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Sustainability-Oriented Innovations in Food Waste Management Technology

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Abstract: Food is essential to our survival, yet the Food and Agriculture Organization of the United Nations (FAO) estimates that about 820 million people were undernourished in 2018. In this context, food waste generation is a particularly salient issue. Wasting food means missing opportunities to feed the growing world population and consuming scarce resources, such as land, water and energy used in the production, processing, distribution and consumption of food. Firms in HORECA (hospitality, restaurant and catering) represent a considerable share of total food waste and, more importantly, are characterized by an overall low sense of awareness about the sustainability-oriented innovation opportunities and challenges of minimizing food waste. This article draws on an in-depth case study to explore the use of technological advancements in downstream value chain. This case study draws on a tech startup providing services for HORECA companies to address a new way for companies to solve the food waste challenge. Adopting technological innovations to quantify and minimize wastage via collaborations with third-party companies can be a strategic and cost-effective way to supplement a company's open innovation activities.

Keywords: food waste; sustainability-oriented innovation; technology; management; food value chain; foodservice; restaurant; hospitality; quantification; minimization; case study

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1. Introduction

Food waste epitomizes an unsustainable system of food production and consumption. The Boston Consulting Group (BCG) calculates that the amount of food wasted each year will rise by one-third by 2030, "when 2.1 billion tons will either be lost or thrown away, equivalent to 66 tons per second" [1]. Considering all people in the world affected by moderate levels of food insecurity together with those who suffer from hunger, over two billion people do not have regular access to safe, nutritious and sufficient food, including 8% of the population in Northern America and Europe [2]. The Coronavirus pandemic has only deepened the hunger crisis and "by the end of the year, 12,000 people per day could die from hunger linked to COVID-19, potentially more than will die from the disease itself" [3]. In contrast, food scarcity coexists with excessive consumption. Globally, two billion adults were overweight in 2016, with over one-third of them obese. The increasing global prevalence of this public health crisis has serious implications, including an increasing risk of type 2 diabetes, cardiovascular disease, stroke, and some types of cancer [4]. Furthermore, rising population levels combined with shifting dietary patterns in emerging economies will put increasing pressure on global food supply; more food is necessary to feed people. The world population is predicted to reach 9.9 billion by 2050 [5] and this growth will require at least a 60% increase in agricultural production to meet the demand for food and other uses [6].

Food waste represents a social distress, an economic malfunction and an environmental disaster. It is, moreover, an ethical issue: the estimated 129 million tons of food waste generated in Europe alone [7] could ensure a fairer redistribution of resources and a

reduction of environmental pressure to respond to food needs. This, in turn, would lead to enriched natural ecosystems and the services they provide [8]. Alas, one-third of all edible food produced for human consumption is wasted or otherwise lost from the food chain per year, or about 1.3 billion tons. This significant quantity of waste generates substantial amounts of greenhouse gas emissions, promoting climate change.

Wastage emits harmful greenhouse gas emissions. In particular, the food industry is responsible for 26% of global greenhouse emissions, 6% of which is a result of food that is never eaten and ends as waste [9]. Methane gas is produced when food waste decomposes under anaerobic conditions at food waste landfills, with methane presenting a global warming potential 25 times higher than that of CO_2 [10]. Despite the utterly alarming statistics and although in certain regions like the EU there are clear indications of a shift away from landfilling towards preferred waste management approaches, it has been estimated that in the United States alone 88 million tons of food are wasted every year at the retail and consumer levels, equivalent to over 170 million tons of CO_2 and a total value of USD 165.6 billion [10].

Food waste occurs in every step of the food value chain. In developed countries, over 28% (24 million tons) of waste comes from food services, primary production and wholesale and retail [11]. Commercial food service, which includes the hospitality sector, is third in the food value chain in terms of the amount of food waste produced, even though it has significant potential for waste prevention. Consumer foodservices include restaurants, fast food chains, cafés, cafeterias, canteens, and dining halls, as well as event catering. In spite of playing such a predominant role in food waste, there is a dearth of research pertaining to the quantification of food waste management by commercial food service. There is a gap of studies undertaking applied work in sustainable management solutions for foodservice organizations.

A strong commitment to sustainable development by adopting sustainability-oriented innovations (SOI) may have the potential to be beneficial to a wide range of companies in the foodservice. Adams et al. define SOI as a type of innovation that requires "making intentional changes to an organization's philosophy and values, as well as to its products, processes or practices to serve the specific purpose of creating and realizing social and environmental value in addition to economic returns" [12]. SOI responds to the call for a new technological paradigm [12,13]. As research shows, interaction with third-party technology providers can foster the innovative capacity of companies for SOI [13]. Technological innovation is particularly salient to concerns expressed by scholars as a result of their work on quantification within food supply chains [14–16]. Moreover, technology provides businesses with tools to increase food waste valorization options [17], assess the true value of waste [18], improve minimization and recovery strategies [19], and trigger awareness among professionals [20]. Interestingly enough, the relative importance of technological sustainable solutions for commercial foodservice establishments is still not explored in many studies on food waste minimization.

This article sheds light on the opportunities and challenges tied to the implementation of sustainable technological innovations in commercial foodservice in an attempt to address the food waste challenge. The approaches of applying new technology to waste quantification, the characteristics and applications to minimize wastage are described in detail. Companies in foodservice contribute to a considerable share of total food waste and, more importantly, are characterized by an overall low sense of awareness about the challenge of minimizing food waste [20,21]. Through in-depth case research, this paper investigates a startup offering automated technology-based artificial intelligence (AI) tools, designed for quantifying food waste versus long-established manual quantification practices. The research focuses on the advantages of minimizing food waste and improving the management of existing wastage provided by technological SOI. This research has several theoretical and practical implications.

2. Background and Motivations

According to the Food and Agriculture Organization of the United Nations (FAO), food waste is defined as food which is fit for consumption but discarded by choice or because it has spoiled or expired, with 'food' referring to "processed, semi-processed or raw edible products going to human consumption" [2]. The fact that food wastage is recognized as a mounting, yet avoidable, challenge has driven the United Nations to adopt target 12.3 as part of its 17 Sustainable Development Goals to: "by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses."

Additionally, many member states of the European Union have started to put standards in place in order to incentivize food waste mitigation within certain industries or even penalize food wasters, for example, retailers in France [22]. Countries adopt different strategies to address wastage of food [23]. For example, Korea has established partnerships between the NGO KZWMN, different government authorities, local communities, and private enterprises to reduce food waste by 20% [24]. In the U.S., emphasis is placed on educating customers to reduce food waste from excess ordering and consumption [25]. Other countries primarily rely on private initiatives to promote food waste prevention [26].

Saving unnecessary costs by addressing food waste is not only a social and environmental priority, its quantification and minimization is profitable for the foodservice industry, considering that, across all industries, food waste costs a global annual average of EUR 2.4 trillion [27].

SOI Technological Applications for Food Waste Quantification

SOI is more disruptive than other forms of innovation [28,29]. Sustainability challenges many aspects of the service production and delivery, as it requires foodservices to develop longer term strategic planning as well as adopt new resource management processes and behaviors. With regard to food, SOI requires a multi-stakeholder approach to collaboration and business practices. Technology plays a central role in addressing the food waste challenge [30]. Without wide-range collaboration between foodservice businesses and technology providers, the likelihood of success is limited [31]. Despite acknowledging the importance of technological advancements in the upstream food chain phases, few studies have evaluated the viability of technologies for downstream activities with low technology readiness levels with respect to food waste quantification, minimization, valorization and overall sustainable management.

A recent literature review suggests several research propositions for reducing food loss and waste, including developing standardized and up-to-date data collection and concept definitions in food loss and waste and a reduction in greenhouse gas emissions [21,32]. Technology providers can develop apps and data that provides foodservice companies with food waste information and advantages of digital solutions in food surplus management [33]. Popular media has promoted the potential value of these new ventures [34]. Beyond technology, a few companies have introduced new sustainable business models around the notion of zero waste [35]. Another important aspect of the food waste challenge is the role of customers. Several studies explore the factors that predict consumer engagement and strategies for reducing food waste [33,36,37]. Behavioral aspects, consumer awareness and pro-environmental attitudes are the main determinants of consumer engagement in restaurant food waste mitigation [23,38].

Despite the significance of this issue to the global foodservice industry, the link between technology, SOI practices and food waste management has received limited attention. An exception is [20] recent research on the interrelationships of foodservice provisions and innovations in food waste management through the lenses of innovation theory. The study presents a range of waste management initiatives using the distinction between incremental innovations (those revolving around work processes and technologies) and radical innovations (innovations exploring opportunities to significantly change waste management approaches). This study also points out different approaches to food waste

based on waste characterization, management practices and management's beliefs, knowledge and awareness. The aim is to identify practices that are innovative in one way or another [20]. Standard waste management programs that do not take into account management readiness to adopt new technologies can be a barrier to the effective implementation of food waste innovations. This study also shows that interest in innovation as a systematic process to minimize waste and facilitate waste management is limited [20]. The absence of friendly, automated, cost-effective technological innovations can be a barrier to improving the quantification and valorization of food waste.

Only recently and with the increasing technological advancements in the artificial intelligence (AI) sphere has a more automated approach in measuring food waste become available. Automating food waste quantification significantly reduces the hassle for restaurants and also opens doors for long-term measurements, benchmarking and new standards and regulations.

3. Material and Methods

Case Study

This paper draws on a single case study. Empirical generalization from single case studies is difficult because statistical techniques often do not apply. Notwithstanding this, research method studies argue that case studies offer theoretical generalization and provide useful information for assessing the empirical generalizability of results [39]. Food waste studies have extensively used case study and explorative research methods. A considerable amount of research has been conducted based on a business case to illustrate innovative approaches to minimize food waste [40], the introduction of emerging technologies [17], or generation and collection of waste practices [41]. In order to analyze the role of technological innovations in quantification of food waste and its sustainable management in the commercial foodservice sector, this paper conducts an in-depth case study [42]. The case study methodology is a method that helps articulate information from various sources as the basis for conceptualization and theory building [42,43]. The case methodology is not driven by hypothesis testing. Similarly, theories are not set up at the beginning. The research question was as follows: how do tech startups provide technological SOI to quantify and measure food waste?

Food waste quantification is a novel phenomenon but difficult to study with a sample. Due to its characteristics, Kitro is a representative, prominent case [39,44] that is deemed appropriate for this study. The collected material includes primary and secondary material both in interviews and data forms, and archival information about the background of the startup, its technological solutions, and its plans for future. Semi-structured interviews were carried out by the first author among employees of the case study company and senior-level corporate managers and executives from foodservice companies that have agreed to acquire quantification solutions and business which have decided not to invest in these technological devices. Interviews with senior managers allowed us to explore the factors influencing the decision of whether to invest in new technological devices. Data for this paper has been supplemented with informal communications with founders of other startups in the nascent market of quantifying wastage, as well as with experts in food waste management, including consultants, project development managers, and academics. The interview protocol was slightly adapted in content and vocabulary to the different respondent profiles, but in every case included questions about actual measurement practices, the use of technology and opportunities for new innovations, and the main challenges and contingency measures adopted by foodservice professionals.

In interviews with employees the history of how and why of the case study company was started were discussed as well how the company has developed its technology and partnered up with companies in the foodservice and hospitality industry to launch its technological innovation. The corporate journey of Kitro and the establishment of collaborative relationships with hospitality companies is discussed in detailed. With respect to the

founders of the startup company, they were also interviewed but they agreed to discuss and consolidate their input in field of technology and the company case.

4. Results and Discussion

4.1. Food Waste Quantification

The first objective of this paper is to provide an account of how companies down the food value chain engage in actual food waste quantification. Quantification techniques are rarely discussed in articles on waste management, and no studies have reported about them, their occurrence or characteristics in the foodservice sector. Based on extensive fieldwork carried out in foodservice providers, including hotels, canteens, food chains and restaurants, a first account of the actual quantification methods used in the industry is offered.

Existing methods used for the capturing of food waste data in the hospitality industry are primarily manual. This is the main conclusion extracted from observational records on the different methods used by foodservice companies to quantify food waste. This data derives from hundreds of on-site visits and commercial interactions carried out by employees of the case study company with professionals in the hospitality and foodservice industry. Fieldwork reveals three major quantification mechanisms, as follows:

a. A staff member stands next to a trash bin and observes, writes down and sometimes even places the item on a scale before throwing it in the trash [45].
b. Food waste can also be measured short-term by having 4–7 different color containers where they separate the waste into different categories (e.g., starch, protein, etc.) and weigh it at the end of the day. The so-called Food Waste Bin Tracker Spreadsheet is a popular to measure waste
c. A more digital solution is a tablet attached to a counter-top scale. Staff members place an item on the scale and type into the tablet what it is before disposing of it.

Data collected by the Kitro team suggests that these methods are all time consuming, inaccurate, costly and do not provide a holistic overview of the food thrown away. Management must rely on their staff to type in what is thrown away, which often leads to inconsistent and erroneous results. For this reason, many companies do not know what fills their trash bin and allow unfathomable amounts of money and valuable resources to land in the trash day after day. Using technological innovations via collaborations with third-party companies can be a strategic and cost-effective way to supplement a company's open innovation activities.

Since 2010 technological competition for sustainable solutions in the global foodservice industry has included the development of new technology to improve quantification, minimization, and valorization of food waste. A number of technological startups collaborate and establish formal relationships with hotels and restaurants to introduce sustainability waste management practices. While in some industries and activities firms have more leverage to deal with sustainability, foodservices need to collaborate with oftentimes startups to put in practice sustainability. They cannot do it in isolation. Hence, the importance of developing fruitful relationships with external agents. Table 1 provides an overview of the main characteristics of existing technological providers of food waste quantification solutions.

Table 1. Overview of the main food waste quantification service providers.

Company	Date of Establishment	Headquarters	Main Activity	Characteristics of the Technological SOI
LeanPath	2004	Portland, US	High volume kitchens (food not made-to-order)	A pool of tracking stations to measure food waste
LightBlue	2012	Singapore	Commercial kitchens	FIT Food Waste Monitoring Tech
Winnow Solution	2013	London, UK	High volume and commercial kitchens	Patented smart meter technology attached to food waste bin
Kitro	2017	Zurich, Switzerland	Commercial kitchens	Automatic food waste classification using machine learning
Orbisk	2019	Utrecht, Netherlands	Commercial kitchens (food made-to-order)	Computer vision and AI data recording terminal

Existing sustainability-oriented technological solutions on the market are Winnow Solution in the UK [46,47], LeanPath in the U.S., LightBlue in Singapore, Kitro in Switzerland, and Orbisk in Netherlands [48]. These companies help foodservice businesses move away from manual measurements with paper and pen to digital, automated solutions including the application of AI technology. The technology offered by some of these companies currently requires employees to manually note the items being thrown away resulting in time invested on tracking items. More advanced solutions do not require any manual input from the user's side. Moreover, complimentary technology and offerings on the market are forecasting technology provided by players such as Delicious Data [49] or more traditional food waste consultants, such as LightBlue Environmental Consulting and its PLEDGE on Food Waste, which, together with its FIT ("Food Intel Technology") food waste monitoring technology for commercial kitchens, also offers technical online workshops and audited certification on food waste prevention for establishments and professionals [50]. There are clear opportunities to strengthen prevention advice by working with an automated food waste management device [51].

In general, startups provide foodservices access to waste metrics. Whilst there are certain differences across firms, their technological SOI can be summarized as follows:

- A solution that integrates the data network connectivity with the waste disposal machine
- A device that measures food waste volumes directly from the disposal unit. Waste data can be shared immediately via any network.
- The actual output offers reporting and data to help supervisors and employees identify ways to prevent waste.

Existing solutions to measure and analyze food waste vary in how to achieve this in a non-intrusive and fully automated way. Those that are not seamlessly integrated into existing workflows may create an extra step for the kitchen and service staff. Likewise, current tools for assessing food waste that are highly complex or lack accuracy [52] are onerous for employees in terms of time, resources and work and are therefore mostly used for short-term measurements (food waste audits). However, they are sometimes still referred to as "automatic" as they provide the food waste analysis mostly via an online dashboard [14].

Food waste quantification service providers emphasize their technology helps find solutions to the waste problem and proves effective in identifying opportunities for more efficient methods of food purchasing, storing and handling, meal planning and preparation, and waste prevention in general. Technological devices attempt to overcome the lack of common standards for quantifying and reporting food waste [53]. All providers acknowledge that setting a common methodology for quantifying food waste is a prerequisite to ensure monitoring progress toward reduction targets [7,27]. The development of quantification methodologies is a central concern also in the academic literature [14].

4.2. A Technological SOI for Food Waste

Founded in 2017, Kitro is a startup embarking on a global challenge by harnessing the power of technology and using it for sustainable change. Created by hospitality insiders, the company strives to bring back the value of food, so it is appreciated and not wasted. The Swiss startup focuses on finding innovative solutions to manage food waste tailored to the hospitality and restaurant industry [54]. The initial focus of the startup was on Switzerland because the country is among the most advanced in Europe in terms of waste management initiatives and public awareness [55,56]. Given the innovativeness of their offering, the company plans to quickly expand to other countries.

Kitro is currently a team of 12, based in Switzerland. The company has been invited to speak at over 20 high-level events, such as "Sustainable Europe 2030: From Goals to Delivery" of the EU commission in Brussels or the Global Restaurant Investment Forum in Dubai. Awarded by multiple organizations, such as the World Tourism Forum Lucerne, the Milestone Premiere Award in 2018, or the HITECH Entrepreneur 20X Award, Kitro continues on its journey to bring a product to the market that can have a real impact

on the way food waste is handled. Customers are mostly canteens such as universities, including the EPFL Campus (Swiss Federal Institute of Technology, Lausanne), or hotels like Hotel d'Angleterre (Geneva), Kursaal (Bern), and the Weisse Arena Gruppe (Laax). They have provided continuous measurements for the fourth year in a row. Having measured in more than 70 properties mostly in Switzerland, the company plans to expand into neighboring countries.

With AI as the foundation, Kitro offers an automated food waste data collection and analysis solution that can be adopted by food and beverage outlets worldwide (Figure 1). Kitro is targeting the commercial foodservice industry by providing users with an automated solution to measure and mitigate food waste. The goal is to prevent unnecessary waste through long-term data collection and optimized operational practices. In addition to the detailed analysis, Kitro also offers a service to ensure customers are empowered to achieve the highest possible savings in terms of food waste and cost, resulting in a lower carbon footprint.

Figure 1. Kitro technology (from Kitro.ch).

Kitro's quantification methodology is a premium IoT-solution for food waste management. It works with a combination of a hardware and a software system. The hardware consists of a camera positioned above the customer's existing waste bin and connected to a scale placed below it. Images of the waste bin's contents are collected whenever new waste is disposed in the bin (See Figure 2). The recording is triggered by the scale located below the bin. The resulting images depict the changing content of the trash bin as food lands in the bin. The software recognizes both unavoidable waste (e.g., peelings) and avoidable food waste (e.g., dressed dishes). Technology allows to systematically analyze returned plates and undertake potential adjustments on the type of dishes served and the size of the portions.

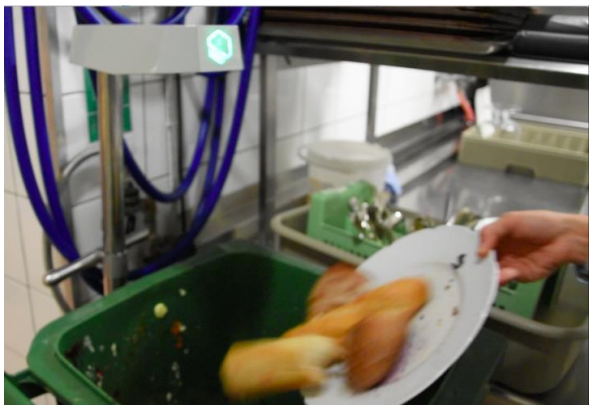

Figure 2. Kitro technology (from Kitro.ch).

Kitro applies a novel approach for automatic food classification using machine learning. The input data for this estimation includes a sequence of images captured by the camera and physical weight changes from the scale sensor. Once the items on the images have been classified, the analysis is presented in an online dashboard. The detailed findings of the food waste situation allow restaurant owners and executive chefs to make data-driven decisions. The expectation is that optimizing their work practices will lead to more resource-efficient processes and a significant reduction in food waste and food cost. No matter the method used to measure food waste, there is a clear benefit to quantifying the waste and sharing its impact and cost with management and kitchen staff. This is particularly the case for catering businesses [48]. Past measurements prove that the mere act of food waste quantification already increased awareness within the property to the point that there was a visible reduction in food waste.

4.3. From Quantification to Minimization

The adoption of automated technology in foodservice not only facilitates wastage quantification but it also gives establishments with actionable measures. Restaurant owners and executive chefs gain access to an online analytics dashboard, which gives them deep insights into their food waste components, quantities, cost and sources of waste. As a result, restaurant owners and executive chefs can take data-driven decisions to optimize work practices related to tracking progress on reduction targets and exploring mitigation strategies. At the managerial level, quantification enables new budgeting (inventory) tools for planning and control. Kitro's post-sale customer service further supports them by suggesting best practices and setting goals. Through external communication of their results foodservice establishments can increase their competitiveness not only through resource-efficient operations but also by portraying a positive image to their end consumers.

In past measurements with over 50 kitchens in Switzerland, Kitro achieved a maximum avoidable food waste reduction of 55% and food cost savings of 5%. Based on these historic results and external case studies by other food waste measurement solutions on the market by Food Loss+Waste [57] and Winnows's cases studies [58], it is anticipated that avoidable food waste reductions of up to 70% are achievable. A case study conducted by Kitro employees in a luxury hotel in Switzerland showed that direct benefits of measuring food waste become apparent after only 5 weeks. In this study, the focus was the breakfast buffet where enormous amounts of eggs, sausage and bacon were thrown away. This was a previous blind spot for the chef as it went directly to the staff canteen and had never been measured. By changing the setup of the buffet, adjusting portion sizes and assigning one person responsible for refilling the buffet based on demand, they were able to significantly reduce their avoidable breakfast waste by more than 10kg per week resulting in cost savings of EUR 1500/USD 1800 in only 5 weeks.

Data-driven changes in kitchen operations that can drastically improve a restaurant's food margins are shown in another example. A staff canteen focused on serving local and seasonal food for sustainable reasons and had Brussel sprouts on offer multiple times a week. Every time these green vegetables went out for service, moments later they could be found in the trash bin. The recording of the returned food waste allowed the property to understand consumer preferences and change their menu offer.

Table 2 outlines a summary of the case company's results per customer segment between 2017, 2018 and 2019. According to data collected by the case company, efforts invested in food waste mitigation can quickly pay off and lead to cost savings of CHF 25,000–150,000 per year (depending on outlet size, type, etc.).

The interviewed top executives emphasize that achieving sustainable operations is a holistic project that has to involve the whole team. They indicated that consistent communication within cross-departmental team members is key to success. The sustainability/marketing department should be just as involved in the process as the kitchen and service team to ensure that everyone plays their part. While the kitchen team focuses on analyzing the results and implementing changes in the kitchen, the service team will have

to be briefed on what to tell customers in case portion sizes are smaller than before and if supplements can be requested. The marketing team can then create visibility by publishing the results in a concise manner in order to increase awareness.

Table 2. Kitro results with selected test customers (2017–2019).

Main Facts	Canteens	Hotels	Restaurants
% of total test customers	34%	34%	31%
Average size (seats)	275	150	340
Average reduction of avoidable food waste	20–50%	25–60%	15–40%
Average savings (CHF)		25,000–150,000 [1]	

[1] Savings estimated for the three-year period.

Consistent with existing research, all interviewed experts pointed out that quantification of food waste to detect operational inefficiencies and improve operations has proven to be a valid method to produce quick results. Once initial waste reductions have been achieved, continuous measurement ensures that food waste levels are under control and do not fluctuate after changes in menus, seasons, or staff. Experts suggested that, like in most other aspects of business, relevant KPIs (key performance indictors) are key to performance improvements and therefore picking a KPI related to food efficiency/food waste should become a norm in F&B outlets in the 21st century.

Interviews with senior executives from businesses that have decided not to invest in technological quantification solutions pointed out to potential resistance in market adoption as members of the kitchen team may be reluctant to take on waste control tasks. While the goal for food waste quantification is to support chefs in their work, it has also become apparent that some are worried about being criticized as a result of the waste measurements. Increased cost is another concern reported mainly from small-scale businesses. There seems to be a link between the organizational culture and the success of a food waste measurement system [59]. Further studies would have to prove that assumption, but preliminary results based on past measurements show that in organizations where a "blaming culture" was practiced, staff members were scared of criticism, which ultimately led them to not use the system correctly. Therefore, it is crucial to shift the mindset of each individual and ensure that everyone in the company feels included in the project [16,60]. This can be greatly facilitated by top management with an open communication and shared goal setting with involved parties [61–65].

Another reason slowing down rapid adoption is the fact that, in the first step potential, customers need to be educated on the impacts of food waste, not only on an environmental but also economical level. Food waste quantities are often underestimated by management, resulting in the food service industry missing out on this viable financial opportunity.

The substantial ROI of food waste reduction has been recognized only recently by the industry as long-term measurements become more accessible and feasible through enabling technology. For an industry that is constantly struggling with cost control, a trend for increasing market adoption of automated food waste management solutions can be expected.

Adopting technological SOI via collaborations with third-party tech companies can be a suitable, cost-effective way to supplement a foodservice company's standard operating activities, as the in-depth case study of a European startup providing innovative waste quantification technology suggests. The role of innovative solutions to lower costs and increase business sustainable development are of utmost importance in navigating through economic downturn and social uncertainty [66–69]. This is particularly the case in the current market conditions of extreme volatility by the COVID-19 virus pandemic [70].

This study contributes to recent research illustrating how wastage quantification SOI increases awareness. It helps assess environmental impacts, prompts change in behavior, improves management practice, enables establishments to track progress on reduction targets and explore mitigation strategies, and promotes new budgeting (inventory) for

planning and control. Future research should address the precise nature of these managerial opportunities by means of cross-sectional, longitudinal studies. These are promising paths for future research on sustainability technological innovation, wastage quantification, and management [71].

5. Conclusions

This paper reports field data on food waste quantification methods and an in-depth case analysis of a startup company offering automatic technology for quantifying food waste. The topic of food waste has recently received increased media attention with an increasing number of initiatives being created in response to the problem. Consumers increasingly demand sustainable products and more regulations and standards. The tourism and food catering industries, including hotels and restaurants, must react to the increasing demands of their guests. From an applied perspective, SOI in the form of digital green solutions are potentially easy to implement and may have a big environmental impact without costing any additional money. It is surprising that technology-driven quantification, which is usually listed among the main innovations in sustainability articles on food waste management, has rarely been reported in applied research (for an exception [15]). The importance of technology is particularly important for commercial foodservice activities because sophisticated food waste management is not often implemented in these establishments.

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