
SUMMARY OF PhD THESIS

Food Loss and Waste phenomenon in the Romanian agri-food chain: Behaviours, trends and innovative solutions towards a circular economy

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1. INTRODUCTION

For many years, the production and consumption patterns of European populations have followed a take-make-consume-discard approach. Regardless of the activity sector, under this business model known as *linear economy*, used products, items, components and materials have been discarded into landfills, resulting in enormous amounts of waste. In the agri-food sector, the shift towards a *circular economy* is particularly impactful and this transition not only conserves resources but also promotes resilience in food production systems.

Historically, one-third of food production is globally lost or wasted along the agri-food chain, with food waste at the retail and final consumer levels estimated at about 950 Mn. tons yearly, representing almost 20% of total global food production. This waste significantly impacts the environment, with a carbon footprint of 3.3 gigatons equivalent and poor management of water resources, given the vast amounts used for unconsumed food. Moreover, nearly 1.4 billion hectares, one-third of the world's total agricultural area, are used to produce food that is never eaten. This trend needs to change course, for the sake of the future generations.

In the context of Romania, a country which is balancing between economic constraints and the potential for food self-sufficiency, adopting more efficient ways of managing resources is not just a strategic necessity but an imperative. By prioritising pragmatism, innovation and resource management in the agri-food sector, Romania can increase its food security and contribute to the European continent's sustainable economic growth.

2. PURPOSE AND OBJECTIVES

This PhD research chose to look at the behaviours, perceptions, feelings, backgrounds, social representations and already implemented solutions of all stakeholders who converge in the broad space of food production and consumption: farmers, processors, distributors, retailers and end consumers with two additional segments, NGOs and companies already active in the post-consumption phase.

As a result, the main goal that guided this research and provided a framework for addressing the phenomenon was to identify the main causes of the FLW (food loss and waste) phenomenon in Romania and the factors involved in food waste at the Romanian agri-food level, as well as to investigate behaviours and trends that need to change course for the successful implementation of a future circular economy approach.

Five specific objectives broke down the general aim into smaller directions, each of them being detailed into the published articles, presented *in extenso* in this PhD Thesis:

- Mapping the situation at Global, European and National (Romanian) levels;

- Identifying food waste causes and drivers within the entire Romanian agri-food chain, with a focus on households;
- Identifying the main food waste consumer typologies and behaviour patterns;
- Understanding how perceptions and emotions can influence consumption behaviours;
- Demonstrating that technology and AI/ML can provide viable solutions to food safety related challenges.

3. GENERAL METHODOLOGY

In order to reach the objectives, a complex approach was used, which implied a methodological mix, based both on the qualitative and the quantitative research. The literature synthesis was based on a systematic review, known for its explicit and practical way of identifying, selecting and critically evaluating results. This methodology approach was appropriate for the Eastern European agri-food system landscape investigation, where the selection of articles relied on the keyword vs. region algorithm, established when the research model was formulated. Using descriptive statistics and semantic similarities the combination of one or two terms plus the time horizon were considered.

The personal contribution section starts with qualitative research which provides a comprehensive analysis of the FLW phenomenon within the Romanian agri-food chain. This involved conducting interviews with farmers, food processors, retailers, HoReCa and NGOs representatives as well as consumers, an exploration of their experiences and perceptions of food waste within their daily activities. The semi-structured interview was chosen as the most appropriate data collection tool for this qualitative research due to its flexibility and ability to capture personalised responses.

Further on, a quantitative component included large-scale surveys to quantify the prevalence and patterns of consumption and to identify causes and factors responsible for food waste within the Romanian households. This nation-wide survey assisted by the IRES Institute could explore behavioural patterns of food waste in an emerging market using sociological evaluation techniques. The study used a questionnaire administered through the CATI method, incorporating elements that measured relevant concepts related to the investigation of food waste among households. These included besides causes, several socio-economic-political factors that foster food wastage, characteristics of food products, consumers' behavioural skills on food management, price sensitivity and attention to purchased food. The sample comprised 1742 individuals aged 18 years and above with 5 socio-demographic features, including gender (49% male and 51% female), age (18–65 + split as follows: 26% aged 18–35, 29% aged 36–50, 24% aged 51–65, and 21% aged 65+), education level (37% primary, 48% secondary, and 15% higher education), place of residence (54% urban and 46%

rural), and region of origin (34% from Transylvania–Banat, 45% from South Bucharest–Dobrogea, and 21% from Moldova. The cluster analysis was used to delimit different typologies of consumers according to the way they contribute to the reduction, promotion, distribution and reuse of food items.

A second qualitative approach, centred on consumers only, included both word cloud and sentiment analyses. Whilst word clouds are rudimentary and basic images made out of text where the word size symbolises its frequency (a method which cannot stand alone as research analysis), the complimentary sentiment analysis was found to outperform dictionary-based methods like content analysis.

Finally, the collaboration with the Bonapp® platform allowed a significant improvement of the research material due to explicit data provided by this anti-waste pioneering mobile application already used by Romanian consumers. The app provided data such as: number of orders, number of unique clients, number of active locations, number of signed and active leases (locations), number of offers, number of offered and sold boxes, amount of saved food (kg) and quantity of CO₂ saved (kg). The data collection was spanning from November 2021 to April 2023 and exclusively pertaining to the cities of Bucharest and Cluj-Napoca (the second city in terms of population after Bucharest) where the mobile app was accessible at the research time. In addition to the descriptive statistics, and to investigate the relationships between the different variables in the dataset and to assess which variable is the best predictor of a particular outcome, the research applied a methodology involving regressions in SPSS (Statistical Package for the Social Sciences, V.20).

In conclusion, the triangulation as a methodological representation heightened the understanding of the connections between theory and first-hand findings.

4. RESULTS

This section presents *in extenso* a series of four published articles as a result of doctoral research:

1. **The Romanian agri-food chain seen through the lens of the FLW phenomenon: A research on farmers, processors, distributors, retailers and NGOs [ProEnvironment]**

The agri-food chain representatives were studied within this scientific article to understand their roles, challenges and current contributions to the FLW (food loss and waste) problem. The main interests of the *farmers* category focus on increasing the cultivated area and livestock, producing sufficient quantities of raw material, delivering products to factories and wholesale markets. Farmers mentioned that they face major challenges such as drought, labour shortages, price instability for inputs, energy, fuel, fertilisers, fluctuations in imports, lack of long-term storage space, processing, and valorisation of finished products. Also, insufficient funds for modernisation and

purchase of processing machinery, lack of land lease and high competition were mentioned as current challenges. Moreover, farmers proposed strategies such as composting, biogas production and conversion of waste into other products. In the analysis of the interviews with Romanian *processors*, four main distribution channels for final products were identified: direct channel, short channel, long channel, and dual channel. In general, most processors consider recovery and reuse of surplus to be important and economically beneficial. This perspective is mentioned most frequently, so processors reuse surplus efficiently with the aim of gaining additional revenue and reducing waste.

The main issue facing *retailers* is employee retention due to strong competition in the labour market. Also, rising electricity and fuel prices have led to a decrease in the profitability of companies, which has led to a reassessment of pricing strategies. On the *distribution* side, there is a problem of information about the origin and quality of products, so consumers often prefer cheaper imported products to local ones. According to the replies, the causes of partial distribution/sale of products are determined by the following factors: non-compliance with product storage temperature, handling errors, fraud on the part of employees in terms of relabelling, carelessness in the stock control process, non-compliance with contractual terms by suppliers and non-compliant products received from producers. Among the major challenges experienced by them, we name high operating costs and competition. Most companies in the *HoReCa* sector face the problem of finding and retaining the staff needed to provide quality service to customers. This is the biggest obstacle mentioned, including for guesthouses. At the level of the *non-governmental organisations*, we identified the need for funds to support the development and expansion of projects, including the hiring of staff, space and capacity limitations for the storage and distribution of donated food, fluctuations in funding sources due to the unstable economic situation, insufficient sponsors, technical problems with internal donor software.

Analysis of stakeholders' responses highlighted the importance of collaborative efforts and improved legislation to reduce food waste.

2. Consequences of recent crises on the FLW consumer behaviour: A national wide representative research-The case of Romania [Foods]

The various consequences of recent crises on the consumer behaviour were examined through a Romanian national wide representative study on household size, age, and gender to identify key food waste consumer typologies.

Based on the quantitative data analysis, three consumer typologies were identified according to the food waste behaviour, including (1) low-income young wasters, (2) conscious middle-age wasters, and (3) well-educated mature non-wasters. These typologies can be used by policymakers and marketers to develop targeted strategies to reduce food waste. The main findings deriving from the description of clusters show

that *low income wasters* prioritise buying local products and rely heavily on shopping lists when they go shopping, often basing their decisions on food sales or special offers. Price and origin are very important factors in their food choices, with a preference for local products. They do not pay much attention to the sensory characteristics of the food they buy and do not buy in large quantities or stockpile food due to a lack of storage space. *The middle-age consumers* are educated, mature, and have a higher income, with an age range of 36–50. They have a net household income of over EUR 400 and throw away more than 4 kg of food per month. They moderately use shopping lists when they go shopping and show moderate importance to promotions. For them, the price of the product is important but not a main factor in the buying process and they prefer quality food such as organic and local products. *The well-educated mature non-wasters* (monthly income of more than 800 EUR) present a series of factors and motivations behind their behaviour. One is related closely to the higher education and income levels, which have increased, over years, their awareness of the environmental and economic impacts of food waste and their ability to assess more objectively the FLW phenomenon. They also have more anti-waste resources available, such as larger kitchens and storage spaces that make it easier to buy and store food in bulk.

3. A qualitative study on the consumer behaviour related to food waste: The Romanian perspectives through word cloud and sentiment analysis [Sustainability]

This article featured the major role played by emotions and sentiments in shaping consumer decisions related to food purchase and consumption, a detailed analysis of nuanced factors contributing to food waste, with a focus on the complexities inherent in food related behaviours. The data provided by the answers within individual interviews helped identify key issues and challenges, such as environmental concerns or supply chain inefficiencies. Through the consumer opinions, a comprehensive understanding of the other stakeholders' assessments for waste improvement was noted, whether through the implementation of eco-friendly farming practices, optimisation of production and distribution channels, change in shopping habits or management of uneaten food items. Based on qualitative data, four clusters of consumers were identified, according to their awareness and sensitivity to food: the Epicureans, the Organised, the Refined and the Minimalists, a categorisation based on key words related to sentiments, experiences and expectations regarding food, such as joy, trust, surprise, anticipation, preference, information.

This classification suggests that informed and sustainability-conscious consumers have the potential to exert positive pressure on the other stakeholders of the agri-food chain to adopt more sustainable farming, processing and distribution practices.

Across the four identified clusters, some key findings can be enumerated: consumers seek a pleasant and varied dining experience, indicating a concern not only

for the functional aspects of food, but also for its aesthetic and taste components; innovation in food preparation and plating can also have a significant impact; education programmes and cooperation among stakeholders combined with automation at every level of the supply chain can directly contribute to fighting food waste.

4. Innovative strategies for food waste reduction and the use of mobile applications in the agri-food sector [Economic Engineering in Agriculture and Rural Development]

The Bonapp.eco mobile application and its impact on food consumption patterns was analysed here, due to its direct support for sustainable production and consumption, offering numerous managerial, practical, and social implications. From a managerial perspective, findings show that by using such applications agri-food companies can optimise their anti-food waste policies, leading to substantial budget savings by managing food surplus, as opposed to the more costly waste management methods. This offers economic, social, ethical, and environmental advantages, aligning with the companies' Corporate Social Responsibility (CSR) goals. Also, broadband internet and internet connectivity provide excellent prospects for the development of offline businesses, which can seamlessly transition online and naturally flourish. Simultaneously, online businesses can strengthen their market presence by integrating social platforms within their operations.

Integrating mobile apps into food waste management has several noteworthy implications for businesses. First and foremost, it increases visibility and marketing opportunities by showcasing a company's commitment to reducing food waste, attracting environmentally conscious consumers, and bolstering the brand's image. In addition, mobile apps and other technological tools contribute to operational efficiency through real-time inventory management, demand forecasting, and supply chain optimisation, minimising overstocking and reducing waste across various industries. These apps also engage consumers in the fight against food waste by providing offering discounts on surplus items and encouraging responsible consumption habits.

5. CONCLUSIONS AND RECOMMENDATIONS

In recent years, many stakeholders in the global agri-food chain have stepped up their efforts to reduce food waste and other forms of unethical practices of rapidly spoiling the planet's limited resources. Clearly, in addition to financial resources, these actions often require new skills, technical expertise and technological advances, sometimes from outside the agri-food chain. But IoT is now available everywhere and, thanks to the Internet, access to information and online education has never been easier. Consequently, failing to combat the issue of food loss and waste while actively participating in the system that perpetuates it is no longer acceptable and numerous

studies in the literature support this stance. As we are all consumers, we are also stakeholders. This applies equally to each of us.

It's also essential that we understand the importance of resilience (adaptation) to current challenges (climate change, crises, geopolitical context). We must accept that, when we talk about food security, there is no universal solution that can be applied to all of us, nor to all of our cities, regions or even countries. To make systemic change, it's vital to change our past habits, while recognising and holding on to the diverse cultural backgrounds that shape our communities. Improving our behaviour to meet new standards and new needs is the least we can do.

The part of this research which focused on food waste perceptions among agri-food chain stakeholders through semi-structured interviews, found that strategies like composting, biogas production, shelf-life monitoring and surplus utilisation seem to be already implemented, despite challenges like labour shortages, rising input prices and inadequate distribution infrastructure. NGOs play a crucial role in redistributing surplus food to vulnerable groups. For more visible results in reducing food waste, other strategies such as improving supply chain efficiency, educating consumers from very early stages and supporting food recovery programmes like those assisted by food banks. Practical activities, school games through voluntary work including multi-actor cooperation and educational campaigns for business sector employees are recommended to promote sustainability.

The Romanian nationwide study on consumers identified three typologies based on their food waste behaviour. They are as follows: low-income young wasters, conscious middle-age wasters, and well-educated mature non-wasters. Policymakers and marketers can use these classifications to craft specific strategies aimed at reducing food waste. Also, seven factors contributing to food waste behaviour have been identified: (1) attitudes towards food waste, (2) household income, (3) food storage habits, (4) food safety concerns, (5) meal planning and preparation, (6) purchase behaviour, and (7) socio-demographic characteristics. Attitudes towards food waste are crucial, as individuals who are more concerned about the issue tend to be more mindful of their consumption and anti-waste habits. Household income also significantly influences food waste, with higher-income individuals generally wasting more food, potentially due to over-purchasing, poor meal planning, and less concern about the cost of wasted food.

If the consumers' feelings and emotions are analysed and understood, the outcomes of such a sentiment analysis investigation can be used by businesses to tailor their products and services in order to meet the evolving needs and preferences of their market. The research found that consumers are increasingly aware of environmental impacts, favouring local production and showing concern for food waste.

The last part of the research emphasised the benefits of mobile applications and other AI-backed tools in promoting sustainable behaviours. Applications like

Bonapp.eco (which has successfully redistributed surplus food, showing significant user growth and acceptance) boost connectivity among agri-food chain actors, offer cost-saving opportunities, reduce over-buying, contribute to a better shopping experience and provide access to quality niche products. They also generate data-driven insights into consumer practices and trends which could be of use to other industries dealing with environmental issues.

Innovating more, cooperating better and sharing knowledge extensively on resilient farming practices and reasonable food consumption, these are the main recommendations for future research to unlock the full potential of agri-food sector and make it more responsive. Future research directions should focus on the long-term impact of such technologies and their integration into broader initiatives. More comparative studies are increasingly necessary to deal with the European food security issue, particularly in the context of Romania and its geopolitical landscape. More innovative solutions and creative synergies at European level, supported by standardised legislation against food waste, should remain at the top of the policymakers' priorities. By actively engaging with other stakeholders across the agri-food chain and analysing in detail their valuable feedback and proposals, best practices and requirements, decisive steps can be taken towards building a more food-equitable future for generations to come.

6. ORIGINALITY AND PERSONAL CONTRIBUTION

The innovative contribution of this PhD thesis lies in its examination of the FLW phenomenon within the entire agri-food chain in Romania, encompassing stakeholders from farmers (producers), processors, distributors, to final consumers. In the framework of this research, a plural methodological approach incorporates both qualitative and quantitative studies. This multidimensional methodology enabled a comprehensive examination of food waste dynamics across the entire supply chain in Romania within a European context, involving all participants at every level of the study. Notably, the association of Bonapp Enterprise, a dynamic company active in the Romanian agri-food sector, added significant depth to the research, providing one-of-a-kind insight on community engagement and practical perspectives.

The national study on anti-waste households' behaviour provides instrumental understandings of the ramifications of recent crises, such as the COVID-19 pandemic and geopolitical tensions (the Ukraine-Russia conflict), coupled with security concerns arising from Romania's proximity to the war zone. This study represents a useful empirical investigation which not only exposes the immediate impacts of these crises on consumer conduct, but also offers perceptions into the underlying socio-economic and psychological factors shaping attitudes towards food consumption and waste management.

Moreover, the exploration of technological innovations, particularly AI/ML devices and mobile applications, emerges as a promising avenue for addressing those challenges, for revolutionising the efficiency and sustainability of the entire food supply chain in Romania. By exploiting the power of AI, coupled with the widespread accessibility of mobile applications, the potential for real-time monitoring, predictive analytics and targeted interventions throughout every stage of production, distribution and consumption is unprecedented. These technological advancements not only offer solutions to reduce food loss and waste, but also pave the way for a higher transparency, traceability and consumer engagement.

Thanks to the comprehensive examination of the multifaceted issues surrounding food loss and waste within the Romanian agri-food chain, this holistic approach represents a significant contribution to the ongoing dialogue on food waste management and circular economy initiatives, both within Romania and on a broader global scale.