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Innovative Strategies for Reducing Household Food Waste

A Gamified Approach to Fostering Spontaneous Pro-Environmental Behaviors

Abstract

This thesis addresses the issue of domestic food waste through the development of an innovative concept that leverages gamification and persuasive design. The aim is to create a mobile game that uses engaging mechanics and immediate feedback to encourage consumers to adopt more sustainable behaviors and improve food management efficiency. The game, combined with advanced technologies, seeks to significantly reduce domestic food waste, contributing to the United Nations' Agenda 2030 goal of halving per capita food waste by 2030. The research involved a survey of 68 Italian participants, primarily from Rome, to identify key behaviors and motivations related to food waste. Additionally, qualitative interviews were conducted to gain deeper insights into individual perceptions and practices concerning food waste. The findings highlight the necessity of personalized and community-driven approaches to effectively reduce food waste. This thesis offers a comprehensive analysis of the problem, comparing it with previous professional studies and exploring solutions that integrate sustainable interaction design, behavioral design, and innovative technology. Through the conceptual development of the game "Pianeta 2050," the research demonstrates the potential of combining educational tools and interactive feedback to foster long-term sustainable practices.

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1. Introduction

Every product we purchase in our consumer society has an expiration date, more or less near, by which it should be used at its maximum potential. Uncontrolled consumption is a problem in itself, but even more serious is the waste that occurs when, despite purchasing, we do not consume the products at all. This phenomenon is particularly relevant for food products, which have a very short shelf life. There are already services that reorganize and reintroduce wasted food products from stores into the market, and numerous strategies are in place to avoid losses along the supply chain. However, when products reach consumers' homes, it becomes very difficult to monitor and guide correct behavior. Managing food within households represents a significant challenge, often leading to substantial food waste. Keeping track of purchased products and consuming them before they expire, as well as properly storing leftovers, can be complicated, especially for those with jobs and families. Additionally, information and awareness on the issue of food waste are not adequately addressed and disseminated by public entities, creating a certain distance between the events and the environmental problems caused by food waste and our perception.

1.1 Problem of Food Waste

Domestic food waste represents one of the most urgent challenges of our time. Every year, approximately 1.3 billion tons of food are wasted globally, while nearly 1 billion people suffer from malnutrition and another billion face hunger¹. This waste not only represents a huge inefficiency of the global food system but also has serious environmental consequences. Wasted food contributes significantly to the production of greenhouse gases, as the decomposition process of food in landfills produces methane, a very potent greenhouse gas². Moreover, the production of food that is then wasted entails a massive use of natural resources, including water, energy, and land². According to the United Nations' "Food Waste Index Report 2024," over 1 billion meals per day were wasted in 2022, while 783 million people suffered from hunger, and one-third of the global population lived in conditions of food insecurity. The food sector is responsible for 30% of total energy consumption and 22% of global greenhouse gas emissions. Wasted food accounts for about 8-10% of global greenhouse gas emissions, and if we considered food waste as a country, it would be the third-largest emitter of greenhouse gases in the world, surpassed only by China and the United States³.

1.2 Importance of the Issue

Addressing the problem of food waste is crucial for several reasons. Firstly, reducing food waste can significantly contribute to mitigating climate change. The production, transportation, storage, and disposal of wasted food involve unsustainable use of natural resources, including land, water, and energy². Reducing food waste means reducing the pressure on natural resources and decreasing the ecological footprint of the food sector. Secondly, food waste has important economic implications. It is estimated that food waste costs over \$1 trillion annually worldwide³. This cost includes not only the value of the lost food but also the resources used to produce, transport, and dispose of it. Reducing food waste can therefore generate significant economic savings and improve the efficiency of the global food system. Furthermore, addressing food waste can improve global food security. Reducing food losses along the supply chain and at the domestic level can increase the availability of food for vulnerable populations, helping to combat hunger and malnutrition¹. Finally, reducing food waste can contribute to the sustainability of natural resources, improving the efficiency of land, water, and energy use².

2. Household Food Waste

The problem of food waste is so important that it has mobilized the most important governmental and public entities in the world for years. The United Nations has included this topic into the Agenda 2030, a program of actions aimed at promoting people's well-being, safeguarding the planet, and fostering global prosperity, which has been adopted by 193 countries belonging to the UN in 2015. All participants believe in these goals and partake in the project with the intention of reaching new sustainability levels without excluding any country. The program presents a total of 17 Sustainable Development Goals (SDGs), which are divided into 169 objectives, and tackle a wide range of issues relevant to development, such as the elimination of poverty, food security, and the fight against climate change. Food waste appears in the 12.3 goal, which aims to grant sustainable levels of food production and consumption, and it is proposed to halve per capita food waste at retail and consumer levels by 2030.

The 2030 Agenda for Sustainable Development constitutes a concrete action program aimed at promoting people's well-being, safeguarding the planet, and fostering global prosperity. Adopted in 2015 by the governments of the 193 United Nations member countries, it includes a total of 17 Sustainable Development Goals (SDGs) divided into 169 targets. The SDGs focus on a wide range of issues relevant to development, such as the elimination of poverty, food security, and the fight against climate change. These are shared goals among all countries and people, ensuring that everyone can progress along the path of sustainability without being left behind.

SDG 12.3 aims to ensure sustainable patterns of food production and consumption. It is important to note that the environmental impact of the food sector begins already in the phases of agricultural and agro-industrial production, but food choices and household habits influence greenhouse gas emissions and the energy consumption used for food production and waste management. Of the 1.3 billion tons of food wasted annually, 60% is attributed to households, and these data represent a worrying phenomenon, especially considering that one billion people suffer from malnutrition and another billion suffer from hunger. Furthermore, soil degradation, land aridity, unsustainable water use, overfishing, and marine environment degradation threaten the ability of natural resources to sustain food production.

As it is possible to observe, the food waste phenomenon is heterogeneous. Not only does it derive from different macro issues; the same, final result can be obtained through two different practices, food waste and food loss, which can look similar at first.

2.1 Loss and Waste

It is useful to understand the distinction between food waste and food loss within the food supply chain. Food loss refers to the decrease in the quantity or quality of food intended for human consumption that occurs at the initial stage of the supply chain. This includes production, post-harvest, and processing. Food losses can be caused by various factors such as ineffective agricultural techniques, adverse weather conditions, inadequate transportation infrastructure, and lack of proper preservation technologies. In contrast, food waste occurs at the final stage of the supply chain, namely in distribution, retail, and final consumption. Food waste includes food discarded in supermarkets, restaurants, canteens, and private homes, often due to poor management, excessive purchases, poor meal planning, and confusion over expiration dates.

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Food waste in supermarkets and restaurants occurs at the retail and catering stages. In supermarkets, food waste is often due to products reaching their expiration date before being sold, damage during transportation and handling, or aesthetic standards that lead to the rejection of perfectly edible products but not conforming to certain visual criteria. In restaurants, waste can result from oversized portions, inflexible menus, errors in demand forecasting, and the common practice of discarding leftovers.

Domestic food waste, which is the main topic of this thesis, concerns food discarded at the household level, i.e., in private homes. The main causes of domestic food waste include excessive food preparation, lack of knowledge about proper food storage, and inability to consume food before the expiration date. Additionally, poor planning of purchases and meals can lead to the purchase of excessive quantities of food that end up spoiling and being discarded. However, the motivations that lead people to waste food are much more complex and interconnected.

In both cases, reducing food waste and food loss is crucial to improving the efficiency of the global food system, reducing greenhouse gas emissions associated with food decomposition, and alleviating pressure on natural resources such as water and land. Promoting sustainable consumption practices and implementing advanced technologies in food management are fundamental strategies to address these challenges and move towards a more sustainable future.

To combat domestic food waste, generic warnings about how to handle food are not sufficient. It is essential to study what happens in households and analyze people's behaviors to understand which strategy is most effective to adopt. For this reason, this thesis focuses on the phenomenon of domestic food waste in Italy. A comparison with other regions of the world has been useful to understand how cultural influences, in addition to differences related to the territory and technologies for food preservation, processing, and distribution, are fundamental to identifying the peculiarities of behaviors related to food, its preservation, and consumption, and how crucial it is to design a targeted solution for a specific culture rather than attempting to develop a universal solution.

2.2 Global Household Food Waste Data

Before analyzing food waste on a country-by-country basis, it is important to understand this issue at a global level. According to the United Nations "Food Waste Index Report 2024", in 2022, households worldwide wasted over 1 billion meals per day, while 783 million people suffered from hunger and one-third of humanity faced food insecurity. The report highlights that in 2022, 1.05 billion tons of food waste were generated, equivalent to 132 kilograms per capita and almost one-fifth of all food available to consumers. Of the total food waste, 60% occurred at the domestic level, while 28% was attributable to food services and 12% to retail. These data underline the urgency of focusing on interventions aimed at reducing waste in private homes, where individual and collective actions can have a significant impact.

The economic and environmental implications of food waste also vary based on regional differences. In Italy, food waste amounts to 15 billion euros per year, about one percentage point of GDP. More precisely, Italian households throw away food worth approximately 6 billion euros annually, to which must be added 9 billion euros of supply chain waste (ANSA, A., (2024, February 5). WWF, food waste in Italy is worth 15 billion). This data highlights the importance of addressing the problem not only for environmental reasons but also for economic ones.

In higher-income countries, such as the United States and Western European nations, food waste has a considerable impact on natural resources, including water, energy, and land, used to produce food that ends up not being consumed. In contrast, in developing countries, food losses are often greater in the early stages of the supply chain due to inadequate transportation and storage infrastructure.

2.3 Italian Food Waste in Europe and the World

Food waste is a global phenomenon that varies significantly between different regions of the world, influenced by cultural, economic, and infrastructural factors. Analyzing the differences between food waste in Italy and other European and global regions can offer a clearer perspective on the specific causes and possible solutions to reduce this phenomenon. According to the “Food Loss and Waste: 2023 Progress Report” by Champions 12.3, an international coalition of multi-sector leaders aiming to unite forces to achieve SDG 12.3, cultural differences, along with domestic management practices, significantly influence food waste levels.

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In Africa, domestic food waste is mainly influenced by high temperatures and inadequate infrastructure. In sub-Saharan regions, high temperatures can accelerate food spoilage, while the lack of adequate preservation systems, such as refrigerators and cooling facilities, increases the likelihood of food spoiling before it can be consumed. Households in Northern Africa generate about 140 kg of food waste per capita per year, while in sub-Saharan Africa this value is 93 kg.

In Latin America and the Caribbean, culinary habits and economic disparities play a significant role in food waste. The tendency to cook meals from scratch and use fresh ingredients can lead to a higher generation of inedible scraps, such as peels and bones. Additionally, economic difficulties can affect the frequency with which people buy and consume food, leading to waste when excess food spoils. The average food waste in this region is 95 kg per capita per year.

In North America, food waste is strongly influenced by excessive consumption and portion sizes. The culture of excessive consumption and large portion sizes in the United States and Canada significantly contributes to domestic food waste. Additionally, a strong preference for fresh food and the abundance of options often lead individuals to discard food not consumed in time. In the United States, domestic food waste is about 73 kg per capita per year, while in Canada it is slightly higher at 79 kg.

In Asia, urban growth and hectic lifestyles, along with regional variations in eating habits, influence domestic food waste. In urban areas of East and Southeast Asia, hectic lifestyles lead to unplanned meals and impulsive purchases, increasing food waste. In South Asia, waste varies greatly, from a

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minimum of 19 kg to a maximum of 212 kg per capita per year, with countries like Pakistan recording high levels of waste due to cultural practices and municipal waste collection methods.

In Europe, despite greater environmental awareness, domestic food waste remains high. In many parts of Europe, there is a strong demand for aesthetically pleasing products, contributing to high levels of waste, especially of fruits and vegetables that do not meet visual standards. Economic affluence in Western and Northern Europe is correlated with higher levels of waste, partly due to buying in bulk and preferring fresh over preserved foods. In Eastern Europe, waste is more contained, averaging 53 kg per capita per year, while in Southern Europe it is 83 kg and in Western Europe 80 kg.

In Oceania, geographical isolation and complex logistics contribute to greater waste. In Australia and New Zealand, domestic food waste is about 79 kg per capita per year. Geographical isolation can complicate food logistics, leading to greater waste due to the difficulty of maintaining food freshness during long-distance transportation.

Finally, in the regions of Melanesia and Micronesia, infrastructural limitations and reliance on local food sources cause waste when excess food cannot be effectively preserved or processed. In Micronesia, domestic food waste is 38 kg per capita per year, the lowest among the regions analyzed, attributed to the use of food scraps as animal feed or for agricultural purposes.

Scalvedi and Rossi (2021), in their research titled "Comprehensive Measurement of Italian Domestic Food Waste in a European Framework" published in *Sustainability*, analyze the European context, revealing significant differences within the region itself due to the various culinary cultures of different countries. In contrast, in the Netherlands and Germany, there is a greater emphasis on planning and purchasing foods with a long shelf life. These countries have developed a consumption culture more oriented towards practicality and efficiency, which can reduce waste of fresh foods but can still lead to waste in other categories, such as packaged products. In Spain, the warm climate accelerates the decomposition of fresh produce, contributing to higher waste of fruits and vegetables. The Spanish culinary culture, which values fresh ingredients, similar to Italy, leads to high consumption of these products but also a higher risk of waste.

In Italy, the food culture is strongly rooted in the Mediterranean culinary tradition, which emphasizes the use of fresh and high-quality ingredients. This leads to frequent purchases of fresh foods, which, however, have a shorter shelf life and therefore a higher risk of spoilage and waste. Additionally, the abundance and variety of portions served, typical of Italian culture, can contribute to food surplus and leftovers that often end up being discarded.

By evidencing all these differences, the aforementioned heterogeneity of the food waste issue becomes even more apparent. Each country presents different food waste conditions, and defining a single strategy for all of them would probably lead to unsatisfactory results dealing only with superficial factors. This is the main reason why this research is focused on Italy and its approach to food waste in particular.

3. Factors Contributing to Italian Household Food Waste

We have previously analyzed how different regions of the world, and therefore different cultures, influence behavior towards food and dictate certain norms that people often follow without questioning why they do it, where this habit comes from, or whether it is right or not. In this chapter, we will better analyze the different types of motivations that lead to domestic waste in Italy according to some studies and research conducted. We must consider that we cannot have a linear cause-and-effect discussion but need to take a non-linear approach, considering the entire system of motivations

that, although different, are correlated and together influence an individual's behavior towards food, perhaps in varying percentages.

After analyzing the data from Waste Watcher International and the 2021 study by Scalvedi and Rossi, the results of a survey conducted specifically for this thesis will be presented to add new connections between the data influencing waste and personalize the research for the specific purposes of the thesis.

3.1 Data from Professional Studies

According to Scalvedi and Rossi (2021), several factors have been identified as determinants in domestic food waste in Italy. In the rest of the paragraph, we will analyze the data present in this study that are useful for understanding the main issues to be addressed and the possibilities identified to combat domestic waste.

From the study, planning and organizing shopping and food storage practices were common among respondents, especially among older adults and those living in smaller households. These groups tend to engage more in such preventive practices, showing greater attention to efficient food management, while younger people, especially those living alone, show higher levels of disorganization and waste.

The data reveal a complex relationship between household size and food waste: larger families generate more total waste, but per capita waste is higher in single-person households. Families with young children tend to waste more food than those without. Additionally, young people and higher-income groups are associated with higher food waste, while education level, geographic location, and city size have shown minimal impact on waste patterns.

Emotional attitudes toward food waste are predominantly negative. However, respondents emphasize the economic impacts of waste more than the environmental ones. This suggests that the motivation to reduce waste is often driven by financial considerations rather than ecological awareness.

Despite most families feeling adequately equipped for food storage, unforeseen events and time constraints significantly impact food waste. Although many respondents feel confident in their ability to prevent waste, there are still challenges related to adopting new culinary practices.

Health and taste emerged as the main factors driving food choices, often at the expense of considering the amount of food present at home, which can lead to waste. In particular, larger families and less-educated respondents tend to prioritize having enough food over the concern of accumulating excessive supplies, which can increase the risk of waste.

Domestic food waste levels were classified in the study into four categories, from none to high. The analysis showed that having a sufficient amount of food at home is correlated with higher levels of waste. This indicates a potential area of intervention to reduce waste by balancing food availability with actual needs.

Waste Watcher, the International Observatory on Food and Sustainability, was established in 2013 through a collaboration between the University of Bologna and Last Minute Market. The goal of the Observatory is to monitor and investigate consumer behaviors and food habits, focusing on the economic, social, and environmental impacts of domestic food waste. To achieve these objectives, WWI employs a solid research methodology based on people's opinions, perceptions, and statements.

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The Zero Waste campaign promoted by WWI publishes the results of a research conducted on domestic food waste in Italy every year. Although the percentage of waste is decreasing each year, the amount of food wasted is still extremely high. In fact, according to the 2023 campaign, Italians throw away seventy-five grams of food per day, or 524 grams per week, equivalent to just over twenty-seven kilograms of food per person per year. In this context, it is clear that domestic food waste is a more worrying phenomenon compared to that found in other stages of the food supply chain, such as raw material collection, production, transport, and retail.

The percentage of waste was broken down by product category, revealing that vegetables and fruits are the most wasted foods, accounting for 24.9% and 15.6%, respectively. Additionally, the study highlighted the main reasons for domestic food waste: uneaten food reaching its expiration date is the primary reason, while others include pre-cooked food, food prepared or served too early, personal preferences, purchase errors, children's leftovers, and other motivations. Raising awareness about food waste seems to have had a positive effect in recent years, as only 1% of Italians reported discarding food they no longer liked in 2018, compared to 50% in 2014.

In summary, the results of this research highlight the importance of adopting public policies and promoting responsible practices and behaviors aimed at reducing domestic food waste to improve the efficiency of natural resource use and mitigate the economic, social, and environmental impacts associated with this phenomenon. Based on the research results, WWI has suggested some practical solutions to reduce the phenomenon. Among these, it was recommended to periodically buy products with a long shelf life, alternating them with frequent purchases of fresh products, to avoid accumulating food that might expire before being consumed. It was also suggested to organize the refrigerator and pantry to keep track of product expiration dates, buy small-sized packages, make a shopping list based on a weekly menu, and prioritize the purchase of long-shelf-life products. These are just some of the actions that every consumer can take to limit domestic food waste and help reduce the economic, social, and environmental impact of this phenomenon.

3.2 Survey Insights on Food Waste

In order to better understand the context of food waste in Italy and validate the studies previously reported, a quantitative study has been conducted involving 68 Italian people residing mainly in Rome at the time of the survey, March 2023. The research was carried out through a 22-item online survey hosted on Google Forms, consisting of one open-ended question, 20 single-answer questions, and one multiple-choice question. The sample included participants of various age groups, ranging from young adults (19-35 years) to seniors (over 65 years). The survey was distributed via social media and spread through word-of-mouth.

This chapter aims to present and analyze the results of the survey conducted on food management and waste among Italian citizens, comparing them with data obtained from previous professional studies by Scalvedi and Rossi and Waste Watcher in the following paragraphs.

The decision to conduct a survey, despite the availability of data from professional studies, was made to enable detailed cross-referencing of various information types, aiming to obtain a more precise profile of users who tend to waste the most. This investigation sought to more accurately identify the characteristics and habits of users concerning their food waste behaviors and to define the project's target audience.

The survey was structured to explore a wide range of aspects of the respondents' daily lives, including their shopping habits, type of employment, and amount of free time available. Particular attention was given to the perceptions that individuals have about their own food waste, the time they can dedicate to organizing their pantry, and their awareness of the food waste issue.

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A key element is the awareness of the food waste problem. This data was considered crucial to link it to other aspects related to food, with the aim of identifying any correlations between different levels of awareness and amounts of food waste. For instance, while the study by Scalvedi and Rossi mentions awareness of the issue in relation to age, it does not explore the connection between this awareness and the amounts of waste declared by individuals. The survey was designed to fill this gap, aiming to understand whether greater awareness of the issue could indeed lead to a reduction in food waste.

Through this investigation, it was possible to gather data that not only confirm previous findings but also integrate missing information, thereby creating a more comprehensive and detailed picture of the food waste phenomenon.

Demographic Profile and Household Composition

The distribution of respondents showed a prevalence of young adults (46 participants), followed by adults (13 participants) and elderly (9 participants). The majority of respondents live in households composed of three to five people (44.1%) or in two-person families (25%).

Awareness of the Environmental and Social Consequences of Food Waste

A detailed analysis of the awareness of the environmental and social consequences of food waste by age group reveals that the elderly group is the most aware, with 100% of participants reporting being aware of such consequences. Adults follow closely with 84.6% awareness, while young adults show slightly lower awareness at 80.4%.

Frequency and Reasons for Wasting Leftovers

The management of leftovers varies significantly between age groups. Most young adults (67.4%) tend to throw away leftovers "very rarely" or "never," indicating good management of leftovers. Adults and the elderly show similar tendencies, with 69.2% and 88.9% of participants respectively reporting throwing away leftovers "very rarely" or "never." The main reasons for discarding leftovers are the deterioration of taste over time (39.1% of young adults, 53.9% of adults, 66.7% of the elderly) and the lack of knowledge on how to reuse or re-cook them (30.4% of young adults, 15.4% of adults). This suggests that improving culinary and food preservation skills could further reduce waste.

Frequency and Reasons for Wasting Expired Products

The frequency of disposing of expired products also varies among age groups. Young adults tend to throw away expired products "once or twice a month" (41.3%) or "a few times a year" (43.5%). Adults show a similar frequency, with 46.2% discarding them "once or twice a month" and another 46.2% "a few times a year." The elderly, on the other hand, tend to throw away expired products less frequently, with 66.7% reporting doing so "a few times a year." The main reasons for discarding expired products are uncertainty about the safety of consumption (65.2% of young adults, 46.2% of adults, 66.7% of the elderly) and lack of attention to expiration dates (32.6% of young adults, 53.9% of adults).

Organization of Shopping and Pantry

Most participants shop once a week (42.6%) or two to three times a week (30.9%), indicating a tendency to plan purchases on a weekly basis. However, a significant number of participants (72.1%) have never shopped online, which may reflect resistance to adopting technology for grocery shopping. Pantry organization varies significantly: many participants (23.5%) keep track of both the position and quantity of products, but some (11.8%) store products without any particular order. Improving these practices could further contribute to reducing food waste.

Preferences for a Pantry Organization System

Participants showed a strong interest in features that help reduce waste, such as notifications about foods nearing expiration (73.5%) and recipe suggestions based on available ingredients (51.5%). This

indicates a positive predisposition towards technological tools that can aid in domestic food management. Implementing such systems could significantly improve food management practices.

3.3 Comparison between Survey and Professional Studies

The comparison between the questionnaire data and those reported by Scalvedi and Rossi indicates that older age groups tend to be more aware of the consequences of food waste and engage less in wasteful behaviors. The questionnaire results show that the elderly are very aware and attentive to waste, a result corroborated by Scalvedi and Rossi's data indicating a reduction in waste among older age groups.

The comparison between the questionnaire data and those provided by Waste Watcher International reveals both similarities and significant differences. It is important to note that Waste Watcher's sample is broader and more representative of different categories of respondents at the national level.

Regarding the handling of slightly expired foods, 51.47% of the questionnaire participants indicated they would still consume such products, while 84% of Waste Watcher's respondents said they would check edibility. Comparing the 2023 Waste Watcher data, a figure of 50% is similar to that found in the questionnaire, indicating a correspondence in the results.

Regarding awareness of the consequences of food waste, 83.82% of the questionnaire respondents declared themselves aware, in line with the 78% recorded by Waste Watcher. This suggests a slight decrease in awareness from 2023 to 2024, which remains quite high, although concrete actions to reduce waste are still insufficient.

Regarding food waste in relation to household size, Waste Watcher highlighted that in 2023, households composed of three to five people had a waste rate 29% lower than the national per capita average. Conversely, in households composed of one or two people, waste exceeded the national average by 38%. This trend is also confirmed by the questionnaire, with larger families showing an 8% reduced waste.

Analyzing the causes of waste, Waste Watcher in 2022 found that 25% of respondents forgot food at home, while 19% did not know how to store it properly. The questionnaire data showed slightly lower percentages for both causes (8% and 7%, respectively), suggesting that while forgetfulness is more frequent, the difference between the two motivations is minimal. It is important to note that Waste Watcher does not distinguish between leftovers and expired foods in the context of food waste, treating both categories in an aggregated manner. Conversely, the questionnaire adopted a specific differentiation for each of the two categories, providing a detailed analysis of responses exclusively related to food leftovers. Although the questionnaire sample is significantly smaller, the data suggest a reduction in waste-related attitudes over the course of a year.

Regarding organizational strategies, 42.6% of the questionnaire participants organized their pantry and refrigerator considering expiration dates, compared to 36% in Waste Watcher 2023. The data collected in the same year show a similarity, although with a greater predisposition to organization according to the questionnaire.

Finally, regarding the frequency of food waste, Waste Watcher 2023 indicated that 24% of people waste food at least once a week. The questionnaire revealed that 29.4% of respondents throw away leftovers at least once a week, and an additional 10.3% discard expired foods with the same frequency. However, these percentages cannot be directly summed, as some individuals may fall into both categories. Nonetheless, this comparison highlights that the waste percentages between Waste Watcher and the questionnaire are very similar, although the questionnaire indicates a slightly higher tendency for weekly waste among participants.

In summary, the chapter highlights a correspondence between the questionnaire results and those of professional studies, suggesting that awareness of the consequences of food waste is high, but concrete actions to reduce it are still insufficient. This comparison has allowed for the identification of two distinct profiles of people characterized by a high level of food waste. These profiles are therefore suitable to be considered as targets of the project, in order to analyze their behaviors more thoroughly and identify useful insights for the development of the project itself.

3.4 Target Definition

In the context of this research, it has emerged that identifying specific target groups is essential for designing effective interventions aimed at reducing domestic food waste. The analysis has led to the definition of two distinct target profiles: young and large families with small children, and singles and couples without children.

The primary target consists of young and large families with small children. Demographically, this group includes families with children under ten years old, composed of young adults aged between 25 and 35. Geographically, no specific area has been identified, although there is a slight preference for urban areas where storage space may be limited. Psychographically, these families are interested in sustainability but are more concerned about the economic impact of waste. Behaviorally, they tend to buy more than necessary and face difficulties in managing unexpected events that affect food preservation. This target is motivated to reduce costs and teach their children the importance of sustainability, but often waste food due to the need to always have enough food for the children.

The secondary target includes singles and couples without children. Demographically, this group consists of adults aged between 25 and 45, predominantly high-income professionals. Geographically, these individuals prefer urban and suburban areas. Psychographically, they are interested in health and the taste of food, and are aware of waste, although they are less likely to take preventive measures. Behaviorally, they make frequent and excessive purchases, with limited food management due to a hectic lifestyle. Their focus on sustainability is often accompanied by an interest in health and economic savings, but the lack of time and planning contributes to food waste.

The analysis has identified specific problems associated with these targets. Domestic food waste is a central issue, caused by excessive purchases, poor meal planning, spoilage of fruits and vegetables, and forgetting food in the refrigerator. Large families tend to generate more total waste, while small families present higher per capita waste. Behaviors and habits such as the lack of preventive practices and difficulty in adapting to new culinary habits further contribute to the problem.

These profiles are suitable to be considered as targets of the project, in order to analyze their behaviors more thoroughly and identify useful insights for the development of the project itself.

4. Encouraging Pro-Environmental Behaviors

After outlining the profiles of the research target, it has become clearer that understanding the practical and cultural motivations behind domestic waste is not sufficient to fully define the target profile. The psychological and emotional aspect, which has not been explored, appears to play a crucial role in understanding the deeper reasons why, despite high reported awareness, people are unable to adopt effective pro-environmental behaviors against waste. Over the years, information about the climate crisis has increased, and institutional strategies to reduce waste have intensified. However, as we have seen, awareness seems to have slightly decreased, and waste levels are

decreasing too slowly. This indicates that the solutions currently available on the market and the current level of information are not sufficient to trigger significant behavioral change in people.

Therefore, in this chapter, we will analyze what defines pro-environmental behavior, the psychological barriers that prevent the implementation of such behaviors, and how sustainable behaviors can be induced through behavioral design.

4.1 Pro-Environmental Behaviours (PEB)

"Pro-environmental behavior" (PEB) refers to all those actions that individuals undertake with the intent of minimizing their negative impact on the natural environment. These behaviors can be adopted in various contexts, such as at home, work, transportation, and leisure. The goal of PEB is to reduce pollution, conserve natural resources, and maintain biodiversity. Examples of pro-environmental behaviors include energy saving, waste reduction, water conservation, sustainable mobility, and conscious purchasing.

Various factors influence pro-environmental behavior. Among these, environmental knowledge and awareness are crucial: the greater the awareness of environmental issues, the more likely an individual is to adopt pro-environmental behaviors. Values and attitudes also play a significant role, where ecocentric values (valuing nature) as opposed to anthropocentric values (human-centered) positively influence PEB. Social norms, convenience and ease of implementation, and education and information are other determining factors.

Theories and models that study PEB include the Theory of Planned Behavior (TPB), which suggests that behavior results from the intention to act, influenced by attitudes, subjective norms, and perceived control. The Value-Belief-Norm (VBN) Model proposes that personal values influence environmental beliefs, which in turn influence personal norms and, ultimately, behavior. Finally, the Environmental Proactivity Model emphasizes the importance of collective action and community participation in promoting pro-environmental behaviors.

4.2 Barriers to PEB

Several obstacles can impede the adoption of pro-environmental behaviors. Economic barriers, lack of information, ingrained habits, and distrust in institutions are among the main obstacles identified.

In the book "Living in Denial: Climate Change, Emotions, and Everyday Life," Kari Marie Norgaard explores the reasons why communities do not adopt pro-environmental behaviors despite evidence of the damage caused by pollution. Norgaard introduces the concept of "implicatory denial," which explains how people intellectually recognize the reality of climate change but fail to translate this awareness into concrete actions. The main reasons found by Norgaard include various factors.

Emotional barriers, such as fear, guilt, and despair, can create psychological inertia, leading people to avoid confronting climate change to protect themselves from these negative emotions. This suggests that leveraging these emotions in information campaigns is counterproductive. Contrary to common perception, Norgaard highlights that simply providing threatening information can be counterproductive, reinforcing people's resistance and increasing their inclination to support alternative arguments, even without concrete evidence.

The denial of climate change is socially organized, representing a significant barrier for communities to implement pro-environmental behaviors. According to the scholar, this concept implies that any measure to work on change must address different sets of emotional palettes and, most importantly, different cultural contexts. While feelings may be universal, the tools used to manage these feelings are rooted in specific cultural contexts and within different national identities. This perspective is

crucial to understanding why current information and awareness efforts are insufficient to trigger substantial behavior change in individuals.

Another barrier is political influence, as Norgaard points out that governments and politicians often do not adequately address climate change, thus reinforcing implicatory denial. It is essential to fully understand the complexity of environmental sustainability, including its current and potential impacts on the planet. Scientific research clearly indicates that climate change, pollution, and biodiversity loss represent significant threats to global ecological balance. These issues require a deep understanding by society to adopt behaviors and policies that can mitigate their effects. However, despite the urgency to act, information regarding sustainability is often not adequately disseminated. In particular, the political sector, which should play a key role in public awareness and education, does not always provide complete and accessible information on the issue. This can stem from multiple factors, including conflicting economic interests, deliberate misinformation, or lack of political priority. This lack of political action and the implicit message that climate change is not a priority contribute to maintaining the status quo.

Finally, many individuals believe that their actions will not have a significant impact without collective and systemic change. This belief in personal ineffectiveness and the perception that political actions are impossible to achieve create a barrier to adopting pro-environmental behaviors.

To promote pro-environmental behaviors, it is essential to address emotional and social barriers and create a collective and politically active movement that pushes for systemic change. Norgaard suggests that one way to overcome implicatory denial is to engage people in local political actions and pressure political leaders to act against climate change. Additionally, it is necessary to go beyond simply educating about the facts of climate change and address the underlying emotions and social barriers that prevent action.

Knowles and Eriksson (2015), in the article "Deviant and Guilt-Ridden: Computing Within Psychological Limits," cite Norgaard and her studies to apply them to the field of Human-Computer Interaction (HCI) and suggest an additional barrier to pro-environmental behavior more specifically related to current technological solutions, namely the difficulty in perceiving the effects of non-sustainability. The two authors state that "with regard to climate change, for example, we can observe time-lapse photographs of glaciers and coral reefs, track species extinction, or witness the increase in extreme weather events, but all these phenomena lack the immediacy of feedback that is often necessary to identify a problem." The lack of immediate feedback on the effects of people's behaviors represents a significant obstacle, preventing them from approaching the issue and perceiving their impact more directly and realistically. For this reason, the authors propose the use of simulations and projections through advanced technologies to provide people with a direct experience of the data and news, which are rarely contextualized and connected to individual actions in current propaganda.

4.3 How to Use Behavioral Design for Sustainability

Behavioral design employs a variety of strategies to promote habit change. Some of the most important strategies include simplifying choices, creating incentives, highlighting negative consequences, using social norms, and gradually building habits. Providing positive incentives, such as receiving a reward for adopting a new behavior, can motivate individuals to maintain the new habit. Highlighting negative consequences, such as the potential negative impact on the environment, can push people to avoid undesirable behaviors. Utilizing social norms, which involves communicating the adoption of a certain behavior by other community members, can positively influence individuals and encourage them to do the same. Finally, gradually building habits, that is, adopting sustainable behaviors progressively, can promote the consolidation of lasting habits. To achieve this goal, the

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solution must be designed considering existing individual habits and routines. In this way, it will be possible to create a trigger for the new behavior and promote the consolidation of a new sustainable routine.

However, not all strategies work in every situation, particularly concerning pro-environmental behaviors, where some common behavioral design practices may not help. Often, to avoid losing engagement in behavioral design, emphasis is placed on values related more to achieving personal goals rather than global ones. In the context of digital interventions for sustainability, the prevailing approach has focused on values related to personal self-improvement, as seen in most projects. The study conducted by Knowles et al. (2014), described in the article "Patterns of Persuasion for Sustainability," addresses this topic and makes some observations that prove how important a different approach to these issues is. The design of technologies that offer personal incentives, such as discounts on energy bills or social recognition, to promote behavioral change, is based on the implicit assumption that people are primarily motivated by self-interests, prioritizing personal gain over collective well-being and environmental sustainability.

However, empirical research has shown that people tend to value self-transcendence ideals, that is, values oriented towards the common good and social cooperation, more than self-improvement values. Therefore, promoting exclusively self-improvement values may not be effective in promoting positive actions for sustainability. In fact, emphasizing self-improvement values through technology can create a sort of self-fulfilling prophecy: as people are continuously exposed to advertising messages that emphasize individual success and consumerism, the use of technologies based on this principle could further reinforce such values, making people less inclined to take actions for the common good, especially if they involve a perceived personal cost.

In this context, design plays a fundamental role. Design choices directly influence people's perceptions and behaviors. If the design is based solely on self-improvement values, it could perpetuate an individualistic and consumeristic culture. However, if the design incorporates self-transcendence values, such as solidarity and empathy, it can promote more community-oriented and sustainable behaviors.

In the field of behavioral design, the loss of engagement is often addressed by using rewards that leverage personal self-improvement. These rewards are designed to incentivize specific behaviors by offering immediate or short-term gratifications, such as points, badges, or discounts, and often reflect the prevailing culture of individual self-improvement.

Rethinking the extent of rewards in behavioral design and shifting towards a perspective more focused on self-transcendence values is key to applying behavioral design to sustainability with positive results. Knowles et al. (2014) discuss persuasion patterns for technology focused on pro-environmental behavior. They present a model called "Broad Self-Transcendence," which suggests that, to promote pro-environmental behavior, it is essential to activate self-transcendence values (concern for the well-being of all and nature) more than self-improvement values (personal interests). The values most closely related to pro-environmental behavior are Universalism values, which concern the well-being of all people and nature. Additionally, they emphasize the importance of activating Benevolence values (concern for the well-being of others) to foster environmental concern. These models suggest more effective approaches to designing persuasive technologies that promote sustainable behaviors. Persuasive technologies could use textual, visual, or auditory means to activate values related to peace, equality, and justice. And since people feel better about themselves when they do something good for others, systems that facilitate acts of altruism to promote inner harmony can be beneficial for pro-environmental behavior.

A model that, according to Knowles et al. (2014), is essential to maintain in the design is that of consistency. People are motivated by different values, and the presence of conflicting motivations can make it difficult to design systems capable of engaging a large number of users in changing their behavior. While providing people with multiple motivations may increase the likelihood of adopting a specific behavior, research suggests that if the goal is to encourage long-term lifestyle changes, offering mixed motivations can lead to negative long-term consequences, such as a decrease in spontaneous pro-environmental behavior. Persuasive technologies should communicate a single, clear, and powerful message about environmental protection, avoiding introducing conflicting reasons that could weaken the main message.

Another obstacle lies in the complexity of scientific data and environmental issues, which can be discouraging for the public. This complexity can make it difficult for people to fully understand the urgency and importance of adopting sustainable behaviors. Furthermore, according to discussions by Knowles et al. (2014), activating a value seems to be less effective in motivating behavioral change than clearly explaining the reasons for that value. Therefore, they suggest that exposing people to natural images and emotionally engaging them with nature may be more effective than simple disclosure.

To conclude, the role of behavioral design in promoting sustainable behaviors is essential. While the current emphasis on self-improvement values in digital interventions has shown limited effectiveness, shifting focus towards self-transcendence values and community-oriented behaviors can foster a more profound and lasting commitment to sustainability. By addressing emotional and social barriers and leveraging consistent, clear, and compelling messages about the common good, behavioral design can significantly influence pro-environmental actions. Future strategies should integrate these insights to develop technologies and interventions that not only incentivize individual actions but also cultivate a collective consciousness geared towards the well-being of all and the environment. This holistic approach is crucial for achieving substantial and enduring progress in sustainability efforts.

5. Qualitative Interviews

From the comparison of the data collected through the survey and the information emerged from previous research, a dual target of people particularly inclined to food waste was identified. Additionally, after analyzing the barriers to pro-environmental behavior and possible strategies to overcome them, it was deemed essential to delve into the emotions and peculiar behaviors that motivate people through a qualitative analysis. This approach allows for closer observation of the cognitive mechanisms activated in response to sustainability issues and understanding directly from the subjects what the most effective approaches are to promote pro-environmental behaviors.

The objective of the qualitative interviews was to deepen the analysis of behaviors related to food waste, understand the underlying motivations, and identify peculiarities in the behaviors themselves. Additionally, the aim was to investigate the emotions elicited by different stimuli, including reading an article on food waste and its consequences, viewing images depicting edible food piled in a dumpster next to images of malnourished children in Nigeria, and watching a FAO video on domestic food waste data. This was done to examine how emotions, reactions, and awareness change depending on the method of information dissemination, with particular attention to the emotions and reactions elicited by negative messages about domestic food waste. The goal was to understand whether an excess of written information, viewing negative images, or presenting a very serious video induced positive and encouraging feelings or led to denial and intimidation.

5.1 Analysis and Methodology

Interviews were conducted with six individuals: four belonging to the first target group and two to the second. Initially, four interviews were conducted, involving two people from each group. However, preliminary analysis revealed that the group of young single adults exhibited more interesting dynamics compared to the other target group. Despite having more time available and needing to manage fewer resources, these individuals seemed to have greater difficulty in reducing food waste. For this reason, two additional interviews were conducted with people living alone or with a partner.

The interviews were conducted online via Meet or in person, in individual sessions lasting about an hour. A total of 26 open-ended questions were asked, with an additional 2 specific questions for each target group. The questions were divided into macro topics: personal presentation, experiences and behaviors regarding food waste, knowledge and use of existing products/services, awareness, barriers and motivations, emotional reactions, opinions on community and information, closing questions, and target-specific questions.

For the analysis of the responses, the most significant phrases of the interviewees were highlighted, initially identifying codes and then the main themes, and subsequently constructing an empathy map. This process allowed for the identification of recurring patterns in the responses and a better understanding of the dynamics underlying behaviors and emotions related to food waste.

5.2 Results

The responses and results from the interviews were organized according to the macro-topics outlined in the interview itself. Subsequently, these responses were analyzed to identify emerging trends, citing the most representative and relevant phrases for the research.

Experiences and Behaviors

From the comparison of the data collected through the survey and the information emerged from previous research, it became clear that participants are generally aware that food waste is a problem, although the degree of awareness varies. All participants admit to wasting food to some extent, and the reasons are very similar. Economic loss is considered the main problem caused by food waste, and saving money is the primary motivation for paying attention to expiration dates and buying in a more organized manner.

The main reasons participants give for wasting food include disorganization and forgetfulness. Some specific cases show reasons related to individual characteristics, such as Carlotta, who wastes snacks when they lose their appetizing appearance, or Emanuele, who cannot finish his plate when he is not feeling well psychologically. A common element mentioned by most interviewees is the poor organization of the refrigerator, which tends to "hide" food items, making them forgotten and thus deteriorating.

Participants express regret when throwing away leftovers, but often discard them because they do not want to eat the same dish multiple times. All agree that shopping more frequently and in smaller quantities helps to waste less, as the food is consumed before it expires, the refrigerator contents are better managed, and cravings are better followed, reducing impulsive purchases.

Unexpected events are another reason cited by all participants for food waste, as even planned meals or scheduled leftovers can spoil if unforeseen events arise. All interviewees have difficulties with the preservation of fruits and vegetables, and two find it problematic to manage meat, often sold in quantities not suitable for those living alone. Families seem more attentive to not wasting food to set a

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good example for their children, while singles are primarily motivated by economic savings and the awareness of waste being wrong, despite finding it challenging to avoid waste altogether.

One interviewee, who has a lot of free time and a nearby supermarket, declared that she never wastes anything, thanks to the ability to shop frequently according to her immediate needs.

Knowledge of Products or Services

Most interviewees were not aware of products or services to reduce food waste, or if they knew about them, they had never used them. This lack of use is due to poor information and the perception that waste is not a significant enough problem to require external help. The app "Too Good To Go" was mentioned most frequently, but only two people had tried it, finding it inconvenient due to the collection times and lack of transparency about the box contents.

Awareness and Opinions

The interviewees are mainly divided into two groups: over 40 and under 30. The former group claims not to be informed about the environmental impacts of food waste, while the latter can list some negative effects despite claiming not to be particularly informed. However, no one knew the extent and importance of the problem. The primary motivation against waste is related to social impacts, such as malnutrition in poor countries, rather than environmental impacts, which are undervalued or unknown.

Barriers and Motivations

Safety regarding the consumption of expired foods represents a significant barrier to adopting pro-environmental behaviors. Lack of time and the need for convenience are other factors that hinder being pro-environmental. Interviewees often opt for takeout food when tired, preferring it over preparing meals that would require time and effort. Mood significantly influences their actions, preventing the consumption of meals associated with negative moments.

Reactions to the Article

The article generated various reactions, predominantly characterized by confusion and frustration. One of the most common responses was the difficulty in understanding and contextualizing the large figures mentioned. Such vast numbers create a sense of alarm, but the lack of practical references makes it difficult to grasp the extent of the problem. As one participant described: "My brain senses the alarm but can't actually quantify this information. Without being able to quantify it, it slips away. I know I'm causing harm, but I want to know the best practical behavior to adopt."

Participants expressed a desire for more concrete instructions on how to reduce their environmental impact. Some emphasized the need for visual and practical examples, similar to those on cigarette packages, which clearly show the consequences of individual actions. As one interviewee observed: "On one hand, we need more targeted education, and on the other, clearer examples, like the images on cigarette packages that show the causes of smoking."

Another participant highlighted the ineffectiveness of certain awareness campaigns: "YouTube ads like those from UNICEF showing crying children, if you notice, are the ones people skip the fastest."

The sense of detachment and lack of personal connection to the problem was another recurring theme. The difficulty in perceiving one's role in such a vast issue contributed to feelings of helplessness. One participant reflected: "I honestly didn't think food waste could have such a significant impact on the earth."

Finally, one interviewee stressed the importance of a more holistic and collective view of the problem: "It's not just about environmental sustainability, but also about supporting each other." This highlights

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the need to address the issue not only at an individual level but as part of a collective effort for common well-being.

Reactions to the different ways of presenting the issue of food waste underscore the complexity of environmental communication. It is evident that abstract numbers and data, without a practical context, tend to create confusion and detachment. Conversely, educating the public on specific and easily adoptable behaviors, as well as creating an emotional connection with the consequences of their actions, can foster greater individual and collective commitment.

Reactions to the images

The images had a significant emotional impact, evoking feelings of sadness, anger, and injustice. People recalled childhood teachings about the necessity of not wasting food, often associated with images of hungry children in distant countries. These memories translated into a sense of guilt and frustration when they saw photographs of wasted food. The concrete visualization of food waste amplified the emotional impact compared to simple verbal descriptions.

One participant described the impact of personal experiences compared to images: "I volunteered in soup kitchens for the poor for 5 years, and it made a much stronger impression seeing it in person compared to images." This observation highlights how direct contact with the reality of food waste can elicit a stronger emotional response than merely viewing photographs.

Many participants expressed a sense of detachment and helplessness, acknowledging that while they are aware of the problem, they do not feel capable of solving it. Some reported personal experiences that made the issue more tangible and urgent.

The reactions to the images confirm the importance of providing visual representations of the food waste problem to raise awareness and mobilize people. However, there is also a need to accompany these images with concrete actions and practical instructions to facilitate behavioral change.

Reactions to the video

The reactions to the video revealed a range of emotions and reflections. Many participants found the visualization of the food impacts helpful, recognizing that this approach makes the consequences of daily food choices more tangible. As one participant noted: "Seeing the visualization of food impacts helps."

However, there were also criticisms. One participant expressed skepticism about the simplicity of the solutions proposed in the videos: "What puzzles me about these videos is that after highlighting such big problems, they end up telling you to eat all the food and buy responsibly. It seems too little compared to the problems highlighted." This reflection underscores the discrepancy between the severity of the problems presented and the simplicity of the solutions offered, which may seem inadequate.

Some participants reflected on the role of historical responsibility, wondering how things might be different if there had been greater environmental responsibility in the past: "If we had been responsible already back then, who knows if things would be different now."

The enormity of the problem evoked feelings of helplessness, as reported by one participant: "One thing that struck me is the sense of something so big, so big that it paradoxically makes me feel more helpless." This highlights the need to provide not only information but also tools and support to act.

Another criticism that emerged is the lack of opportunities for the public to be adequately informed and make informed choices: "There is a fundamental lack of giving people the chance to know and choose accordingly. I often leave condiments like cherry tomatoes, etc. I think it's a leftover issue from

my childhood, where being forced to eat things I didn't like left me a trauma." This observation suggests that food education and awareness need to be instilled from childhood.

Finally, the necessity for greater dissemination of this information by authorities and international organizations was highlighted: "In my opinion, it should be more widely disseminated by authorities or the FAO, maybe on the news or on mobile phones which are always on 24/7, yet you don't hear news of this kind. They talk about everything else, like war, but not this." This comment reflects the importance of constant and widespread communication to increase public awareness of environmental issues.

5.3 Final observations

6. Market analysis

In this chapter, a detailed market analysis will be conducted to explore various solutions and technologies employed in reducing domestic food waste. The selection of case studies was guided by the objective of examining a wide range of approaches and technologies, with the intent of identifying the most effective and innovative strategies. By analyzing these cases, the thesis aims to highlight the key features that make some strategies more effective than others, considering factors such as accessibility, ease of use, environmental impact, and consumer engagement. Additionally, it is important to understand how many existing solutions have employed strategies to induce pro-environmental behavior and what the strengths and weaknesses of each solution are. This analysis provides a deeper understanding of the dynamics at play in the fight against domestic food waste and suggests pathways for future improvements.

6.1 Selection of Case Studies

The selection of case studies for this thesis was guided by the goal of exploring a wide range of approaches and technologies employed in combating domestic food waste. The selected case studies, including TT-No Waste, Waste Watcher International's Sprecometro, BEEP, Olio, No Waste, Love Food Hate Waste, Subpod, Zero-Waste Chef, The Salvage Chef Cookbook, Makro Supermarket's fruit labels, and Smarter FridgeCam, represent a diverse set of solutions ranging from the use of advanced technologies, such as apps and smart devices, to more behavior and education-oriented initiatives.

Each case study was chosen for its specific relevance in the area of food waste reduction, highlighting various strategies including consumer awareness, innovative management of food stocks, and effective recycling of organic waste. These studies cover a broad spectrum of operational modes and are exemplary of the various scales of intervention possible in a domestic context.

We have solutions such as TT-No Waste, Sprecometro, BEEP, Olio, and No Waste employ digital technologies to monitor food consumption and reduce waste through artificial intelligence and data analysis. These platforms provide consumers with practical tools to better manage their food supplies and optimize resource use.

Initiatives like Love Food Hate Waste and Zero-Waste Chef are crucial for changing consumer habits through education. These programs aim to instill greater awareness of the environmental implications of food waste and promote responsible consumption practices.

Subpod and Makro Supermarket's fruit labels illustrate how sustainable practices can be implemented in the management of organic waste and the marketing of food products, respectively.

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These examples show the importance of transparency and direct consumer involvement in reducing waste.

The "Salvage Chef Cookbook" and Smarter FridgeCam technology offer practical resources that help consumers use food products more effectively, thus reducing waste at the household level.

6.2 Introduction to the Analysis

After outlining the motivations behind the selection of the case studies, we will proceed with a detailed exploration of each, applying a set of specific criteria to assess their effectiveness and impact in reducing domestic food waste. This analysis utilizes meticulously selected criteria to provide a comprehensive and multidimensional evaluation of the various solutions examined. The criteria used are:

- **Effectiveness in Reducing Waste:** Assesses how effectively each solution helps to reduce the amount of food wasted.
- **Accessibility:** Considers how easily consumers can access these tools or resources, both economically and technologically.
- **Ease of Use:** Analyses how intuitive and simple the product or service is to use.
- **Environmental Impact:** Evaluates the effect that the product or service has on the environment, considering both the direct benefits of reducing waste and the indirect impacts of production and distribution.
- **Cost to Users:** Considers the economic cost to the end-user in acquiring and using the product or service.
- **Sustainability Education:** Measures the effectiveness of the product or service in promoting sustainable practices and educating users about environmental issues.
- **Community Building:** Explores the ability of the product or service to create a community of committed users or to promote collaboration.
- **User Engagement:** Assesses the level of interaction and involvement that the product or service manages to maintain with users over time.
- **Engagement Retention:** Evaluates the ability to maintain user engagement over time and create a habit.
- **Technological Innovation:** Assesses the technological component of each solution to understand not only its effectiveness but also its potential for future adoption and ease of integration into home settings.

6.3 Analysis

TT-No Waste

This app allows you to manage food expirations, drug expirations, DPI expirations, and product expirations in general. It functions as a deadline reminder. Specifically with food expirations, it helps combat food waste by reminding the user, by means of customizable automatic notifications, to consume or donate food that is about to expire thus avoiding throwing it away. With this food expiration app, users are in fact also empowered to donate expired or expiring food and medicines to those who need them most, through a growing circuit involving voluntary associations. Manually uploading the data is not very practical and fast and may cause the users to stop the action after a while, effectively abandoning the project. The TT-No Waste system addresses the users' difficulties by involving both manufacturers and large retailers as well as stores (both physical and online) in the project, becoming in fact a real circuit. The user who buys products at the stores participating in the TT-No Waste circuit (recognizable through a specific sign/logo applied at the entrance or a banner present on the web

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pages) by showing his TT-No Waste Code, will find the purchased products, including the expiration date, already uploaded in the app, without having to enter them manually, with considerable time savings.

Main Features

- **Expiration Monitoring:** The app allows users to track the expiration dates of food and pharmaceutical products to consume or donate them before they expire.
- **Integrated Circular System:** Interaction with producers and stores enables users to have purchased products and their expiration dates automatically uploaded to the app via the TT-No Waste Code.
- **Facilitated Donation:** The app collaborates with volunteer organizations that can pick up and distribute expiring products collected through the system, making it easy to donate and effectively reduce waste.

Strengths

- **Contribution to Sustainability Goals:** Supports the reduction of food waste and promotes environmental sustainability.
- **Interaction and Collaboration:** Involves various actors in the circular economy, from producers to retailers to the final consumer, creating a broad support network for waste reduction.
- **Ease of Use and Social Impact:** Provides a simple and direct way for users to contribute to waste reduction, enhancing the social impact of their daily actions.

Weaknesses

- **Dependence on Third Parties:** The system's effectiveness heavily relies on active collaboration from stores and producers.
- **User Commitment:** Despite the automation of some functions, the user's ongoing commitment to keeping their inventory updated is crucial.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, as it effectively reduces food and pharmaceutical waste by monitoring product expirations and facilitating donations.
- **Accessibility:** Moderate, depends on user access to digital platforms and participation of retail networks.
- **Ease of Use:** Moderate, with some initial setup required but automated features enhance ease of use over time.
- **Usage Channels:** Primarily digital, through a mobile application that integrates with participating stores and producers.
- **Environmental Impact:** Positive, by reducing waste and promoting recycling and reuse of products.
- **Cost to Users:** Low to none, as the app is free to download and use.
- **Education on Sustainability:** High, educates users on expiration management and the importance of reducing waste.
- **Community Building:** Moderate, through partnerships with volunteer organizations and local communities.

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- **User Engagement:** Moderate, incentivized through ease of use and the tangible benefits of waste reduction.
- **Technological Innovation:** High, utilizes digital tracking and an integrated retail system to streamline the waste reduction process.
- **Sustainability of Engagement:** Moderate to high, dependent on continuous participation from users and network retailers to keep the system effective.

TT-No Waste represents an innovative and integrated approach to waste management that goes beyond a simple monitoring app to embrace a comprehensive circular economy system. Although it requires active adherence from various stakeholders to maximize effectiveness, the application has the potential to make a significant difference in reducing waste at both domestic and commercial levels.

Sprecometro di Waste Watcher International

Sprecometro is an app conceived and developed by the Waste Watcher International Observatory of food and sustainability. It measures everyone's food wasting in grammes, assessing its economy could an environmental impact, and proposes, based on the results of the survey, educational content designed to reduce waste quantitatively and qualitatively. It is then possible to assess his progress is overtime by updating one's behaviour on time (waste diary) allowing each person to set reduction targets in line with the UN agenda for sustainable development. It also allows comparison with other users, including by creating reference clusters (family, school, company, public, administration). The Sprecometro is also connected to an Instagram channel where users can share results and progress. The Sprecometro aims to generate awareness and knowledge useful in directing individual choices regarding the sustainable use of natural resources, the reduction and prevention of food waste and the adoption of healthy and sustainable diets.

Main Features

- **Waste Monitoring:** Allows users to record and track daily food waste, fostering awareness and personal responsibility.
- **Educational Content:** Provides feedback and reports based on waste data, with tips on how to improve eating habits and reduce waste.
- **Community and Comparison:** The app enables users to compare their progress with that of other users, creating reference groups such as families, schools, or companies to encourage positive competition and collective improvement.

Strengths

- **Effectiveness:** High, it provides a measurable impact on food waste through a quantitative approach that helps users visualize and understand their personal waste.
- **Education on Sustainability:** Strong emphasis on education, with an approach that promotes a lasting behavioral change among users.
- **Technological Innovation:** Combines data collection and analysis to provide visual and numerical feedback, making the application an advanced example of educational technology and waste management.

Weaknesses

- **Accessibility:** Requires ongoing and conscious effort from users to enter data, which could limit its use among those looking for more immediate or less demanding solutions.

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- **User Engagement:** The regularity of use and the feedback provided are essential for the app's success but can vary significantly among users, affecting overall effectiveness.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, provides a measurable impact on household food waste through waste tracking and behavioral insights.
- **Accessibility:** High, as it requires minimal technological investment and is easy to implement at the consumer level.
- **Ease of Use:** Very high, with a simple interface and straightforward metrics.
- **Usage Channels:** Digital app, accessible through various devices, enhancing user interaction and integration into daily routines.
- **Environmental Impact:** Significant, by directly reducing the amount of food waste produced.
- **Cost to Users:** Low, primarily the time invested in tracking and inputting data.
- **Education on Sustainability:** High, includes educational content on reducing food waste and its environmental impacts.
- **Community Building:** Low, primarily individual use but has potential for community impact through shared results and competitions.
- **User Engagement:** High, through interactive features and regular feedback on progress.
- **Technological Innovation:** Moderate, uses existing technologies for tracking and data management but applies them innovatively for waste reduction.
- **Sustainability of Engagement:** High, as regular use and habit formation are encouraged by the app's design and functionality.

Sprecometro is particularly effective in educating and reducing food waste through an informative and interactive approach. However, its dependency on active user input and continuous commitment represents challenges that could be mitigated with the introduction of more automated features or more impactful awareness campaigns.

BEEP

BEEP is an application that uses barcode technology to obtain detailed information about food products. The app allows users to monitor all product expiration dates stored at home, sending notifications to consume them in time. This system helps reduce food waste by efficiently tracking expiration dates.

Main Features

- **Barcode Scanning:** Facilitates the addition of products to the home inventory by scanning the barcode, offering a simple method to monitor food freshness.
- **Expiration Notifications:** Sends automatic alerts to users to remind them to consume products before they expire.
- **Food Inventory Management:** Allows easy organization of food stocks, helping users plan consumption based on expiration priority.

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Strengths

- **Effectiveness:** High, as it helps users reduce food waste by actively monitoring and managing expirations.
- **Ease of Use:** The app is designed to be intuitive and easy to use, making home food management accessible to everyone.
- **Technological Innovation:** Utilizes advanced scanning technologies and notification integration for an efficient home food management system.

Weaknesses

- **Accessibility:** Requires the purchase of a specific device for barcode scanning, which can be a barrier for some users.
- **Technology Dependence:** The system completely depends on the accuracy of barcode information and the timeliness of app updates, which may not always be prompt or accurate.

Criteria Analysis

- **Accessibility:** Moderate, accessible to those who are technologically inclined and own compatible devices for barcode scanning.
- **Ease of Use:** High, if barcode data were consistently accurate, as the system is designed to automate reminders and inventory management.
- **Usage Channels:** Digital application paired with a physical barcode scanning device, integrates into household management.
- **Environmental Impact:** Potentially positive, with effective reduction of food waste contingent upon the accuracy of expiration date calculations.
- **Cost to Users:** Moderate, due to the need for specific hardware that can read and process barcodes.
- **Education on Sustainability:** Low, focuses more on practical waste reduction through technology without a broader educational component on sustainability practices.
- **Community Building:** Low, primarily used by individuals or within single households without a community engagement feature.
- **User Engagement:** Moderate to high, effective engagement is contingent on user trust in the system's accuracy and the habitual use of the app for shopping and inventory management.
- **Technological Innovation:** Moderate to high, the concept of using barcode technology to manage food inventory and expiration dates is innovative, but the implementation lacks reliability in terms of accurately capturing expiration dates, which diminishes its potential impact.
- **Sustainability of Engagement:** Moderate, the long-term use of the app may be affected by user frustration with inaccurate data, which can lead to disengagement unless improvements are made.

BEEP offers a technologically advanced solution for managing domestic food waste. However, to expand its impact, it would be beneficial to reduce dependence on specific hardware and improve the accessibility and accuracy of product information.

Olio

Olio is a mobile app that allows individuals to share unused food with people in their community. The aim is to reduce food waste by enabling users to post photos of food that would otherwise be thrown away and facilitating its distribution to those who can use it.

Main Features

- **Community Sharing:** Enables users to post and search for available food in their area, promoting resource sharing.
- **Integrated Messaging:** Provides a private messaging system to organize the pickup of food.
- **Incentives for Sustainability:** Promotes responsible consumption practices and reduces waste through community interaction.

Strengths

- **Education and Habit Change:** OLIO not only enables users to share food but also acts as an educational tool by promoting awareness of food waste.
- **Encouragement of Sustainable Behaviours:** The app promotes values of self-transcendence by leveraging community and mutual aid. OLIO users are motivated to reduce waste not just for personal benefits but also for the wellbeing of the community.
- **Effectiveness in Reducing Food Waste:** OLIO has proven to effectively reduce household food waste by connecting users with neighbours and local traders. This allows for the redistribution of food that would otherwise be wasted, significantly contributing to the reduction of greenhouse gas emissions associated with food waste.

Weaknesses

- **Geographical Limitations:** Effectiveness can vary greatly depending on population density and local adoption levels.
- **Distrust and Safety Concerns:** Some users may be reluctant to consume shared food due to food safety concerns.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, as it effectively facilitates the sharing and redistribution of food that would otherwise be wasted.
- **Accessibility:** High, the app is easily accessible to anyone with a smartphone, enhancing the ability to participate.
- **Ease of Use:** High, the app is user-friendly, allowing users to quickly post and claim food items.
- **Usage Channels:** Primarily a mobile app that leverages social interactions to reduce food waste.
- **Environmental Impact:** Significant, by reducing the amount of food waste that ends up in landfills and encouraging local sharing.
- **Cost to Users:** Low, the app is free to use, with no additional costs for participating in food sharing.
- **Education on Sustainability:** Moderate, indirectly educates users about food waste by facilitating an environment of sharing and sustainability.
- **Community Building:** High, strengthens local communities by connecting neighbors and enabling mutual support.

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- **User Engagement:** High, users remain engaged through the process of posting, claiming, and communicating about food.
- **Technological Innovation:** Moderate, uses existing social and mobile technology to facilitate food sharing.
- **Sustainability of Engagement:** High, as the app provides continuous utility and benefits that encourage regular use and community interaction.

Olio is an innovative platform that uses technology to reduce food waste by encouraging sharing and community. To overcome challenges related to trust and safety, it could be beneficial to implement more rigorous verification and safety standards.

NoWaste

The NoWaste app is designed to help users reduce food waste in their homes through efficient food stock management. This application allows tracking of purchases, expiration dates, and refrigerator contents, offering a clear overview of what should be consumed first to reduce unnecessary purchases and waste.

Main Features

- **Inventory Management:** Allows users to record and monitor food inventory in the refrigerator, freezer, and pantry.
- **Meal Planning and Shopping Lists:** Helps users plan meals and create shopping lists based on foods that need to be consumed first.
- **Expiration Notifications:** Sends automatic reminders about foods that are nearing expiration to minimize waste.

Strengths

- **Education and Habit Change:** NoWaste educates users on how to better manage food stocks and prevent waste. With features like expiration tracking and meal planning, the app teaches users to organize their consumption more efficiently, promoting habits that can reduce domestic food waste.
- **Promotion of Sustainable Behaviors:** The app encourages sustainable behaviors not only through direct food management but also by helping users realize the economic savings from reducing waste. This aspect can further motivate users towards a sustainable lifestyle, linking personal improvement with broader benefits for the community and the environment.
- **Effectiveness in Reducing Food Waste:** NoWaste is effective in reducing domestic food waste by offering tools to actively monitor and manage food stocks. Features such as notifications for expiring products and priority-based organized lists help minimize food waste.

Weaknesses

- **Dependence on Technology and User Diligence:** The app's effectiveness heavily relies on users' commitment to keeping the inventory updated.
- **Limitations in Teaching Broader Sustainable Practices:** While effective in teaching stock management, it may not cover other important aspects of food sustainability.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, helps users track and manage their food inventory to minimize spoilage and overbuying.
- **Accessibility:** High, available to anyone with a smartphone or computer.

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- **Ease of Use:** High, designed to be intuitive and integrate seamlessly into daily shopping and cooking routines.
- **Usage Channels:** Mobile and web applications that help manage household food inventories.
- **Environmental Impact:** Positive, by reducing the amount of food waste generated at the household level.
- **Cost to Users:** Low, typically free or with a nominal fee for premium features.
- **Education on Sustainability:** High, provides tips and strategies for reducing food waste at home.
- **Community Building:** Low to moderate, primarily focuses on individual users, with potential for sharing tips and experiences in online forums or social media.
- **User Engagement:** High, particularly if the app includes reminders and personalized suggestions.
- **Technological Innovation:** Moderate, utilizes basic app functionalities but applies them to the important issue of food waste reduction.
- **Sustainability of Engagement:** Moderate to high, depending on the user's commitment to continually inputting inventory data and following the app's recommendations.

NoWaste is an effective and easy-to-use solution for those looking to reduce their domestic food waste. However, its success depends on the user's ongoing commitment to keep the app's information updated.

Love Food Hate Waste

Love Food Hate Waste is an initiative launched by the Waste & Resources Action Programme (WRAP) in 2007 aimed at reducing food waste in the United Kingdom. This campaign is known for its broad outreach and effectiveness, claiming to have helped almost two million households reduce their food waste, saving a significant amount of money and preventing thousands of tonnes of waste.

The campaign provides a variety of resources to help individuals and families reduce food waste at home. These include practical tips on food storage, portion planning, and using up leftovers. The Love Food Hate Waste app enhances this by offering features like recipe suggestions based on the food you already have, meal planners, and a shopping list tool to prevent over-purchasing. The app is designed to help you track your food usage and minimize waste through better kitchen management.

Moreover, the campaign extends its impact by working with retailers and manufacturers to improve food packaging and labeling, which helps in reducing food waste at the consumer level. It has also gone global, with adaptations of the campaign running in countries like Australia, New Zealand, and Canada, focusing on reducing food waste worldwide and mitigating its environmental impact.

Main Features

- **Educational Resources:** Provides advice on how to properly store food, plan portions, and use leftovers effectively.
- **Mobile App:** The mobile app offers features such as recipe suggestions based on what you already have, meal planners, and tools for shopping lists.

Strengths

- **Education and Habit Change:** The campaign effectively educates users on sustainable practices and helps change daily habits.
- **Global Reach:** It has a significant impact not only in the UK but also globally, adapting the campaign in countries like Australia and Canada.

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Weaknesses

- **Dependence on Active Participation:** The program's effectiveness depends on users' willingness to adopt and maintain new habits.
- **Lack of Direct Long-term Impact Measurement:** It is difficult to measure the long-term impact of individually changed habits.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, effectively provides information and resources that help individuals reduce food waste.
- **Accessibility:** High, with resources available online and through various media, easily accessible to a wide audience.
- **Ease of Use:** High, the information and tips are straightforward and easy to implement.
- **Usage Channels:** Websites, mobile apps, and printed materials, providing diverse ways to reach users.
- **Environmental Impact:** Significant, by directly reducing food waste through consumer education.
- **Cost to Users:** None, as most resources are available for free.
- **Education on Sustainability:** Very high, core focus on educating the public about food waste and how to prevent it.
- **Community Building:** Moderate, through campaigns and partnerships with other organizations.
- **User Engagement:** Moderate to high, with regular updates and community challenges that keep users involved.
- **Technological Innovation:** Low to moderate, relies more on content and community engagement strategies than on new technologies.
- **Sustainability of Engagement:** High, as the initiative consistently updates and refreshes its content to keep the audience engaged and informed.

Love Food Hate Waste is a valuable resource for reducing food waste through education and habit change. Despite some challenges, the campaign has proven to be extremely effective both nationally and internationally.

Subpod

Subpod is an innovative composting system that integrates with nature, using worms and microbes to effectively decompose organic waste. Its underground design keeps the process odorless and minimally invasive compared to traditional composting methods and acts as a "growth hub" for the garden, enhancing soil fertility and plant health.

Main Features

- **Effective Composting:** Utilizes a simple four-step process involving the addition of organic waste, decomposition by worms and microbes, and ventilation to keep the process odorless.
- **Dual Functionality:** Also serves as a garden bench, offering dual functionality that enhances its appeal and utility.

Strengths

- **Education on Sustainability:** Encourages sustainable living practices, reducing greenhouse gas emissions by preventing organic waste from ending up in landfills.
- **Positive Environmental Impact:** Makes a significant contribution to reducing environmental impact, improving soil health, and reducing waste.

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Weaknesses

- **Initial Investment:** Purchasing a Subpod represents an initial cost that may not be accessible to everyone.
- **Space and Climate Limitations:** May not fit all garden spaces or climate conditions, limiting its applicability.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, Subpod effectively composts organic waste, significantly reducing landfill contributions.
- **Accessibility:** Moderate, suitable for users with garden space and initial investment capacity.
- **Ease of Use:** High, designed to be user-friendly with minimal maintenance required once set up.
- **Usage Channels:** Physical product used in residential or community garden settings.
- **Environmental Impact:** Very positive, enhances soil quality and reduces organic waste.
- **Cost to Users:** Moderate to high, involves an initial purchase cost.
- **Education on Sustainability:** High, promotes composting and sustainability practices through its use and educational materials.
- **Community Building:** Moderate, can be used to engage community gardens and schools in composting projects.
- **User Engagement:** Moderate, requires initial setup and occasional maintenance but remains passive in daily use.
- **Technological Innovation:** Moderate, incorporates design innovations for ease of use and effectiveness but does not use advanced technology.
- **Sustainability of Engagement:** High, once integrated into gardening practices, it provides ongoing benefits and requires minimal interaction.

Subpod is an effective and environmentally sustainable solution that transforms organic waste into valuable resources. However, the effectiveness of the system depends on proper maintenance and compatibility with the local environment of the user.

Zero-Waste Chef

The Zero Waste Chef blog, created by Anne-Marie Bonneau, focuses on reducing waste in the kitchen through sustainable cooking practices. The blog offers a wide range of recipes that minimize food waste and tips for sustainable shopping and the use of kitchen scraps.

Main Features

- **Zero Waste Recipes:** Provides recipes that fully utilize all ingredients and tips on how to store food to extend its shelf life.
- **Education and Inspiration:** Serves as an educational platform, inspiring readers to adopt more sustainable habits in the kitchen.

Strengths

- **Education on Sustainability:** Excellent at providing instruction on how to reduce food waste and improve consumption habits.
- **Environmental Impact:** Encourages practices that have a positive environmental impact, such as reducing the use of disposable plastics and composting.

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Weaknesses

- **Barriers to Participation:** Some readers may find it difficult to adapt to the suggested practices, especially if they live in areas where access to local and seasonal products is limited.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, provides practical tips and recipes for using up all parts of food items, significantly reducing kitchen waste.
- **Accessibility:** High, information is freely available online, accessible to anyone with internet access.
- **Ease of Use:** High, recipes and tips are straightforward and adaptable to various skill levels.
- **Usage Channels:** Online platform, including a blog and social media channels.
- **Environmental Impact:** Positive, directly reduces food waste and educates about sustainable cooking practices.
- **Cost to Users:** Low, primarily free content with optional purchases for books or related materials.
- **Education on Sustainability:** Very high, core focus on sustainable kitchen practices and waste reduction.
- **Community Building:** High, fosters a community of followers who are interested in sustainability and cooking.
- **User Engagement:** High, engaging content that encourages frequent visits and participation in challenges.
- **Technological Innovation:** Low, relies on traditional cooking techniques and communication tools but applies them in innovative ways to waste reduction.
- **Sustainability of Engagement:** High, with regular updates, new recipes, and active community engagement to keep users interested and involved.

Zero Waste Chef is an influential and inspiring initiative that demonstrates how daily choices in the kitchen can have a significant impact on waste reduction. The challenges related to the accessibility and practicality of its proposals can be overcome with increased awareness and community support.

Smarter FridgeCam

Smarter FridgeCam is a smart device that installs inside a refrigerator to provide users with a real-time view of its contents via a mobile app. This camera allows users to see what food they have in the fridge from anywhere, helping them avoid purchasing items they already have, thereby reducing waste.

Main Features

- **Real-Time Viewing:** Allows users to remotely check the contents of their refrigerator via smartphone or tablet.
- **Expiration Tracking:** Some versions of the device can track expiration dates of products and send notifications to consume food before it spoils.
- **Recipe Suggestions:** Uses artificial intelligence to analyze available food items and suggest recipes, encouraging more mindful consumption.

Strengths

- **Reduction of Food Waste:** Helps minimize food waste by facilitating better management of food inventory.

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Weaknesses

- **Dependence on Technology:** The device's effectiveness depends on connectivity and users' technological compatibility.
- **Limited Educational Reach:** While it provides practical tools for managing food, it may not comprehensively address broader educational issues related to food waste, such as sustainable shopping habits or understanding food labels.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, allows users to see the contents of their fridge remotely, helping to prevent overbuying and promoting the use of what they already have.
- **Accessibility:** Moderate, requires users to have a compatible fridge and smartphone.
- **Ease of Use:** High, integrates with smartphones for easy viewing and management.
- **Usage Channels:** Hardware installed in the fridge with a companion app.
- **Environmental Impact:** Moderate, reduces food waste by making users aware of their existing food inventory.
- **Cost to Users:** High, requires the purchase of the FridgeCam hardware.
- **Education on Sustainability:** Moderate, indirectly teaches users to manage food more efficiently.
- **Community Building:** Low, primarily an individual or household tool with little community interaction.
- **User Engagement:** Moderate, depends on the user's interest in using the app to check fridge contents regularly.
- **Technological Innovation:** High, innovative use of camera technology within a fridge to monitor food storage.
- **Sustainability of Engagement:** Moderate, as long-term use depends on the continued relevance and usefulness perceived by the user.

Smarter FridgeCam is a technologically advanced solution that directly addresses the issue of domestic food waste. Despite its cost potentially being a barrier, its innovative features offer significant potential for improving efficiency in managing household food.

Life Extending Stickers - Makro

The Life Extending Stickers by Makro are an innovative solution launched to combat food waste in Colombian supermarkets. These labels help extend the shelf life of fruits and vegetables by indicating various stages of ripeness and suggesting appropriate recipes for each stage. They are designed to educate consumers on the full use of food products, from green to overripe, thereby encouraging more responsible and sustainable consumption.

Main Features

- **Color-Coded Labels:** The labels change color according to the ripeness of the product, providing culinary suggestions for each stage.
- **Promotion of Transparency and Education:** Each label offers clear information about the products, promoting more informed and conscious consumption choices.
- **Ease of Use:** The labels are simple to understand and accessible to everyone, applied directly to products without the need for additional technology.

Strengths

- **Environmental Impact:** Contributes to significantly reducing food waste, extending the average life of fruits and vegetables by six days and reducing food waste by 70 tons per week.

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- **Accessibility and Sustainability Education:** The labels are a low-cost, easy-to-use method to reduce waste and increase ecological awareness.
- **Incentive to Purchase Less Aesthetically Perfect Produce:** Encourages the purchase of less aesthetically perfect but perfectly edible produce, thereby reducing waste.

Weaknesses

- **User Engagement:** The impact depends on consumers' willingness to follow the suggestions on the labels.
- **Dependence on Information Accuracy:** The effectiveness is tied to the accuracy of the information provided on the labels.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, effectively extends the life of produce by informing consumers of different stages of ripeness and associated uses, reducing premature disposal.
- **Accessibility:** High, these stickers are applied directly to produce in stores, making them instantly accessible to all shoppers.
- **Ease of Use:** Very high, requires no additional action from the consumer other than reading the stickers.
- **Usage Channels:** Physical stickers applied to fruits and vegetables in retail environments.
- **Environmental Impact:** Positive, reduces food waste directly at the consumer level and educates about the edibility of less aesthetically appealing produce.
- **Cost to Users:** None, the cost of stickers is absorbed by the retailer or producer.
- **Education on Sustainability:** High, provides valuable information about food preservation and waste reduction directly at the point of purchase.
- **Community Building:** Low, the initiative is informative but does not inherently build community interaction unless coupled with broader educational campaigns.
- **User Engagement:** Moderate, the stickers provide information passively; engagement depends on consumer interest in and action based on the information provided.
- **Technological Innovation:** Low to moderate, uses simple color-changing technology and printed information to communicate with consumers.
- **Sustainability of Engagement:** Moderate, effectiveness relies on continuous use and visibility of the stickers in stores.

Makro's Life Extending Stickers are an excellent example of how a simple and direct approach can lead to significant changes in consumer behavior and the management of environmental sustainability in supermarkets. This campaign not only helps reduce food waste but also educates consumers on how to utilize fruits and vegetables at every stage of their ripeness.

Why Waste?

"Why Waste?" is an initiative that includes a cookbook aimed at minimizing food waste. This book compiles recipes that promote the use of ingredients often discarded, such as vegetable peels, stale bread, or overly ripe fruit, transforming them into delicious and nutritious dishes. Part of a broader effort by Fine Dining Lovers, this initiative not only aims to save food but also to change the way people think and interact with their food, educating both home cooks and professionals on the potential of every ingredient and inspiring a more sustainable approach to cooking and food consumption.

Main Features

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- **Creative Use of Ingredients:** The cookbook encourages the full use of each ingredient, offering recipes that utilize commonly discarded parts such as peels, stale bread, and overly ripe fruit.
- **Diversity of Recipes:** Provides a variety of recipes ranging from quick, everyday solutions to more elaborate dishes, demonstrating how waste reduction techniques can be applied in different culinary contexts.
- **Educational Content:** Each recipe is accompanied by explanations on why using certain ingredients can contribute to reducing food waste, enriched with tips on how to best preserve food to prolong its freshness.
- **Contributions from Experts:** The cookbook includes contributions from renowned chefs, who offer their expertise and innovative approaches to minimizing waste in the kitchen.

Strengths

- **Consumer Education:** Teaches consumers how to make the most of every part of food, significantly reducing the amount of food discarded.
- **Promotion of Transparency:** Provides clear details on how to enhance less attractive or excess ingredients, helping consumers make informed choices that reduce waste.
- **Incentive to Purchase Less Aesthetically Pleasing Products:** Encourages the purchase of products that may not look perfect aesthetically but are perfectly edible, promoting more sustainable consumption.

Weaknesses

- **Barriers to Participation:** Some readers may find it difficult to adapt to the proposed recipes if ingredients are not readily accessible or if the culinary techniques differ greatly from their habits.
- **Dependence on Individual Commitment:** The effectiveness of the cookbook strongly depends on the individual's willingness to implement the suggested practices and adapt their own cooking habits.
- **Cultural and Practical Limitations:** Recipes may not be suitable for all diets or cultural preferences, limiting the reach and effectiveness of the initiative in different contexts.

Criteria Analysis

- **Efficacy in Reducing Waste:** High, effectively extends the life of produce by informing consumers of different stages of ripeness and associated uses, reducing premature disposal.
- **Accessibility:** High, these stickers are applied directly to produce in stores, making them instantly accessible to all shoppers.
- **Ease of Use:** Very high, requires no additional action from the consumer other than reading the stickers.
- **Usage Channels:** Physical stickers applied to fruits and vegetables in retail environments.
- **Environmental Impact:** Positive, reduces food waste directly at the consumer level and educates about the edibility of less aesthetically appealing produce.
- **Cost to Users:** None, the cost of stickers is absorbed by the retailer or producer.
- **Education on Sustainability:** High, provides valuable information about food preservation and waste reduction directly at the point of purchase.
- **Community Building:** Low, the initiative is informative but does not inherently build community interaction unless coupled with broader educational campaigns.
- **User Engagement:** Moderate, the stickers provide information passively; engagement depends on consumer interest in and action based on the information provided.
- **Technological Innovation:** Low to moderate, uses simple color-changing technology and printed information to communicate with consumers.

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- Sustainability of Engagement: Moderate, effectiveness relies on continuous use and visibility of the stickers in stores.

"Why Waste?" is a remarkable initiative that addresses the issue of food waste in a practical and scalable way, offering a valuable resource for promoting a more sustainable future. This final evaluation highlights how the cookbook not only solves a practical problem but also serves as a catalyst for broader cultural change towards sustainability in everyday cooking.

CPGR System

The CPGR System (Consumer Product Goods Resource) is a sophisticated inventory management system designed to minimize household food waste. By tracking food items from purchase to expiration, the system provides real-time updates and notifications to ensure optimal use of all food products, reducing unnecessary waste.

Main Features

- Tracking System: Enables monitoring of which products are present at home, in what quantities, where they are stored, when they were purchased, their expiration dates, and whether they have been partially or completely consumed.
- Alerts and Reminders: Sends notifications to prevent products from surpassing their expiration dates.
- Shopping List: Automatically creates a shopping list based on available food at home and monitors the consumption of periodic products.
- Recipe Suggestions and Alternative Products: Suggests recipes using expiring ingredients and recommends alternative products at more affordable prices.
- Database: Maps and categorizes all relevant data generated along the food supply chain, from supermarkets to food products and their characteristics.

Strengths

- Efficient Inventory Management: Provides complete control over domestic food stocks, improving food management and reducing waste.
- Education on Conscious Product Use: Educates users on how to better manage food and plan purchases to reduce waste.
- Environmental Sustainability: Reduces food waste, contributing to decreased environmental impact.

Weaknesses

- Manual Product Entry: Manual entry may reduce user engagement.
- Limited Monitoring: Only products in the refrigerator can be monitored, limiting the system's reach.
- Lack of a Community Environment: Does not promote a community environment that could further encourage waste reduction.
- Lack of Awareness and Knowledge: Does not generate deep awareness and knowledge among users regarding sustainable practices and waste reduction.

Criteria Analysis

- Efficacy in Reducing Waste: High, effectively reduces waste through meticulous tracking and management of food items.
- Accessibility: Moderate, requires users to have technological proficiency and access to the necessary digital platforms.

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- **Ease of Use:** Moderate, the system is feature-rich which may require a learning curve for optimal use.
- **Usage Channels:** Digital, primarily accessed through an application or web interface.
- **Environmental Impact:** Very positive, significantly reduces the amount of food waste which contributes to environmental sustainability.
- **Cost to Users:** Moderate, possibly requires a subscription or purchase fee for the software.
- **Education on Sustainability:** Moderate, while it promotes efficient food usage, it lacks direct educational content on broader environmental impacts.
- **Community Building:** Low, focuses on individual households without fostering broader community engagement.
- **User Engagement:** High, regular interactions through notifications and inventory updates keep users engaged.
- **Technological Innovation:** High, utilizes advanced tracking and data management technologies to optimize food storage and usage.
- **Sustainability of Engagement:** Moderate to high, the system's utility in reducing waste can promote sustained use, although it may require continual updates and feature enhancements to maintain user interest.

The CPGR system represents a significant step forward in the technological management of domestic food, with the potential to greatly reduce food waste through its advanced tracking and expiration management capabilities. However, to maximize its impact, enhancing integration with the home environment and reducing reliance on manual user input will be essential. Additionally, creating a stronger sense of community and promoting greater awareness among users could strengthen the system's effectiveness and increase long-term engagement.

6.4 Conclusions

Based on the analysis of existing solutions for domestic food waste, the thesis could focus on several areas and concepts that are not yet fully explored or integrated in current solutions. This focus would aim to address gaps and potential innovations that could significantly impact waste reduction. Here are some potential focus areas:

Integration and Automation: Many existing solutions require significant input from the user, which can lead to reduced engagement over time. It can be explored a more integrated and automated system that reduces the burden on them. For instance, an app that combines smart product scanning, meal planning, and automatic notifications for using food before it expires, all in one.

Ongoing Education and Gamification: While many solutions focus on initial education, ways to maintain interest and engagement over time could be explored. Implementing gamification to teach consumers how to reduce food waste, rewarding sustainable behaviors, and creating challenges among users could be a rich area of opportunity.

Predictive Analytics and Personalization: Utilizing artificial intelligence to analyze user data and predict their behaviors could lead to more effective personalized recommendations. This system could suggest recipes based on ingredients already in the home and predict when they might expire, thus minimizing waste.

Overall Sustainability of the Product/Service: The entire lifecycle of the product or service developed could be considered, including the materials used, production, usage, and disposal. Exploring solutions that not only help reduce food waste but are also designed and manufactured sustainably is crucial.

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Community and Local Collaborations: While many apps focus on the individual, users might explore solutions that facilitate community or local collaboration. This could include platforms that connect people in the same neighborhood or community to share excess food.

Advanced Sensor Technology: Implementing advanced sensors to monitor conditions like temperature, humidity, and ripeness inside refrigerators or pantries could predict when food is about to spoil and suggest ways to use it promptly.

7. Casi Studio

8. Strumenti per il concept

9. Final Concept

The following chapter presents in detail the design concept developed within this thesis: "Planet 2050". This ambitious project aims to induce spontaneous and sustainable pro-environmental behaviors over time, focusing specifically on reducing household food waste. In an era where environmental awareness is more important than ever, it is crucial to explore and implement new strategies that can positively influence people's daily habits.

"Planet 2050" was conceived as an innovative response to today's environmental challenges, with particular attention to education and user engagement through gamification. This concept not only educates but also aims to transform daily actions into sustainable behaviors, making the impact of our choices on the planet visible and immediate in a playful and positive manner that attracts people to the theme rather than pressuring and alienating them.

Throughout this chapter, the details of the concept will be illustrated, from its functionalities and game mechanics to the creation and management of the virtual planet, and the immediate feedback users receive based on their actions. Additionally, the innovative integration of IoT technologies, including sensors and the food waste scale, as well as the strategic collaborations that will facilitate the spread of the game, will be explored.

Finally, the application of the theories and tools studied in previous chapters will be examined, demonstrating the synergy between theory and practice in sustainable design.

9.1 Pianeta 2050: Funzionalità e Meccaniche

The concept of "Planet 2050" is primarily developed as a mobile and tablet game, aimed at restoring a virtual planet rendered inhospitable through the adoption of sustainable shopping and food management habits. The name was chosen to reflect the year scientists have identified as the point of no return for our planet, by which significant changes in our habits must be made to ensure the sustainability of life on Earth. This name embodies the idea that the virtual planet created in the game represents what our actual planet could look like in 2050, depending on the choices and actions we take today.

Users start by downloading the game and answering a questionnaire that evaluates their eating habits. Based on their responses, they are assigned a role that reflects the most significant area where they can contribute, and personalized and sustainable goals are calculated for both the user and the environment. Users can choose to play solo or form a team with up to three people, creating a small

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community that collaborates to restore the planet. The initial state of the virtual planet varies based on the users' habits, and each achieved goal alters the planet's characteristics, providing immediate feedback on the consequences of their actions.

The game is interactive and requires users to upload data related to their shopping and food waste weight to the app. Through collaboration with supermarkets, users can receive their shopping lists directly on the app via virtual supermarket cards, eliminating the need to manually enter each food item. The game automatically calculates if the shopping follows the set guidelines and goals, assigning a score to the user and altering the planet's state based on their performance.

A key element of the game is a separately sold scale placed at the bottom of the compost bin, which calculates the amount of food waste produced and sends the data to the app. These data are used to assess the sustainability of the waste produced and provide feedback on how to improve consumption habits.

Below, the main features of the game and the basic mechanics that drive the user experience are described in detail.

9.2 Download and Initial Test

The user begins the experience by downloading the game and completing an initial questionnaire. This questionnaire evaluates the user's eating and shopping habits, allowing for a personalized gaming experience. Based on the responses, a specific role is assigned that reflects the most significant aspect where the user can contribute. For example, if the user consumes and wastes a lot of meat, they will be assigned a role with the primary goal of reducing CO₂ production and intensive farming.

The initial test will include questions about demographic information, shopping habits, preferred diet type, level of attention to product ecology, specific dietary needs, levels of leftover and expired product waste, culinary skills, and flexibility and willingness to change habits.

Game Mechanics

The "Planet 2050" concept is primarily developed as a mobile and tablet game aimed at restoring a virtual planet made inhospitable through the adoption of sustainable shopping and food management habits. The name was inspired by the date indicated by scientists as the point of no return for our planet, by which significant changes to our habits must be implemented to ensure the sustainability of life on Earth. This name reflects the idea that the virtual planet created in the game represents what we might actually have in 2050, depending on the choices and actions taken today.

Registration and Profiling

Users begin the experience by downloading the game and completing an initial questionnaire. This questionnaire assesses their eating and shopping habits and allows for a personalized gaming experience. Based on the responses, users are assigned a specific role that reflects the most significant aspect they can contribute to. For example, if a user consumes and wastes a lot of meat, they are assigned a role with the primary objective of reducing CO₂ production and intensive farming.

Shopping Scanning

After shopping, users can scan the QR code at the partner supermarket checkout or photograph the receipt. The app automatically recognizes and records the purchased products, categorizing them by type of food and quantity. This system allows monitoring the impact of shopping choices on the environment, assigning scores based on various criteria such as the sustainability of purchased

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products, the amount of processed food versus fresh food, the purchase of local or organic products, and the reduction of waste through appropriate quantities.

Points Assignment and Personalized Feedback

Each shopping trip receives a score that is immediately displayed on the app. In addition to the score, users receive personalized advice on how to improve the sustainability of their next shopping trip. These practical suggestions can include tips on replacing meat with legumes or buying less processed food. Visual animations show the impact of food choices on the user's virtual planet, encouraging tangible progress through the positive visual improvement of the virtual environment.

Evolution of the Virtual Planet

Every user action contributes to changing the appearance of the virtual planet. For example, reducing meat consumption causes more flowers and plants to grow, while buying local products decreases pollution. Both individual and group goals make the gaming experience more engaging. For instance, users can participate in challenges like "Zero Meat Week," earning rewards and recognition if they achieve thematic goals.

Collaboration and Community

Users can create groups by inviting friends and family to join them. Each group chooses a unique name for their planet, such as "EcoWorld" or "GreenVille." Collaboration is encouraged through group goals that, when achieved, unlock special features and give more points than usual. The game also includes a community section where users can connect, share progress and challenges, and visit other users' planets for inspiration. Weekly or monthly leaderboards show the top-scoring groups and individuals, maintaining user interest and engagement.

EcoScale Accessory

A key element of the game is the EcoScale accessory, a scale sold separately that is placed at the bottom of the compost bin. This scale calculates the amount of food waste produced and sends the data to the app, providing real-time monitoring of food waste. These data are used to evaluate the sustainability of the waste produced and provide feedback on how to improve consumption habits.

Collaboration with Supermarkets and Waste Watcher

The game collaborates with supermarkets to automate shopping scanning and encourage user participation. Through a partnership with Waste Watcher International, aggregated and anonymous data on food waste from users are shared for research and analysis, contributing to global food waste research. This collaboration not only promotes the game but also facilitates the dissemination of sustainable practices on a global scale.

User Journey: Planet 2050

Anna, a 32-year-old living in a major Italian city, is environmentally conscious and seeks ways to reduce her ecological impact. She downloads the "Planet 2050" app after seeing a billboard in the supermarket. She completes the initial test, invites her friends to join her group, and together they configure their virtual planet. She scans her shopping at the partner supermarket, receives feedback and advice on using products, and installs EcoScale in the compost bin to monitor food waste. By participating in weekly challenges and interacting with the community, Anna and her group earn points and unlock special features on their planet. Finally, data on food waste from Anna's group are shared with Waste Watcher International, contributing to global research.

Group Creation and Planet Naming

Users have the option to start a new group or join an existing one. When creating a new group, the user becomes the leader and can invite friends and family via the app. Once the group is formed, they choose a unique name for their planet, like "EcoWorld" or "GreenVille." This name represents the collective identity of the group and is used for leaderboards and community challenges.

Shopping Tips and Goals

The advice provided by the app is personalized and detailed, based on the user's eating profile and previous shopping data. These suggestions include specific tips, such as reducing meat consumption by purchasing more legumes, or more general advice, like always checking expiration dates and properly storing leftovers. Shopping goals are designed to be achievable and motivating, encouraging sustainable behaviors through positive feedback and virtual rewards.

Themed Events and Challenges

Every week or month, the app introduces themed events, like "Zero Meat Week," encouraging users to temporarily change their eating habits to earn extra points and unlock special rewards. Participation in these events not only increases user engagement but also provides educational opportunities to explore new sustainable eating behaviors.

Community Interaction

The community section of the app allows users to connect with each other, share progress and challenges, and visit the virtual planets of other groups. Weekly or monthly leaderboards show the top-scoring groups and individuals, creating a friendly competition that further motivates users. This community interaction strengthens the sense of belonging and offers mutual support among users.

Continuous Feedback and Improvement

The app provides continuous feedback on achieved goals and areas for improvement. Users receive regular updates on their progress and new goals to achieve. This continuous feedback mechanism is essential for maintaining high motivation and promoting sustainable pro-environmental behaviors over the long term.

Conclusions

"Planet 2050" represents an innovative and integrated approach to educating and motivating users towards sustainable eating habits. The game mechanics, community interaction, use of IoT technologies like EcoScale, and collaboration with supermarkets and research organizations demonstrate the effectiveness of strategies adopted to promote pro-environmental behaviors. The game not only raises awareness among users but also actively engages them in a process of change, making sustainability an integral part of their daily lives.