercial sector, and non-governmental organizations to view surplus food distribution as a practical approach to achieving SDGs (Pollard & Booth, 2019), However, several researchers argue that this technique does not minimize food waste or insecurity (Caplan, 2017; Mourad, 2016).

3. Methods and Methodology

Mustamin et al. (2020) analysed sixty articles published between 2009 and 2018 and pointed out that quantitative statistical approaches dominate food waste and loss research and that qualitative approaches are lacking. For this reason, quantitative research techniques have been chosen to examine nine years of food loss and waste data in Hungary and explore the impacts and mediators of FL&W. The main focus of the primary research was data collection and analysis. To conclude the research, secondary data from the FAO database from the period 2009 to 2017 was used to study Hungary's food loss and waste status. The FSC has an enormous role in causing food loss, so one of the least researched stages of this chain must be examined in the future to develop practical policy tools.

An iterative technique has been used to balance secondary data and current literature, allowing for better comprehension of data emergence and theoretical limitations. Descriptive statistics were used to calculate the mean, standard deviation, the relative percentage change compared to the base year (2009), and the average percentage change compared to the previous year.

The Mann-Whitney non-parametric test was applied for pair-wise comparison of agri-food products. Cluster analysis and multi-dimensional scaling were used to create a similar crop group and the studied factors were graphically represented in a multi-dimensional space. The Ward method with Euclidean distance was applied in cluster analysis to form clusters based on similarities. This analysis allows for finding connections between Hungarian agri-foods. All calculations were performed using the PAST software (Hammer et al., 2001).

4. Results and discussion

The published FL&W data of the FSC in Hungary is rather fragmentary and limited, with many researchers ignoring staple foods including wheat, maize, rice, sorghum, barley, rye, and oat. To meet SDG 12.3.1, it is necessary to investigate the FSC and consumers level. Below, descriptive statistics of agri-food crops are shown.

Table 1. Descriptive statistics of studied agri-food crops. *Source: Author's estimation*

Variable	Mean	Std. Dev.	Min	Max	Lower 95% CI of mean	Upper 95% CI of mean	Relative % change (base=2009)	Average % change (base=prev. year)
wheat	1.33	0.73	0.3	2	0.77	1.89	-85%	-21%
maize	1.85	0.54	1.17	2.78	1.43	2.27	-49%	-8%
rice	0.75	0.33	0.31	1.23	0.50	1.01	-8%	-1%
sorghum	1.69	0.74	1.09	3.37	1.12	2.25	-32%	-5%
barley	1.00	0.12	0.84	1.15	0.91	1.10	-4%	0%
rye	0.57	0.52	0.12	1.2	0.17	0.97	657%	29%
oat	0.69	0.29	0.25	0.91	0.46	0.92	248%	17%

The trend of seven types of staple crop waste and loss is recorded yearly in Hungary. The wheat loss was -21% on average, which was a steep decline in FL&W. Maize, and sorghum loss and waste were consistently reduced by an average of -8% and -5% a year in

Hungary. However, rice and barley do not significantly change, representing 0% and -1%, respectively. In contrast, FL&W was sharply higher for rye and oat, respectively, accounting for 29% and 17%; counting 2009 as a baseline; the most significant relative change can be seen in the rye at 657%. Among cereals, oat stands second at 248% loss and waste, while rice and barley show a stagnantly downward trend.

Table 2. Result of pair-wise comparisons with Mann-Whitney probability. *Source: Author's estimation*

Crops	wheat	maize	rice	sorghum	barley	rye	oat
wheat	-	31	23.5	36	27	12	20
maize	0.427	-	1	29	0	1	0
rice	0.145	**0.001**	-	3.5	22.5	30	31.5
sorghum	0.724	0.331	**0.001**	-	4	4.5	0
barley	0.251	**0.000**	0.122	**0.001**	-	27	15
rye	**0.013**	**0.001**	0.376	**0.002**	0.249	-	36
oats	0.077	**0.000**	0.452	**0.000**	**0.027**	0.723	-

Note: Significances (p-values) are indicated in bold text.

Table 2 shows the results of the Mann-Whitney test in a matrix form (rows and columns correspond to the agri-food products). The diagonal is empty because it shows no comparison of agri-food products. Significances (p-values) can be found under the diagonal, while Mann-Whitney U test statistics are given above the diagonal. If the p-value is lower than 0.05, this can be considered a significant difference between the agri-food crops in the rows and columns. For example, rye and wheat are significantly different (p=0.013) but wheat and oat are not so much different (p=0.077).

For better understanding, cluster analysis was performed to form clusters based on similarities, and Multidimensional scaling (MDS) was conducted for visualizing the level of similarity of individual agri-food crops. Here MDS represents data in a two-dimensional space.

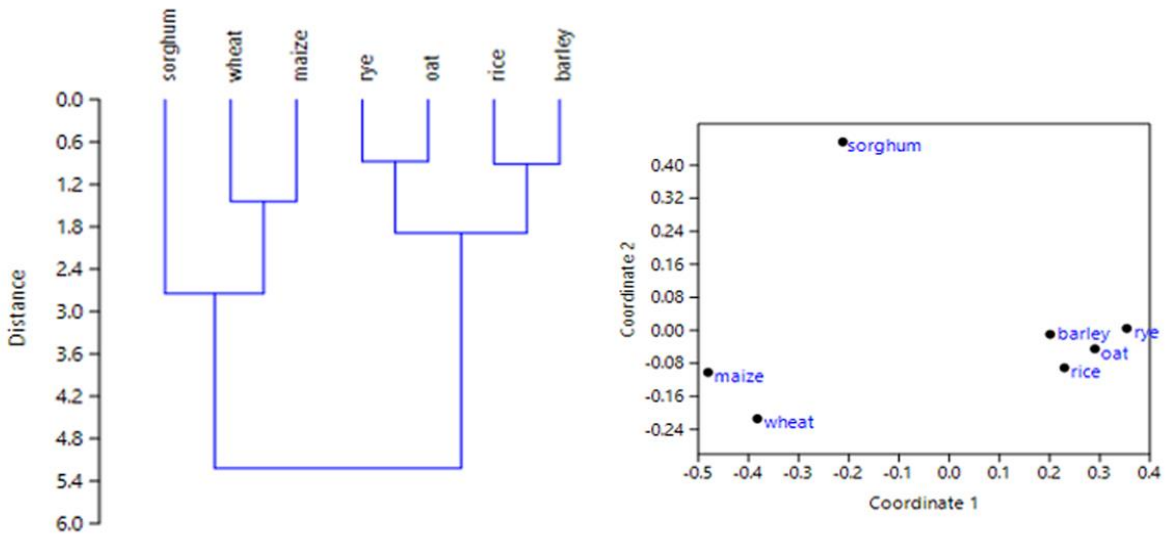

Figure 1. Cluster analysis and multidimensional scaling. *Source: Author's estimation*

The results of cluster analysis and multidimensional scaling confirm that rye and oat belong to the same group as barley and rice. Wheat and maize are in the same group, and sorghum is somewhat different. In terms of wheat and maize loss and waste, there has been a decreasing trend over the past few years. However, there is a stagnation in the sorghum trend. In contrast, FL&W trends appear to be increasing in oat, rye, rice, and barley. The difference is the result of the last four years, from 2014 to 2017.

According to the analysis, Hungary's wheat and maize crop waste has drastically declined. Conversely, Hungary suffers from a significant waste problem concerning two crops:

rye and oat. These problems are widespread both in the supply chain and at the consumer level.

Rye grain and oat are used for flour, bread, beer, crispbread, and animal fodder. Moreover, both crops are edible cooked or raw, depending on the recipe. (Wrigley, 2016). Besides, rye grain is used in some whiskeys and vodkas. In the Hungarian supply chain and at consumer levels, the amount of lost and wasted raw and bakery products made from rye and oat is 29% and 17% on average, respectively. However, FL&W are generated in the Hungarian food industry at four different stages: 1. production level, 2. processing level, 3. supply chain level, and 4. consumer level (Bori, 2018). Achieving food security and sustainability is uncertain for the different levels of FL&W. As well as the main hindrance to achieving the SDG 12.3 targets and objectives of CAP and the European Green Deal.

According to the Center for Global Development's (CGD) research, the Russian-Ukrainian conflict has already significantly impacted several countries' economies and supply chains. As a direct result of the military conflict in Ukraine, it is estimated that nearly 40 million people will become severely impoverished (Mitchell et al., 2022). Moreover, issues in Hungary like COVID-19, food price hikes, difficulty obtaining fuel, and the impact of military conflict in Ukraine can potentially worsen the country's condition. In addition, FL&W will negatively exacerbate the overall situation. However, some countries have reported lower levels of household food waste during lockdowns because of the pandemic (Lipisinski, 2020).

As defined by Stangherlin & de Barcellos (2018), mediating factors on FL&W include societal factors (external influences such as direct and indirect socio-cultural influences on the individual); personal factors (household characteristics and individual psychological influences) and behavioural factors (behaviours, routines, and habits related to the food preparation). In terms of social factors, food losses are primarily observed at all levels of the supply chain. Product defects and technical errors are the most critical factors leading to food loss in processing industries (Richter & Bokelmann, 2016).

Raak et al. (2017) found that food loss is mainly caused by three reasons: process problems (technical errors, human error, cleaning losses), quality assurance, and the high level of expectations that consumers have for products. For aesthetic reasons, retailers discard many edible foods that should be sold. Nevertheless, the food sector's competencies, measuring the precise amount of FL&W, and better tracking capability can control and overcome FL&W issues. However, around 52% of companies in Hungary reported they kept records of food losses; 9.7% reported they calculated losses using other records besides the ones about calculating food losses. The remaining 20% of companies estimated the number of losses and waste, while 8.6% said they could not figure out losses from registered data or other sources (Kurthy et al., 2021). However, many organizations are integrating sustainability into their business strategy, and the potential impacts of food waste are a significant motivator for them to operate in the industry. They consider that collecting excess food and providing it to those in need is the greenest option. These green options included disposal of food waste in landfills, increasing intensive organic cultivation, and reducing the resource loss associated with making food available to consumers. This procedure entailed collecting benefits from leftover food and cutting costs throughout the supply chain.

Hungarian agriculture is less resilient to severe weather in the production sector and less prepared for it because of the slow development of automation and digitalisation. Improved yields and less waste can be achieved by advancing precision agriculture and climate adaptation practices. Besides, food waste will also be reduced by developing the food processing industry (Bori, 2018). Food losses can happen during processing time, including cleaning time, equipment defects, human errors, experimental time, uncontrollable fermentation, or inadequate baking or roasting. During manufacturing, losses can also take place: losses include residues generated from cutting raw materials or semi-finished products, which can be further used in other food processes. For example, the ends of cheese blocks could be used as raw material in manufacturing processed cheese (Raak et al., 2017).

Inadequate transportation at the retail level might result in products being damaged or expiring before they reach retailers. Furthermore, irregular or too early use-by dates result in enormous quantities of products being wasted. However, many supermarket chains have initiated operations where they sell aesthetically defective products because aesthetic issues result in significant amounts of food being wasted (Bori, 2018).

According to the FAO (2011), fruits, vegetables, roots, and tubers have the highest proportion of waste in the world, with 45% ending up in the garbage can. Due to bad consumer

habits, people buy more food than they need and then throw away much of it. Visiting a new place causes people to overbuy or overorder food due to a lack of awareness of the portion size (Wang et al., 2017; Xu et al., 2020). Some of the waste is generated at the point of sale due to refrigeration problems, inappropriate handling practices, and consumer damage. A weekly menu plan needs to be created by way of using items nearing expiration and making a list of the other ingredients that are needed to prepare the dishes. Food spoilage can be prevented by observing what things go into the refrigerator and what should not. According to a UN Food and Agriculture Organization report, stalks, peels, leaves and seeds have some nutritional value, even though they usually end up in the garbage (FAO, 2011).

Both corporate and consumer level awareness is needed to reduce FL&W. In the Hungarian food sector, there should be widespread awareness-raising and education campaigns targeting all aspects of the FSC to raise consumer awareness of the adverse impacts of FL&W (Stangherlin & de Barcellos, 2018). Food industry sustainability and waste reduction are promoted by a Hungarian organization called Responsible Gastrohero.

This organisation actively supports restaurants, cafes, and environmentally friendly bars and provides environmentally-friendly certifications to such places (Responsible Gastrohero, n.d.). In addition, two crucial Hungarian national strategies in this sector focusing on reducing FL&W are the "National Waste Management Plan (2014-2020)" and the "Food Chain Safety Strategy 2013-2022".

The "Food Chain Safety Strategy 2013-2022" significantly impacts food quality preservation. Three key elements that influence food quality and food chain security, are: (1) the production process' level of vulnerability to various risks, (2) an increased food consumption pattern and food quantities putting pressure on the monitoring system, and (3) the lack of effective communication and transportation between food chain stakeholders. As a result of controlling these risks, there will be better quality food for customers and, consequently, there will be less food waste (National Food Chain Safety Office, 2014).

According to the NWMP, food waste should be managed along with the agricultural and biodegradable municipal waste. Agriculture, forestry, and the food industry generate 30-35 million tons of biomass each year, 15%–20% of which is waste. Composting and energy production account for approximately 80% of biomass use. A company can also reduce food waste by switching to sustainable consumption practices (for example, green procurement) (Ministry of Environment and Water, 2014).

A solution to FL&W is surplus food distribution by corporations. Food donations are carried out by partner organizations with the assistance of the National Food Bank in Hungary. Donors include private individuals, business groups, and government agencies. Retailers and food producers contribute the majority of donations.

Note: Using food donations to reduce food losses and waste, and gaining corporate benefits (source: Hungarian Food Bank Association (2022):

- *Cost-cutting measures include reduced garbage management and storage expenses.*
- *With the value of donated food delivered, companies can reduce their corporate tax base by 20%.*
- *The logistics part of donated food collection and distribution can be handled by charitable organizations. As a result, business organizations can save time and money.*
- *By avoiding regularly throwing food in the trash, responsible food producers/traders can reduce their environmental footprints.*
- *Wasted foods can be donated to reduce CO2 emissions by 2kg per kilogram, which will minimize the negative impact on the environment.*
- *Waste reduction can become a substantial part of corporate social responsibility (CSR) and sustainability strategy.*

At the consumer level, the five norms related to the reduction of FL&W and the encouragement of conscious consumption include 1. minimizing consumption of unsustainable food (e.g., food is produced by using fossil fuels that emit higher levels of greenhouse gases.), 2. selecting foods with sustainable sourcing (e.g., organic food produced

by using cycle resources, promoting ecological balance, and conserving biodiversity), 3. shifting the demand towards more sustainable goods (e.g., avoid meat-based food), 4. consumption of ecologically efficient foods (e.g., beans, leafy greens, organic vegetables, and fruits), 5. wise purchases and participating in waste recycling are highly recommended.

The COVID-19 problem has highlighted the necessity and relevance of eliminating food loss and waste worldwide. Initiatives by the Hungarian government and several corporations show that a 50% decrease is feasible through donating to food banks and raising awareness among consumers. These examples should inspire everyone to believe that significant savings are possible. However, both supply chain and consumer levels should feel the pressing nature of this issue right now. The number of food losses and waste has decreased by double digits in just a few cases. SDG 12.3 is due in only eight years. There is not much time to waste to achieve the FL&W reduction target and sustainability.

5. Conclusions

Sustainable and conscious consumption will improve food security, reduce FL&W, boost economic growth, and combat climate change. However, SDG 12.3 is directly affected by FL&W, over-purchasing and over-consumption.

Hungary must improve the efficiency of its supply chain management and raise awareness about FL&W while also promoting conscious consumption among stakeholders to realize SDG 12.3 and move towards sustainability. Furthermore, businesses must be responsible for managing the transformation of the food system. To bring resilience and reduce FL&W, agricultural and food companies must work together. More flexible, shorter, and diverse supply chains are possible, as are the reduction and avoidance of food waste, the development of farming methods beyond legal requirements, and the reinforcement of the need to protect natural resources (BCSDH, 2020).

Food security is negatively impacted by climate change. Keeping agricultural productivity and ecosystem services sustainable is challenging because of the drastic loss of habitat, species, and biodiversity resulting from climate change. These changes will continue into the middle of the 21st century. In Hungary, agroecological conditions are highly dependent on climatic conditions, which can drastically be affected by relatively minor climatic changes. Nonetheless, food waste can be radically reduced, which requires less agricultural land. A resulting surplus of such areas will benefit biodiversity conservation and restoration. Taking such actions will help us adapt to climate change and create a healthier planet.

This research does not recommend specific policy adaptations for all countries. Instead, it gives a specific country a range of FL&W reduction options to explore. Achieving SDG 12.3 target by fostering a sustainable transition will benefit Hungarians' everyday lives.

This study identified several key FL&W trends affecting Hungary positively and negatively. First, it has been proven that Hungary is on track to meet its SDG 12.3 targets by reducing wheat, maize and sorghum waste by -21%, -8% and -5% each year, respectively. Second, hunger and food insecurity have been tackled through several food donation collections and awareness-raising initiatives that have put Hungary one step closer to achieving a 50% FL&W reduction by 2030. Third, rye and oat losses increased considerably in Hungary – to 29% and 17% respectively –, which causes food insecurity and decreases sustainability. Fourth, food prices continued to rise, making it harder to keep food affordable and stable.

The main limitation of this study is a data gap. From 2017 onward, FL&W data concerning Hungary is unavailable. Quantification methods of FL&W must be standardised according to the legal, societal, economic, structural, and monetary frameworks of each country. Additionally, further research is needed to establish reliable long-term national time series, comparisons of the produced data with other countries, and a comprehensive assessment of the impact or effectiveness of prevention policies also present challenges to decision-makers, researchers, and practitioners over the long run.

The findings of this study suggest that a 50% FL&W reduction in Hungary could be strategically and economically feasible. Yet, several significant obstacles remain in the food sector including import dependency, rising food prices, scarce resources, lack of awareness, and political limitations concerning sustainability targets.

Data Availability Statement: Data supporting the reported results can be found in the database of the Food and Agriculture Organization of the United Nations (FAO). Data available at https://www.fao.org/faostat/en/#data.

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