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Digital Platforms: Mapping the Territory of New Technologies to Fight Food Waste

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Structured Abstract

Purpose – The reduction of food waste is still a pending issue that governments have still not resolved. In response to this problem mobile platforms are emerging that follow food ecology and the responsible consumption of food, and self-management of their access to allows the communication between people and their use of food.

In this paper, we will analyze the main digital platforms that deal with solving this problem, especially those that fulfill a social commitment through the distribution and reduction of waste.

Design/methodology/approach – To provide solutions, we will address the importance of new technologies in the fight against waste, using digital platforms to manage food and to eliminate the loss in surplus products. To do this, we will first analyze from a theoretical point of view the concepts of "loss", "waste "and" surplus product", incorporating data of their impact between Spain and Italy. Next, we will analyze the influence of new technologies in the detection and distribution of products destined to become food waste. To carry out this qualitative research, we will apply the research strategy of theory building from multiple case studies (particularly 16 different digital platforms against food waste were analyzed), which is a methodological approach that uses cases as the basis to develop theory inductively.

Findings – We must make the public aware of the importance of being responsible consumers. To this end, we must disclose the problems associated with food waste and surplus product, presenting alternatives and new consumption habits. For this, it is necessary to collaborate and build synergies with organizations of different origins (consumers, producers and activists) involved in sustainable agrifood models. In this sense, digital platforms are essential tools to fight against food waste, preventing certain products from being considered unfit for human consumption. In this study we suggest that, based on the review of the literature and the analysis of apps and blogs, we look for solutions to surplus and food waste both from the environment of the entrepreneur and the consumer and all using the new technologies.

Research limitations/implications – The research has raised different limitations. On the one hand, it is a subject that has not been analyzed from a doctrinal point of view, so it is not easy to find bibliographic references. On the other hand, digital platforms that act on food waste are not cataloged. This has made it difficult to search for elements of analysis to obtain results in the work. Finally, the sample can vary in a short period of time since the digital platforms are in a boom, which means that they constantly change.

Practical implications – This work allows a theoretical approach to the concepts of "loss", "wastage" and "surplus product", incorporating data on its impact in Spain and Italy, comparing it with the rest of Europe while providing figures and data on their impact. On the other hand, it allows us to know how new technologies can help the detection and distribution of products destined to become food waste. Finally, there are examples of platforms that are offering service in different areas, incorporating a novel classification that allows us to know the differences depending on their origin and destination.

Originality/value – The originality of the work can be summarized in the following points: There are no doctrinal works that analyze in a combined way the food waste with the new technologies; The relationship with the 2030 Agenda in which responsible consumption is one of the achievements pursued by the United Nations and we position our research as an evidence of platforms that are currently working in the interest of reducing food waste. Furthermore, we provide an early classification of platforms based on their usability and objectives of reducing, reusing and recycling food.

Keywords – Digital platforms, food waste, responsible consume, surplus products, sustainable development goals

Paper type – Research paper

Introduction

Food is a very valuable resource that must be managed and consumed with utmost care, taking advantage of all its nutritional capacity regardless of the customs and social habits that characterize each community in space and time. According to this reasoning, no food should be considered as waste.

We face a great paradox: on the one hand, there is the scourge of poverty, on the other, every year 1.3 billion tons of food is wasted worldwide (Michelini *et al.*, 2018). Waste is in this sense a characteristic problem of developed societies that each year causes the loss of thousands of tons of food. To reduce waste, it is necessary to act from a cross-cutting, multifaceted perspective that takes into account specific actions in each link of the food chain while addressing economic, environmental, nutritional and cultural solutions among others, since all they influence how food is consumed.

To address these problems, alternative distribution formats have emerged aimed at both reducing excess and food waste while seeking to generate a positive social impact. Traditionally, the systems that have been used have been food banks and social supermarkets currently complemented by digital technology and the phenomenon of the shared economy through web platforms and applications for food sharing.

The main objective of this research is to *identify when the food production chain produces excess and waste, and then identify how platforms, blogs and websites that fight against this phenomenon work, by pointing out differences and similarities of standardized platforms that can represent benchmarks in two European countries: Spain and Italy.*

To answer this question, two different aspects of this topic have been analyzed. On the one hand, the analysis of the phases where the excess and waste of food is produced (production, distribution and consumption phases) (Morone *et al.*, 2018) to reach the conclusion that it is in the last phase (consumption) where the new technologies operate (Principato, 2018). On the other hand, blogs, platforms and existing websites in two countries (Spain and Italy) have been analyzed, where gastronomic culture is well established. Specifically, the existing digital tools in supermarkets, restaurants and at home have been taken into consideration.

First of all, we analyze from a theoretical point of view the concepts of “loss”, “waste” and “surplus product”, incorporating data on their impact between Spain and Italy. The reason why Spain and Italy have been selected is because they represent benchmark and comparable countries around this topic (Food Sustainability Index, 2018).

Next, we analyze the influence of new technologies on the detection and distribution of products destined to become food waste. We argue that new product or service development with certain technological characteristics (Harvey *et al.*, 2019; Michelini *et al.*, 2018; Santoro *et al.*, 2017a) can

contribute to the reduction of food waste and will provide a mapping of the territory of such new technologies in Spain and Italy to shed light on the potentialities that these tools can have in the food waste battle. Our mapping is based on the main challenges for food waste and provides a comprehensive overview on how technologies can respond to such challenges. In particular, Spain dominates the landscape of new technologies against food waste and represents a benchmark for food and beverage practitioners throughout Europe to replicate the progresses made.

Our perception is that new technologies have been implemented in a short time, which will probably displace traditional systems. However, there is a shortcoming related to the generational digital gap and, on the other hand, their territorial character, since these tools work locally.

To the best of our knowledge, it is the first study of its kind, and it is also original in that the use of main platforms, blogs and websites to fight against waste and excess produced by the food production chain is analyzed in greater detail than in previous studies and comparatively, taking into consideration two European countries that can be regarded at the forefront in managing this phenomenon.

A better understanding of the role and ability of web technologies to fight food waste is essential for academics, companies and policy-makers.

Literature review

Food waste has received increasing attention in recent years especially if we take into account the unfavorable environmental, economic and social consequences for the sustainability of the planet. Proper waste management is recognized as an essential prerequisite for sustainable development (UNEP, 2011; UNHSP, 2010), although historically public waste management focused on eliminating potentially harmful substances or materials from human settlements (Wilson *et al.*, 2012; Velis *et al.*, 2009). It is currently estimated that the food sector causes approximately one third of all greenhouse gas emissions (in the EU) (Garnett, 2011), although society is aware that the risks due to climate change and the loss of biodiversity has not reached bottom (Rockström *et al.*, 2009; Cordell *et al.*, 2009). Many consider waste to be an unfair “luxury” that humanity cannot afford. Consequently, reducing this waste is one of the actions necessary for more sustainable food security (Godfray *et al.*, 2010; Foley *et al.*, 2011).

Stuart (2009) estimates that North America and Europe discard 30 to 50% of their food supplies, enough to feed the world’s hungry three times. Gustavsson *et al.* (2011) suggests that one third of the edible parts of food produced for human consumption are lost or wasted, equivalent to 1.3 billion tons per year.

The distribution of food losses and waste varies between developed and developing countries, and

between producers and consumers (Gustavsson *et al.*, 2011; Hodges *et al.*, 2010; Lundqvist *et al.*, 2008). Food losses and waste are greater in developed countries with an average food loss of 280-300 kg per capita per year in Europe and North America and an average food loss of 120-170 kg per capita per year in sub-Saharan Africa and South and Southeast Asia (Papargyropoulou *et al.*, 2014). In developing countries, most food losses occur in the early stages of the Supply Chain Cycle (SCC). This is due to bad harvesting technologies, lack of transport and poor storage in combination with extreme weather conditions. In developed countries, food waste during the consumption stage accounts for more than 40% of total food losses and waste (Gustavsson *et al.*, 2011).

On the other hand, UNEP emphasizes the economic benefits of resource efficiency and waste reduction and suggests that minimizing the use of resources, waste and other emissions have the potential to generate cost savings, identify new fields business and increase employment and competitiveness (UNEP, 2011).

In addition to environmental and economic impacts, food waste also has social implications (Salhofer *et al.*, 2008). These tend to focus on the ethical and moral dimension of food waste, particularly in relation to inequality between wasteful practices and food poverty (Evans, 2011; Stuart, 2009; Wrigley, 2002). In this sense, the issue of global food security is becoming increasingly important on local and global agendas, the reduction of food losses and waste throughout the SCC, as well as alternative diets, are considered as a first step to achieve food security (Haberl *et al.*, 2011; Schönhart *et al.*, 2009; Engström and Carlsson-Kanyama, 2004).

Edwards and Mercer (2007) mention the “ethics of food waste” and explore the emergence of movements of groups that consume food that has been thrown away, to minimize its environmental impact and address social inequality in terms of access to food. Gregson *et al.* (2013) highlight the conflict between social values linked to “savings” and the environmental values that underpin reuse and the implications of this conflict for the generation and prevention of waste. In short, food waste is immoral (Parfitt *et al.*, 2010).

For this reason, in recent years, an increasing number of studies have examined food waste and consumer behavior in order to reduce food waste in developed countries. For this, it is necessary to have a deep understanding of the factors that shape the perception and behavior of both the consumer and the producer at home and at the point of purchase as well as their position regarding the management of the products that are purchased, they are consumed and wasted.

On the other hand, several studies (Lee *et al.*, 2012; Nam and Pardo, 2011; Paskaleva, 2011; Scuotto *et al.*, 2016; Wolfram, 2012) have analyzed the effect of new technologies on an urban and innovative environment in which they try to implement systems to favor socioeconomic development, as well as to obtain a better market management (Del Giudice and Straub, 2011) and an improvement

in the quality of life (Almirall *et al.*, 2014).

In general, it can be assumed that initiatives related to new technologies produce a favorable and positive organizational climate that encourages the proactive participation of citizens in the innovation process. This attitude allows us to take advantage of innovation to improve the social environment (Vrontis *et al.*, 2016). In this sense, citizens, companies and public organizations tend to cooperate to develop knowledge and technological innovations that improve their relationships especially in the urban sphere through the greater circulation of knowledge and collaboration of companies and citizens in cooperation projects (Dyer and Noneoka, 2000; Pinegar, 2006).

In this sense, the projects in which new technologies are used are recognized as a necessary process to foster the collaborative spirit in urban contexts where to promote commercial opportunities (Del Giudice and Maggioni, 2014; Grant and Baden-Fuller, 2004).

Currently, what seems more interesting is that new technologies are democratizing and reorienting innovation processes, bringing technology closer to users, allowing them to improve their quality of life and improve their relationships personal and professional (Campbell, 2013). The exchange through social networks and apps favor the reduction of heterogeneity within society, increasing competitiveness among companies. In this sense, new technologies contribute collaborations, promoting new models and innovation processes for both companies and consumers. (Carayannis and Alexander, 1999; Santoro *et al.*, 2017b).

With this objective, the current article informs how new technologies can be used to combat food waste and answer the question of how can surplus and food waste be handled more sustainably, involving both consumers and producers (Aschemann-Witzel *et al.*, 2015).

For this, an approach based on academic research, literature review and analysis of apps present in the market has been followed. The contribution of this article is to provide a holistic image of the factors that cause food waste by identifying possible action points for further reduction, highlighting the means offered by new technologies to reduce the impact of the surplus on the market. At the same time, the foundations are laid to continue working on future trends, analyzing the barriers and opportunities for a more sustainable management of surplus and food waste throughout the food supply chain, creating a guide to establish options more appropriate to meet the growing challenge of food waste.

Methodological approach

This qualitative paper applies the research strategy of theory building from case studies, particularly multiple cases (Eisenhardt and Graebner, 2007). According to many authors (Eisenhardt, 1989; Gilbert, 2005; Weick, 1993; Yin, 2014), building theory from case studies is a research strategy that

involves using one or more cases to create theoretical constructs, propositions and/or midrange theory from case-based, empirical evidence.

Eisenhardt (1989) describes the process of inducting theory using case studies, from specifying the research questions to reaching closure, and he concludes that this research approach is especially appropriate in new topic areas and that the resultant theory is often novel, testable, and empirically valid.

Yin (2014) shows the case-study research process as a “linear but iterative process” and provides practical and technical discussions on each of the six elements of case-study analysis: plan, design, preparation, data collection, analysis and reporting. He establishes the basis for case studies as a research method but also provides a twofold operational definition, covering both its scope and its features, that clearly distinguishes it from other methods. Yin shows how case-study research constitutes an all-encompassing method that covers the logic of design, data collection techniques, and specific approaches to data analysis. In his opinion, a case study is «an empirical inquiry that investigates a contemporary phenomenon (the “case”) in depth and within its real-world context» (p. 16).

So, the crucial notion about this methodological approach is to use cases as the basis from which to develop theory inductively, in the sense that it is situated in and developed by recognizing patterns of relationships among constructs within and across cases and their underlying logical arguments (Eisenhardt and Graebner, 2007). Eisenhardt (1989) explains that replication logic is central to building theory from case studies, in the sense that, every single case serves as a distinct experiment that stands on its own as an analytic unit. Furthermore, every case study emphasizes the richness of the context in which the studied phenomenon (the theme of the research question itself) occurs.

In the case of this research, data on the 16 cases were collected through literature, their websites and direct interviews in order to build early replicable insights in the field of technology applied to food waste and analyze common patterns and similarities between the two countries under investigation.

In particular, it was possible to conduct direct interviews with the communication managers of seven of the sixteen cases analyzed. The interviews were all carried out by telephone and they lasted around 40 minutes on average.

Concepts: loss, waste, surplus products

Food loss and food waste are the two of the main reasons for food unsustainability (Civera, 2018). The foods that are used for consumption form part of a process called the food chain, which starts with agricultural production and ends in households and restaurants (Delley and Brunner, 2018;

Garrone *et al.*, 2014; Silvennoinen *et al.*, 2014). At another level is the so-called food cycle, which differs from the food chain by incorporating other agents (retrievers and recyclers) in the management of food.

Loss, waste and surplus products occur within the food chain or food cycle as phases through which products are not made available for consumption for different reasons that we explain below.

Loss in the food chain

Loss is considered the circumstance under which food suffers deterioration and is no longer fit for consumption. Losses occur throughout the entire food chain, occurring for various reasons such as climatic conditions, pests, storage of products, etc. In developed countries losses are more frequent at the beginning of the chain (production, post-production and transformation) and especially in the post-production phase (Bagherzadeh *et al.*, 2014; Martindale and Schiebel, 2017).

MAGRAMA (2014) considers that losses occur when organic products generated during the agrifood transformation process are rejected because they do not meet the required quality criteria. This means that losses are intrinsic to the production process (Bonadonna *et al.*, 2019) and although while in some cases these are inevitable, they can sometimes be eliminated by solving existing deficiencies in infrastructure or by improving the management of the food process (Parfitt *et al.*, 2010).

Waste in the food chain

Taking FAO (*Food and Agriculture Organization of the United Nations*) as a reference, food waste is defined as «any change in the availability of food, in its capacity to be consumed, or in its sanitary characteristics or quality, that deprive it of being consumed by people» (2011).

In other words, waste refers to the situation in which food is discarded despite still being fit for consumption, which usually occurs at the end of the food chain (distribution and consumption) (Parfitt *et al.*, 2010), that is, when the product is completed and ready for consumption but not made available to the final consumer. In this case, the product is not incorporated into the food chain due to poor internal management. Therefore, its conversion into waste is avoidable, since the product, if eaten, would not harm human health.

As can be seen, loss and waste are very similar concepts that correspond to situations related to the mismanagement of food at some stage of the food chain.

These percentages vary depending on the country and the type of product measured. Therefore, we will take Spain and Italy as models of analysis to determine the impact of waste in the different phases of the food consumption process.

SPAIN

Following the report carried out by the UPM (Technical University of Madrid) Food Bank Board

titled “Food waste in Spain: Statistical data, origin and legislation to reduce it” (Afonso and Sastre, 2017), we present data on loss and waste in the different stages of the food chain.

a) Production phase

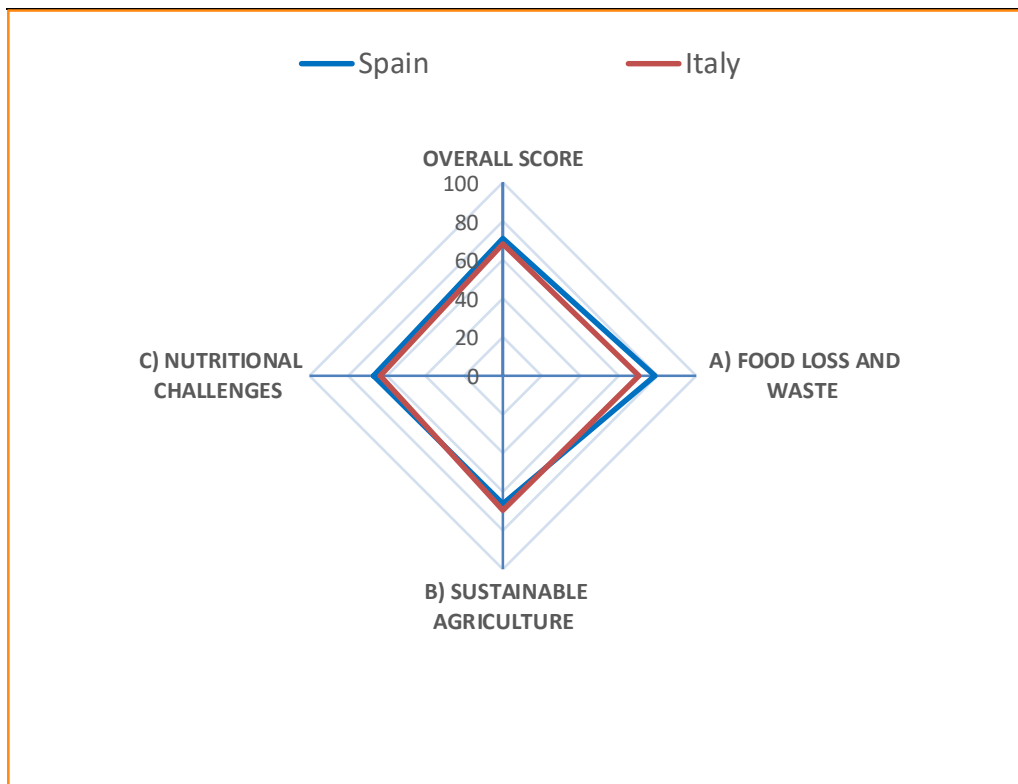
The production phase refers to what happens upstream of the food supply chain, or during the cultivation or breeding, harvesting and processing of the raw material.

At this stage, the greatest waste occurs primarily due to the lack of expertise in the management of agricultural land, the lack of adequate electricity and water infrastructure, problems with the storage and transport of goods.

Table 2 includes data on the estimated percentage of food unused during the food production phase.

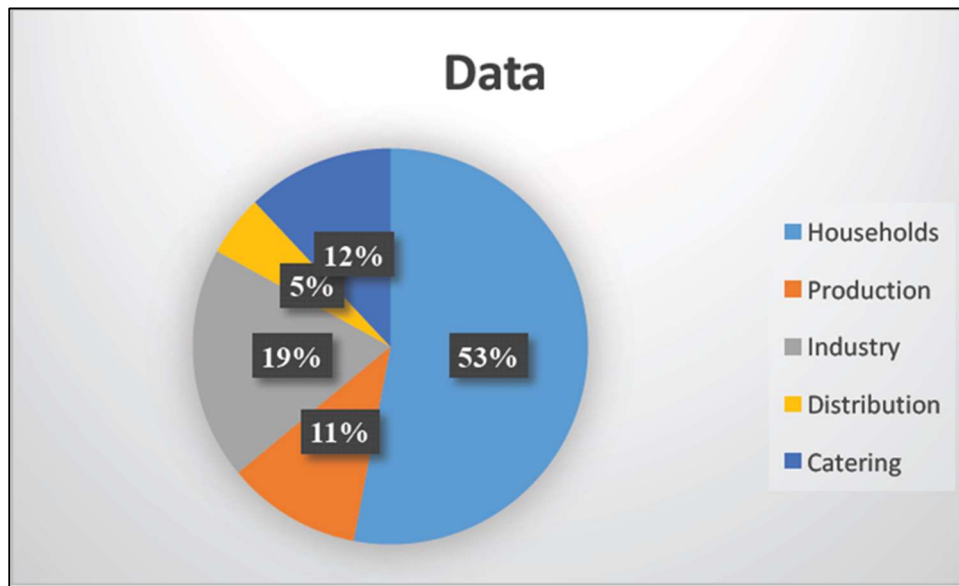
It can be seen that losses are much higher than waste in the production phase, since the products analysed are perishable.

Figure 1. Comparison overview between Spain and Italy based on the FSI



Source: <http://foodsustainability.eiu.com>.

Figure 2. Food loss and food waste in the food chain in the EU-28



Source: FUSIONS, 2016.

Table 1. Policy response to food waste: top performers

Rank	Country	Score (out of 100)
1	US	100
=2	Argentina	96.3
=2	Spain	96.3
4	South Korea	90.7
=5	France	88.9
=5	Italy	88.9

Source: Fixing Food 2018.

b) Industrial phase

In this phase, the most consistent waste occurs mainly during the industrial transformation where, due to inappropriate marketing practices, the products that are aesthetically not likely to meet the consumer's satisfaction are discarded.

Table 3 includes data on the estimated percentage of food wasted during industrial processes: preparation, processing, conservation and manufacturing.

From Table 3, it can be seen that a greater percentage of waste occurs in fruit and vegetables than in bakery and pasta products. This is because an important part of the waste produced in the industrial phase is due to standardization of size and quality of food products (Halloran *et al.*, 2014; Strotmann *et al.*, 2017).

c) Distribution phase

The withdrawal of most of the products in the distribution phase is due to the fact that they have passed the use by date or best before date on the shelves. 78.8% of distributors withdraw an average

of 5.6% of their products for these reasons (MAGRAMA, 2013).

The distribution phase includes the transportation of food from the place of production to its arrival on the market, with three main causes identified as being responsible for waste (Waste Agency of Catalonia, 2011):

- Market trends, which have led to an increased demand for refrigerated products (fresh pasta, prepared and packaged salads, fresh fruit juices, etc.), which alters the management and duration of the stock.
- Natural conditions: The seasonal nature of the demand, the duration of fresh products and changes in the weather etc.

Table 2. Estimation of loss and waste in the production phase according to sector (%)

SUBSECTOR	CITRUS FRUITS		OTHER FRUIT		VEGETABLES		FATS and OILS		WINE		CEREALS and LEGUMES	
	<i>Loss</i>	<i>Waste</i>	<i>Loss</i>	<i>Waste</i>	<i>Loss</i>	<i>Waste</i>	<i>Loss</i>	<i>Waste</i>	<i>Loss</i>	<i>Waste</i>	<i>Loss</i>	<i>Waste</i>
<i>STAGE</i>												
Crop	17.8		18.9		21		21.5		17.2		21.9	
Harvest	0.74	1.86	0.32	1.9	5.06	1.54	0.39	4.35	2.07	1.88	1.48	1.61
Conditioning		2.8		1.98		1.61		2.19		1.57		1.72
TOTAL	18.54	3.94	19.22	3.88	26.06	3.15	21.89	6.54	19.27	3.45	23.38	3.33
Total losses/waste	22.5		23.1		29.2		28.4		22.7		26.7	

Source: MAGRAMA, 2014 b.

- Mismanagement of products: Failures in both communication and demand predictions.

Of these three causes, the third is due to human factors, since it is the only one that can be improved in order to reduce food waste.

Together with the causes that result in waste in the food chain are also failures in management by end consumers. Next we will see what happens in catering and households with regard to the management of food products (Mondello *et al.*, 2017; Peira *et al.*, 2018).

d) In restaurant and catering services

The restaurant and catering sector is one of the sectors generating the most waste due to poor management in storage and oversized portions that in most cases end up being thrown away (Michalec *et al.*, 2018). These errors could be avoided by acting on the following factors:

- Reducing the size of portions and the range of menus offering closed menus that do not allow customers to choose between dishes.
- Logistics and planning of services (reservations and buffets) so that no food is in excess.
- Changing the habits and attitudes of citizens, who should take any food left over from their restaurant meals home with them in order to avoid it being wasted.
- Raising awareness of the problem of waste in the sector, which still does not believe it

necessary to reduce waste.

e) At home

The magnitude of waste in households, together with the large number of family units, means that responsible behavior and any small action to avoid food waste have a positive multiplying effect (Jagau and Vyrastekova, 2017; Szabó-Bódi *et al.*, 2018). The factors that influence food waste in the domestic sector include the following:

- Lack of awareness of what is being thrown away, despite the growing concern of society vis-à-vis contributing to improving environmental issues.
- The socioeconomic conditions of families. Thus, for example, single-parent or single-person households generate more food waste than a family of four, since supermarket portions are designed for this type of family. It has also been found that young people (Principato *et al.*, 2015) tend to eat out and buy ready-meal products (from the packaging to the plate or from the packaging to the microwave and to the plate).
- Lack of planning when shopping, which leads customers to buy too much food that ends up being stored rather than eaten, when it then goes off or passes the use-by date rather than being consumed.

Table 3. Estimation of loss and waste in industrial processes according to sector (%)

	Total	Perd.	Desp.
Meat and meat products	11.9	6.3	5.6
Fish, shell fish, seafood	45.8	0.5	45.3
Fruit and vegetables	24.7	14.7	10
Oils and fats	80	0	80
Dairy products	3.6	0.2	3.4
Starches and starch products	23	1.8	21.2
Bread and pasts	36.1	22.4	13.7
Other food products	15.9	2.5	13.4
Drinks	26.2	4.7	21.5

Source: MAGRAMA, 2014 a.

- Cultural attitudes that favor waste, such as not reusing food throughout the day or the loss of the culinary culture in which dishes are made using the remains of other meals.
- Lack of information on storage that helps food last longer or to help consumers distinguish between “use-by dates” and “best-before dates”.

A study conducted by HISPACOOOP (2013) concluded that Spanish households annually throw away 1.5 million tons of food that was fit for consumption, an amount equivalent to 7% of the food they buy.

An estimate of the percentage distribution of discarded foods in households is shown in Table 4. According to these estimates, the foods that are most wasted in Spanish households are fruit and vegetables and bread. However, this is not only due to the fact that they are highly perishable products but also because they are all typical products consumed in homes.

ITALY

In Italy, food waste is worth 0.88% of GDP (data referring to 2017): the estimate is over 15 billion euros, given by the sum of food supply chain (production - distribution), estimated overall at over 3 billion of euros (21.1% of the total amount), compared to the real domestic food waste, that is the one measured in the homes of Italians, which therefore represents just under 80% of the total food waste in Italy and it is worth about 12 billion euros (Table 5).

In 2013, the Italian Ministry of Environment started working on a National Plan for Food Waste Prevention in collaboration with *Last Minute Market*, one of the Italian major player in food waste management. For preparing this waste prevention program the main stakeholders of the food chain were involved in this policy process. The Plan is intended to tackle the problem of food waste all along the supply chain from primary production (only agricultural production) to the final consumption.

In Italy, Law n. 166/2016, composed by 18 articles, represents the national framework for food waste and it has there several types of implications. Thanks to this new law, donating food to charities and food banks is more flexible and easier. The Law is not coercive and does not use penalties, but incentives. Operators from the food sector can donate for free food leftover to organizations and similar that are in charge of the collection of these goods. The collection of leftover agricultural products directly in the field is possible as well (STREFOWA, 2019).

Surplus products

Surplus products are food products fit for consumption that meet health and traceability standards but are nevertheless removed from the consumption loop before reaching their final sales destination due to commercial reasons only.

The surplus products are produced mainly in the agrarian sector as a result of surplus agricultural production once demand is satisfied. These surpluses are typical of the European continent and are used as a regulatory element of the market (forced surplus) (Midgley, 2014), although the associated costs and the viability of their storage have been questioned (García and Pabsdorf, 2015). That is why one of the main actions of the CAP (Common Agricultural Policy) has been to regulate production to avoid surplus food.

Table 4. Estimation of the percentage distribution of food types thrown away in Spanish households

Food groups	Total
Bread, cereals	20
Fruit, vegetables	17
Dairy, pasta, rice, legumes	13
Drinks	7
Meat, ready-meals	6
Cured meats, preserved foods	4
Fish, seafood, eggs	3
Others	10

Source: HISPACOOOP, 2013.

However, surpluses are not only produced in the production phase but can occur in other sections of the food chain such as the industrial phase or in the distribution of food. For example, products that do not reach a certain size or do not have a proper shape or colour are rejected by the market. They are also withdrawn from consumption because of errors in labelling or in the best before date.

All this turns surplus products into “potential waste” that can be avoided if they are reused or recycled. These two concepts are key to improving waste reduction (Stangherlin and de Barcellos, 2018). We use the term reuse to refer to the situation in which products withdrawn from consumption reach households through different sales channels, thereby allowing their access to the final consumer.

In contrast, recycling occurs when surpluses are used for purposes other than feeding people, regardless of whether they are suitable for consumption or not. For example, when surplus or defective products are converted into compost or animal feed (Afonso and Sastre, 2017).

In the near future, it is expected that the reuse or recycling of “avoidable waste” will lead to a situation of “waste avoided” as food policies are gradually imposed, obligating those agents involved in the food chain to manage the withdrawal of surplus or defective but fit-for-consumption products for their reincorporation in the commercial chain.

For example, in France since 2016 there has been a law (No. 2016-138, February 11) which prohibits French supermarkets from throwing away food withdrawn from their shelves, obligating them to donate unsold food to food banks or to give food not fit for human consumption away for animal consumption or to make compost for agriculture (Cantòn, 2015). Italy has also approved a law against waste (No. 2016-166, August 19) to facilitate the donation of food by producers or owners of establishments and allow citizens to take away left over food from a restaurant. It is forecast that these types of measures will be replicated in other European countries.

However, the current trend seeks to create an intermediate category prior to reuse by which agents can intervene before the product has gone off or act on defective products (strange shapes or colors)

so that through price reduction such food products can remain in the commercial chain without going through loss, waste or surplus phases.

The challenges to fight against food waste

The main objective pursued by national, regional and local governments is to reduce waste during the food cycle from the field to the consumer’s table (Varese and Bonadonna, 2019). To this end, the European Union has created a method to measure food waste through a measurement and reporting system that will allow member states and all actors in the food value chain to compare and monitor the levels of food waste and, therefore, evaluate the effectiveness of prevention initiatives established by the European Union (Table 6).

Table 5. Food waste in Italy in 2017

Segment of the food supply chain	Value of waste along the food supply chain in 2017 (euros)	%	
Production waste	833,576,183	5.5	
Industrial waste	1,050,724,941	7.0	
Distribution waste	1,291,731,289	8.6	
Domestic waste	11,858,314,935	78.9	
TOTAL	15,034,347,348	100.0	0.88% of GDP 2017*

* Italian GDP calculated at current market prices in euros

Source: Department of Agrifood Science and Technology Last Minute Market.

These measures respond to the Sustainable Development Goals (SDG 2030) that the General Assembly of the United Nations approved in 2015, among which is Objective 12, which aims to achieve “responsible production and consumption” by 2030, halving food waste per capita at both the retail and consumer level, and to reduce food loss along the production and supply chains. The EU and its member states are committed to this goal.

For its part, the European Parliament (2011) indicated in a resolution the concrete actions that must be undertaken to achieve these objectives. For this, governments should base themselves on two challenges considered cross-cutting:

a) Recover the value of food and determine the economic, social and environmental importance involved in obtaining it. This means recovering the concept of the real value of food above its monetary value, since the increase in economic welfare and the ease of accessing any type of product has led us to distance ourselves from the real effort involved in its production. In this sense, food is increasingly accessible due to increased productivity in agriculture and in the food industry as well as the globalization of the food market. All this has led to ignorance regarding the complexity of the

process and the energy, social and environmental requirements necessary for products to reach the table.

b) Become aware that leftover food is a resource, not a waste. It is clear that food cannot be automatically considered as waste. Therefore, before arriving at controlled storage there is a wide range of management options, including establishing donation programs of surplus food for the needy or reprocessing surplus food for the manufacture of animal feed. These are some of the options proposed by public authorities, although from our point of view we understand that there are other options before arriving at these solutions.

Along this same line of action, the proposal we put forward next is to use new technologies to prevent food becoming waste, thus contributing to a reduction in food waste.

This solution is based on the idea of eliminating the phase that excludes food from the food chain because it is considered unfit for consumption, hereby keeping it within the commercial cycle. To do this, we will use new technologies as tools that allow access to the product before its deterioration and an exponential increase in end consumers.

In the following section, we describe the main digital platforms that aim to fight against food waste.

Context of the research

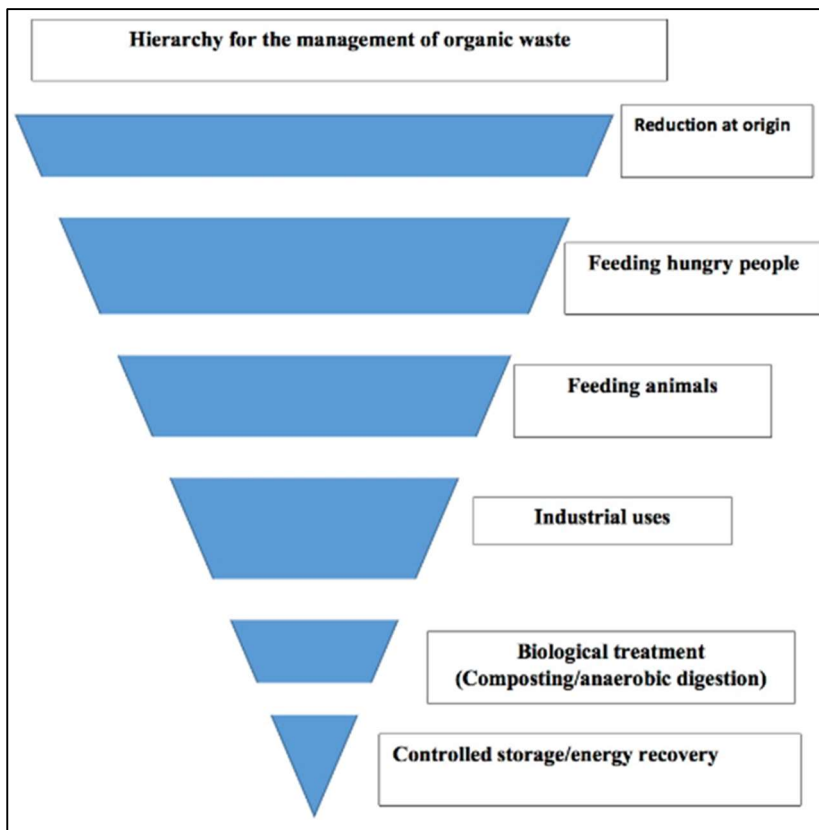
Based on the *Food Sustainability Index* (FSI) developed by *The Economist Intelligence Unit* in collaboration with the *Barilla Center for Food & Nutrition* (BCFN), which investigates best practices in food sustainability of 67 countries in 2018 using three “pillars” as sustainable agriculture, nutritional challenges, and food loss and waste (countries are scored 0-100, where 100 indicates the most sustainable environment), Spain and Italy are two comparable European countries (<http://foodsustainability.eiu.com>). Indeed, both countries achieve an overall score (weighted sum of the domain scores of the three “pillars”) of the FSI that places them in the band of the high virtuous countries in Europe (Spain: 70.90; Italy: 68.10; average value for Europe: 68.20) in the fight for food sustainability. Furthermore, even considering the domain score of the food lost and waste pillar, Spain and Italy achieved excellent performances, respectively with a score of 78.9 and 70.6 compared to an average European value of 69.2.

Table 6. Commission’s action plan to prevent food waste in the EU

Commission’s action plan to prevent food waste in the EU
Develop a common EU methodology to measure food waste and define relevant indicators
Create an EU platform on food losses and waste
Create EU legislation to fight against food waste
Standardise consumption criteria (rules on expiry dates, best before dates etc.)

Source: Information sheet of the European Commission (2016). Reducing food waste: the response of the EU to a global challenge.

Figure 3. Hierarchy for the management of organic waste



Source: US Environmental Protection Agency (USEPA).

Finally, as highlighted by the Fixing Food 2018 report, Spain and Italy are in the top five countries all over the world for the quality of their policy response to food waste (Table 1). Consequently, we aim at exploring the relationship between technology and food waste policies to this end.

Digital platforms to fight food waste

According to Micheline *et al.* (2018), recently, opportunities created by digital technology and the phenomenon of the sharing economy have boosted the increasing number of web platforms and food sharing apps that are being developed by existing organizations or by new entities that work

exclusively online.

In particular, food sharing mobile applications are becoming increasingly popular (Harvey *et al.*, 2019).

As we have shown, the difficulties in accessing sufficient quality food are increasing progressively in our society. At the same time, we are witnessing the rise of various social platforms and citizen complaints that accuse supermarkets and large stores of throwing away a large amount of food, raising the alarm about the excessive waste of food.

In response to this problem, several digital platforms are being created that aim to implement a food ecology through responsible food consumption and self-management of access to it, promoting communication between people and the sharing of food among them.

These platforms have proliferated mainly in cities such as Amsterdam, London, Barcelona, Milan and Singapore, all of them considered “Smart Cities”¹.

In the next section, we analyze different case studies of digital platforms, operating in Spain and Italy, that are responding to the management of food especially through apps² that provide immediate and rapid access to food products.

In supermarkets and restaurants up to consumer homes, a large amount of food ends up in the trash every year. To support those who want to reduce this waste, and even save money, different solutions are springing up at smartphone level: From apps that allow consumers to locate stores that offer products at discounted prices close to expiry or that risk remaining unsold to online communities that allow to share food that is not consumed, up to the platforms that explain how to use leftovers and how to best preserve food.

Taking into consideration the measurement of food sustainability performance proposed by the FSI index, Spain and Italy are respectively first (69.6) and second (60.4) at European level in terms of results for end-user food waste (<http://foodsustainability.eiu.com>), also thanks to the use of tools of this kind and to their own legislative structure on this topic.

We distinguish between several categories of digital platforms according to their impact on food. In particular, we describe those platforms that educate in the management of food, especially in homes, those that avoid food waste, and those that help reduce surpluses.

¹ This refers to a type of urban development based on sustainability that is able to adequately respond to the basic needs of institutions, businesses, and the inhabitants themselves, both economically and in operational, social and environmental aspects.

² An app is a program that can be installed on mobile devices and computers for the user to perform various tasks, such as playing games, receiving current news and downloading multimedia files. Apps usually take up little memory space, are quick to install and are characterised by their dynamism. However, the user is not obliged to enter their data every time they access them, since they are already part of their device’s software.

Digital platforms of a social nature

Digital platforms are Internet sites that serve to store different types of personal and commercial information that in turn act as social networks that facilitate contact with friends, family and other social agents. These platforms work with certain types of operating systems and run programs/applications with a range of contents, such as image games, simulations and videos among others.

Within the digital platforms there are those that have a social character that aim to promote the use of applications as a technological tool at the service of citizens, acting through collective social commitment.

One of the most popular is *apps4citizens* (apps4citizens.org/que-es-a4c/), which promotes the use of applications for citizen participation and the improvement of democratic quality. The *apps4citizens* applications have a markedly civic-social character and for this reason their classification, although thematic, is based on articulating new scenarios in which citizen participation is the fundamental feature.

Apps for responsible consumption

Digital platforms promote the use of apps as technological tools at the service of consumers, who can use them from mobile devices, allowing them to manage a significant amount of information and facilitating access to services immediately.

All these qualities help users access products that can potentially become food waste or surplus for animal feed or recycling, thus preventing them from leaving the commercial channel and encouraging responsible consumption.

Next, we describe examples of apps that meet this function.

a) Apps that educate in food management

One of the main problems generated in homes is the lack of planning in food purchasing. This situation leads to a poor diet due to lack of foresight vis-à-vis the shopping list (not having the necessary ingredients to make a recipe, repeatedly eating the same products, eating out) or in contrast buying products in excess that rot in our refrigerators or expire in our cupboards.

The pace of life, especially in cities, prevents us from being able to plan for food that will be consumed periodically, which would allow us to plan to buy the products necessary to have a healthy and balanced diet at a reasonable price.

For this there are apps that try to help the user on this mission of planning family meals, indicating the necessary foods for correct meals while allowing users to connect with other apps that offer recipes and sustainable products, which leads to responsible consumption.

a.1. Pepperplate (<https://www.pepperplate.com>)

Pepperplate is a free app available for *iOS*, *Android*, *Windows Phone*, *Amazon* and *Nook*. In *Pepperplate* different recipes can be added to those offered by the site to plan the week's menu. It also works as a shopping list, choosing organic products that encourage responsible consumption.

a.2. Food.com (<https://www.food.com>)

Food.com is an app that sends weekly recipes according to the preferences and nutritional restrictions of the user (celiacs, diabetics, vegans etc.). The app is free and its financing comes from advertisements and also from the agreements it has with the stores it recommends for buying food. Another auxiliary service offered is to request the location of the user in order to be able to inform users of local offers, thereby encouraging local consumption.

The risk of these apps is that they act as “branded apps”, since many of them, when recommending products, refer to their brands, thereby ignoring the true interest of the consumer. For example, the *Thermomix* app is only for *Thermomix* users or apps such as *Consumer (Eroski)* contain a meal planner and a shopping list linked to the brand. This practice varies depending on the place where consumers shop. It has been shown that apps in English are more honest, offering free recipes, offers linked to stores and many useful functions for the user.

a.3. UBO – Una Buona Occasione (<http://www.unabuonaoccasione.it/it>)

The *UBO* awareness-raising initiative, with a dedicated portal and app, informs consumers about the proper preservation of food, thus countering food waste.

The project was conceived by the Protection Sector of Citizens and Consumers of the Piedmont Region and by the Commerce Department of the Valle d'Aosta Region, and financed by the Ministry of Economic Development, in collaboration with various partners (University of Turin, *Slow Food*, *CinemaAmbiente*, *Museo A come Ambiente* and the experimental Zooprophyllactic Institute of Piedmont, Liguria and Valle d'Aosta).

In the *UBO* app, you can find tips on preserving as many as 500 foods as well as information on its water footprint, nutritional intake, reuse of leftovers and waste. Moreover, there is space for news on the seasonality of fruit and vegetables and for suggestions on how to make the shopping list.

a.4. Eco dal frigo (<https://www.ecodalfrigo.it>)

Eco dal frigo is a platform curated by *Mission Bambini* that allows you to create tasty recipes, combining the ingredients available in the fridge. A way to give new life to food, strenuously opposing food waste.

a.5. PucciFrigo

PucciFrigo is an app for *Android* that remembers food deadlines, avoiding unnecessary and costly waste. Its use is simple and intuitive: it is sufficient to mark, just like on a sheet of paper, the name

of the food and its expiry date to keep it constantly monitored. Food icons look happy and smiling when there are still many days to the expiry date, while they gradually become sadder as it approaches. Daily notifications alert you to the imminent expiration of a food or remind you to update *PucciFrigo* with the latest products purchased or consumed.

b) Apps that avoid waste and help manage surplus products

Another focus of waste is restaurants and catering and supermarkets and large stores that do not manage well their product stocks. For this, apps exist that try to respond to waste and surplus, avoiding the loss of food that, although in good condition, does not get a second chance because it is removed from the commercial loop.

b.1. Too Good To Go (<https://toogoodtogo.com/en>)

Too Good To Go is an app designed for those vendors who do not want to throw away their still-consumable products at the end of the day. Merchants (bars, restaurants, bakeries, pastry shops, supermarkets and hotels) are directly connected to consumers through the app in which they can offer products at reduced prices (about a third of the full price) at the end of the day for users. It often involves leaving products not sold that day in baskets: the consumer does not know exactly what they will find.

This app has several advantages. The first is, of course, to limit food waste, which allows businesses to carry out a zero-waste activity. In addition to this ecological function, the app allows consumers to access products at very low prices and also to discover products they probably did not know. *Too Good To Go* therefore allows users to discover a new responsible and economical way to consume. To date, more than 11 million Magic Boxes have been purchased in Europe, which has allowed the environment to avoid the emission of more than almost 23 million tons of CO₂.

b.2. weSAVEeat (<https://toogoodtogo.es/es>)

weSAVEeat (the Spanish *Too Good To Go*) is an app to fight against food waste that allows users to buy, with a discount of between 50% and 70%, surplus food that collaborating establishments have not managed to sell during the day.

This app aims to raise awareness in consumers and food stores to avoid food waste. The application is available for all mobile devices in both the *Apple Store* and *Google Play*.

Its operation is very simple: through the app installed on their mobile phone, consumers can access batches of food available in nearby stores associated with it (restaurants, bakeries or take-away establishments) and can pick them up at the end of the day before closing time, paying conveniently through the mobile device.

Thus, in addition to saving a significant amount of money, *weSAVEeat* users save food products in perfect condition that would have ended up in the bin.

b.3. Eat you later

Eat you later is a free app that helps establishments sustainably manage their surplus food. The platform allows them to sell leftover food at a reduced price. In this way, they monetize what they believed was lost and at the same time help to stop waste.

These types of applications are common in Nordic countries such as Norway or Denmark, which have reduced waste by 25% thanks to activists, supermarkets and companies. They are also being applied successfully in countries such as Italy and France.

Among its partners are restaurants that opt for a style of sustainable and ecologically oriented foods, or food chains such as herbalists, specialized stores for gluten-free food or gourmet shops. Each establishment has absolute freedom to set the prices they consider appropriate, but usually offer a discount of between 30% and 60%. In some cases, shops set times to pick up orders, which are usually around closing time.

b.4. Tapper (<https://tapper.es>)

Tapper is a platform that was created thanks to a social entrepreneurship competition. Its aim was to create a meeting point between consumers and food establishments to reduce food waste. Its operation is very simple: affiliated businesses post on the app those foods that are about to expire. The customer can reserve the products at that price and pick them up in the next half hour.

b.5. Myfoody (<https://myfoody.it>)

Myfoody is a platform, and also an app available for *iOS* and *Android*, that collects all the discounted supermarket offers: just click on a store to get a list of last-minute sales with their price. A map simplifies the search: the yellow placeholders indicate that there are offers in progress, the white ones that at the moment there are none. The offers are not limited to products close to expiration, but also to those with defects in packaging, which are not lacking in supermarkets.

b.6. Bring the Food (<https://bringfood.org>)

This app, developed by the researchers of the *Bruno Kessler Foundation* in collaboration with the *Fondazione Banco Alimentare*, an Italian food bank, makes it possible to donate food through charitable organizations in the area. It is mainly aimed at supermarkets, bakeries and fruit and vegetable shops that can publish offers of food surpluses, making them visible to nearby non-profit organizations. The latter can book them, receiving in exchange a code for the withdrawal. *Bring the Food* can also be accessed through the website.

b.7. LastMinuteSottoCasa (<https://www.lastminutesottocasa.it>)

LastMinuteSottoCasa, born on the web as an anti-waste community, has an app that serves to put shopkeepers who have expiring food in touch with a network of customers in the area, who are presented with unrepeatable offers on their mobile phones.

c) Apps to promote savings in food consumption

This type of application uses the principles of collaborative consumption³, allowing consumers to share food and thereby avoiding surplus or loss through product expiry or spoiling when not consumed.

c.1. Yonodesperdicio.org (<https://yonodesperdicio.org>)

This is a website promoted by *Prosalus*, a Spanish NGO created to defend human rights relating to food, health and water. This app offers the creation of a food collaboration network that operates through *Google Play*. Users simply register and enter their postcode, following which they can start giving and receiving food for free. It works thanks to a map in which food in users' local areas can be identified. *Yo No Desperdicio* has created a community committed to tackling household food waste through local food exchange. Its members can post a photo of the food item they wish to get rid of, its quantity, location and expiry date and they can then link up with others to swap items. Users can also share recipes and tips to prevent food waste in the first place.

c.2. NiLasMigas (nilasmigas.com)

Ni Las Migas is a project that was founded in 2016 with the aim of reducing the impact of food waste. It operates through a mobile application that, based on geolocation, puts clients in contact with establishments that have food in perfect condition but that have not found an end consumer. By means of their mobile phones, users, also known as “migueros”, reserve the products at a lower price that they later collect from the premises at the indicated time, saving and helping to reduce the surplus.

c.3. OLIO (<https://olioex.com>)

OLIO is an app that allows the creation of a community of neighbors and local shops to avoid wasting food. With the use of *OLIO*, for example, it is possible to share, in order not to waste them, foods near the expiry date, excess vegetables grown in your own garden, food scraps from a party or what remains in the fridge before a journey.

The app is simple and immediate through the creation of a personal profile and the immediate visualization of geographically closest food availability, or by adding a photo of what you want to donate and indicating the place and method of collection, which is then organized via private messaging. *OLIO* is born to share food, but everything can actually be made available to those who need it, from furnishing accessories to stationery items.

Conclusions

Food waste is clearly a complex issue with a multitude of factors that can be approached from

³ Collaborative consumption uses digital platforms through which users contact each other to exchange goods or articles, almost all free of charge, and altruistically.

different perspectives. In this study we suggest that, based on the review of the literature and the analysis of web apps, blogs and platforms, the solutions to surplus and food waste both from the environment of the entrepreneur and the consumer employ the new technologies in the final phase (consumption) and have their major effects locally, due to the characteristics of relationships established locally.

From the consumer environment, food waste is related to the composition of the household in terms of age and number of members, which influences the nutritional skills of households with older people, access to education of new generations, the ability to plan the home economy and the technology gap.

On the other hand, consumers have other motivations to avoid wasting food, such as saving money, ethical reasons related to equity (for example, in light of world hunger), religious values or beliefs or environmental concerns. These ethical reasons are reflected in the apps related to the collaborative economy.

Another group of apps take into account factors related to awareness and capabilities, which determine if, how and to what extent consumers can manage food supply and handling throughout the circle from purchase planning, food choices and its storage, planning and meal preparation. Here are the group of apps and blogs promoted by supermarkets that offer “shopping list” services or recipes with seasonal products and cooking.

We must also refer to apps that use other variables such as health (allergies and intolerances), environmental care (packaging), or the enjoyment of food.

Companies also point to this trend because through new technologies they can make better use of their products by offering their surpluses and perishable products at a better price when they are about to expire.

Another way to build customer loyalty is through the creation and motivational activities in which the entrepreneur empathizes with his client. For example, creating a virtual community to share experiences of gastronomic or environmental type.

These behaviors go beyond mere lucrative considerations, since practices to avoid food waste are part of a lifestyle and consumer identity. Consumers can be proud of being a smart shopper or a home manager, enjoying the creative process of addressing leftovers or developing their identity through the formation of social relationships in grassroots networks.

Research on food waste has increased considerably in size in recent years and that future research should explore consumer behavior of food waste in greater depth, focusing on contexts, foods and new technologies. This should lead to results of an even greater practical application. It would be desirable to go from analyzing the current situation to experimenting with new approaches and

solutions, in particular through intervention studies, which until now are poorly represented.

In this study we suggest that, based on the review of the literature and the analysis of web tools, we look for solutions to surplus and food waste both from the environment of the entrepreneur and the consumer and all using the new technologies.

With more in-depth studies of our type, it should be possible to provide interested parties with more accurate estimates of the impact of new technologies in this context. At the same time, we must identify needs, develop prototypes and achieve an entrepreneurial mindset that helps us fight both against surpluses and in reducing food waste.

In effect, this research allows a theoretical approach to the concepts of "loss", "wastage" and "surplus product", incorporating data on its impact in Spain and Italy, comparing it with the rest of Europe while providing figures and data on their impact.

Finally, the new technologies will allow us to replicate solutions of local dimension on a global scale, multiplying the scope of the solutions that are being implemented in different parts of the planet. We provide an early theoretical classification of food waste technological platforms (Table 7). With our classification, it is easier for practitioners to acknowledge the state of the art and for startupper to assess what is missing in terms of digital platforms of such a kind.

Table 7. Theoretical classification of food waste technological platforms and apps

1) Digital platforms of a social nature	
2) Apps for responsible consumption	<i>a) Apps that educate in food management</i>
	<i>b) Apps that avoid waste and help manage surplus products</i>
	<i>c) Apps to promote savings in food consumption</i>

Source: own elaboration.

In this sense, digital platforms are essential tools to fight against food waste, preventing certain products from being considered unfit for human consumption. With their use everyone wins: food businesses get an income from the surplus production they would have thrown away, consumers have access to excellent products at bargain prices, and both take a small but important step against food waste.

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