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Master thesis

Transforming Circular cities with technologies: The case study of a university canteen in Turin, Italy.

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Transforming Circular cities with Technologies:
The case study of a university canteen in Turin, Italy.

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I express my profound gratitude to my supervisor, Prof. Dr. Patrizia Lombardi, for welcoming me into her esteemed research group and allowing me to delve into a subject of great interest. Her guidance and support have been pivotal in the development of this thesis and have inspired me to pursue further research in this field.

I extend my heartfelt thanks to Dr. Chiara Genta, whose unwavering support and insightful guidance have been instrumental from the inception of this project. Her assistance in organizing a site visit to canteen provided a significant contribution to my research, offering practical insights that enriched my work.

This thesis is dedicated to my father Suresh, Mother Chitra, and Brother Varadarajan, who are my human diaries around whom my world revolves. Their belief in me has been a constant source of strength and motivation.

A special thanks to my lovely grandparents, Relatives, cousins, friends and my housemates who have always supported and encouraged me, in everything. Also, my sincere gratitude to my internship office for their support in this journey.

Thanks to Vignesh Mani, Monish, Adhavan, Kishorevijay, Prerna Kumari, and Harini who has constantly been with me hearing my rants and supports me always, also some from afar, but who I always feel close to.

This thesis marks the end of my Master's journey at Politecnico di Torino, a journey filled with immense learning experiences and invaluable memories over the past three years. This project represents not only the fulfilment of my academic goals but also my dedication to contributing to the university's sustainability initiatives, particularly in reducing Carbon emissions through the mitigation of food waste in the university canteen.

It is a testament to the collaborative effort and social cohesion fostered among the students involved in the research process. I hope that the policies formulated through this research will contribute significantly to the university's sustainability goals and inspire further advancements in creating a future city integrated with sustainable technologies.

I am honoured to present the results of this master's graduation project, a reflection of my dedication, hard work, and the support of those mentioned above.

Thanks to 'ME'

We have never seen food's true potential because it is too big to see. But viewed laterally it emerges as something with phenomenal power to transform not just landscapes, but political structures, public spaces, social relationships, and cities.

- Carolyn steel, Hungry city: How food city shapes our lives

TABLE OF CONTENT

Abstract (IT)

Fin dai miei primi anni, mia madre mi esortava costantemente: "Consuma tutto il cibo nel tuo piatto". Eppure, su scala globale, un terzo di tutto il cibo prodotto per il consumo umano va sprecato (Jenny Gustavsson, 2011). La ricerca in questo ambito si è finora concentrata principalmente sui fattori comportamentali che influenzano la produzione di rifiuti alimentari, mentre le istituzioni formali e informali che riguardano la gestione dei rifiuti svolgono un ruolo altrettanto importante nel modellare il comportamento individuale e aziendale. Questa ricerca si concentra su come gestire meglio lo spreco alimentare tra gli studenti attraverso ricerche bibliografiche, interviste e sondaggi tra gli studenti.

Seguendo il concetto di De Carlo come luogo di sviluppo e conservazione della conoscenza, le università hanno la responsabilità unica di dare l'esempio e guidare l'innovazione per la sostenibilità. In Italia, la Rete delle Università per lo Sviluppo Sostenibile (RUS) è stata istituita per promuovere la cultura e le pratiche per la sostenibilità, aprendo la strada all'esplorazione delle dimensioni della sostenibilità legata al cibo all'interno delle università. Gabriele et al. (2021) (p. 965) affermano che è necessario svolgere ulteriori ricerche sul "coinvolgimento generale nelle questioni relative allo spreco alimentare e sulla consapevolezza generale da parte degli studenti dello spreco alimentare come problema".

Per cominciare, questa tesi esamina il comportamento degli studenti in materia di spreco alimentare attraverso un approccio di studio di caso singolo e un sondaggio tra gli studenti per comprendere la correlazione tra consapevolezza, coinvolgimento, impatto sullo spreco alimentare e intervento della tecnologia nella mitigazione dello spreco alimentare nelle mense universitarie. Mira a rafforzare le strategie esistenti di circolarità alimentare implementando miglioramenti guidati dalla tecnologia nel comportamento in materia di sprechi alimentari. Attraverso questa integrazione strategica della tecnologia, l'obiettivo è non solo migliorare le attuali pratiche di gestione dei rifiuti, ma anche contribuire allo sviluppo di ambienti urbani sostenibili e resilienti all'interno del contesto universitario.

In definitiva, la tesi mira a fornire raccomandazioni politiche a sostegno della circolarità nella gestione dei rifiuti alimentari con la tecnologia, contribuendo a un futuro più sostenibile e senza sprechi sia per i campus universitari che per gli ambienti urbani.

Abstract (EN)

From my early years, my mother consistently urged, "Consume every bit of food on your plate." Yet, on a global scale, one-third of all food produced for human consumption goes to waste (Jenny Gustavsson, 2011) . Research in this area has so far mainly focused on behavioural factors influencing production of food waste, while the formal and informal institutions that relate to the management of waste play an equally important role in shaping individual and company behaviour. This research focuses on how food waste can be better managed among students through literature search, interviews, and student surveys.

Following De Carlo's concept as the place for knowledge development and conservation, universities hold a unique responsibility to lead by example and drive innovation for sustainability. In Italy, the Italian University Network for Sustainable Development (RUS) was established to promote culture and practices for sustainability, paving the way for exploring food-related sustainability dimensions within universities. Gabriel et al. (2021)(p. 965) claim that more research needs to be done on the "general involvement in issues related to food waste and the students' general awareness of food waste as a problem."

To start with, this thesis examines students' food waste behaviour through a single case study approach and a survey among students to understand the correlation between awareness, involvement, food waste impacts and technology's intervention in food waste mitigation at university canteen. It aims to strengthen existing Food circularity strategies by implementing technology-driven improvements in food waste behaviour. Through this strategic integration of technology, the aim is to not only enhance current waste management practices but also to contribute to the development of sustainable and resilient urban environments within the university context.

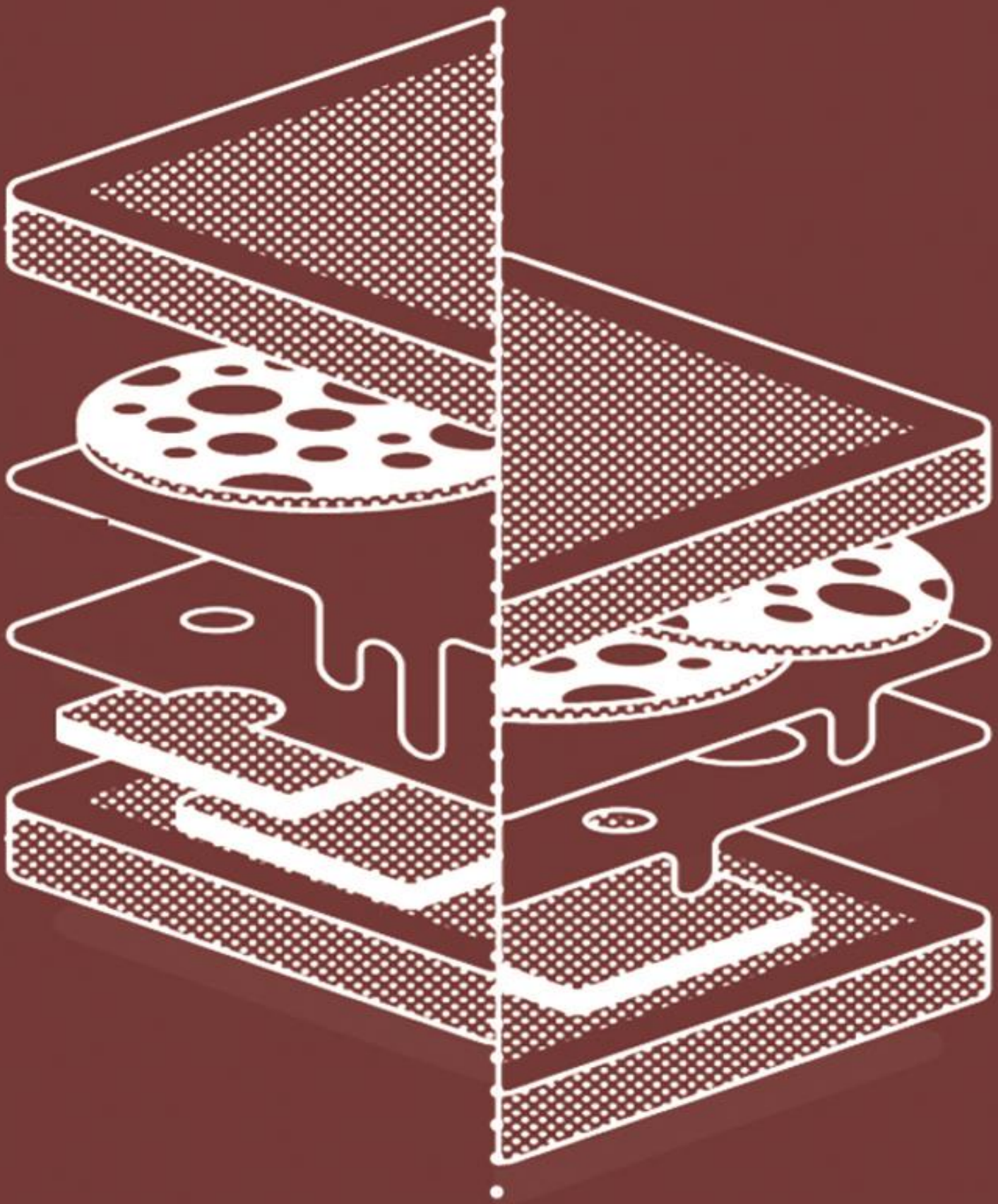
Ultimately, the thesis aims to provide policy recommendations supporting circularity in food waste management with technology, contributing to a more sustainable and waste-free future for both university campuses and urban environments.

List of Acronyms

FSC	Forest Stewardship Council
EU	European Union
UNEP	United Nations Environment Programme
SOI	Sustainability Oriented innovations
CIRFOOD	*Cooperativa Italiana di Ristorazione Food* (Italian Food Service Cooperative)
GIS	Geographic Information System
GDP	Gross Domestic Product
GHG	Greenhouse Gas
SDG	Sustainable Development Goals
RUS	Rete delle Università per lo Sviluppo Sostenibile (Urban Network of Sustainability)
ICT	Information and Communication Technology
FW	Food Waste
FAO	Food and Agriculture Organization (of the United Nations)
AI	Artificial Intelligence
NGO	Non- Governmental Organization
SI	International System of Units

List of Tables

01 INTRODUCTION



1.1 Contextualization and status of the problem

Food intended for human consumption that reaches the final product stage of the food supply chain but remains unconsumed due to disposal is frequently referred to as consumer food waste. The notion of food waste covers the decrease in both the quantity and quality of food. The UNEP Food Waste Index Report (Hamish Forbes (WRAP), 2021) identified 152 food-waste data points in fifty-four countries, the largest global food-waste dataset collected to date. It found that in every country that has measured food waste, it is substantial, regardless of the income level of the country. The impact of the Food waste emissions is the status of the problem. The emissions, largely from decomposing food, contribute to climate change. Simultaneously, climate change poses a substantial threat to landscapes and agriculture, intensifying the pressure on resource availability.

Income group	Average food waste (Kg/capita/year)		
	Household	Food service	Retail
High-income	79	26	13
Upper-middle income	76	Insufficient data	
Lower middle income	91	Insufficient data	
Low income	Insufficient data		

Table 1:Average food waste by World bank - Income classification. Re-drawn by the author. Source: (Hamish Forbes (WRAP), 2021)

1.1.1 Comparative analysis among economies:

The disparity in per capita food wastage footprint on climate between high-income and low-income countries is glaring on a global scale. In high-income countries, this footprint is more than double that of their low-income counterparts, largely attributable to wasteful food distribution and consumption patterns.

This dichotomy becomes even more pronounced when examining the specific challenges faced by developing and developed nations in the food supply chain (FSC).

In developing countries, where much of the food losses occur in the early stages of the FSC, challenges such as poor harvesting technologies, inadequate transportation, and insufficient storage facilities are compounded by extreme climatic conditions (Valeria De Laurentiis, 2014).

The primary culprits here are limitations in cultivation and harvesting, a lack of food-chain infrastructure, transportation constraints, and insufficient investment in technologies.

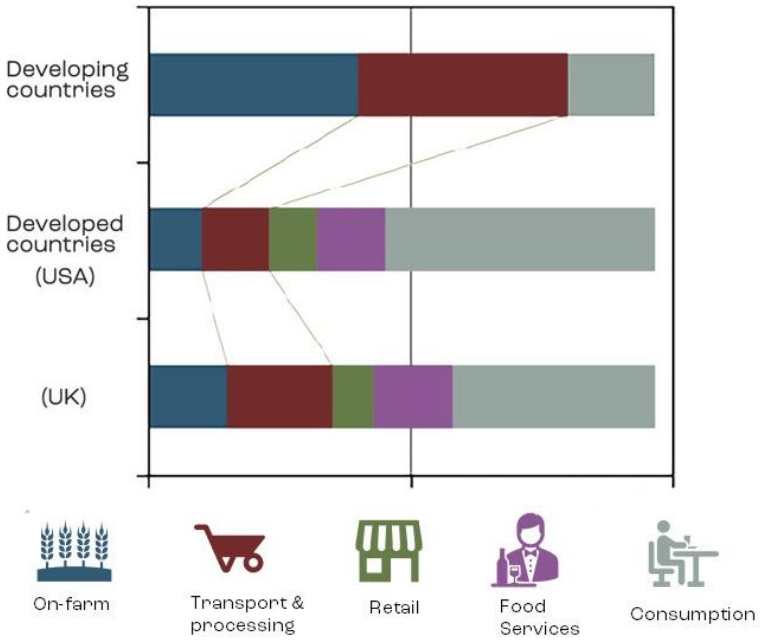


Figure 1:Makeup of total food waste in developed and developing Countries. Image re-drawn by the author. Source: (al., 2010)

On the other hand, developed countries such as USA, UK followed by Europe face a different set of issues. In these regions, food waste during the consumption stage accounts for over 40% of the total food losses and waste in the FSC. The key drivers behind these losses are surplus food generation and consumer behaviour aged between 18 and 30 years are one of the highest contributors to food waste (Jörissen, 2015). Surprisingly, these developed nations, with advanced technologies and robust food-chain infrastructure, grapple with significant waste at the consumer level, highlighting the need for a shift in consumer habits and attitudes.

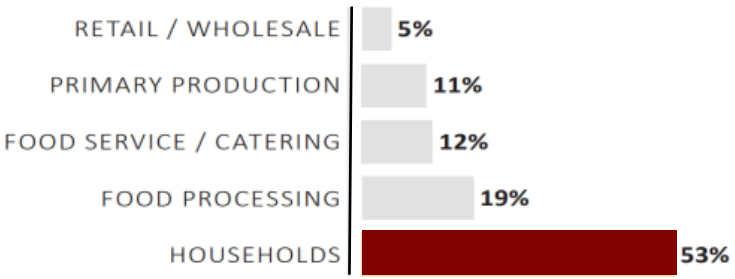


Figure 2:Percentages of waste through each chain in FSC of Europe. Pictorial representation by the author. Source: (Canali, et al., 2017)

1.2 Status quo of food waste in European Union (EU)

In 2021, food waste in the European Union (EU) accounted that each resident discarding almost 131 kg of food. The sheer size of the issue was evident, since the EU generated an astounding 58.4 million tonnes of food waste, which included both edible and inedible components (2023).
Unsurprisingly, household waste accounted for most of the food waste, or 54%, or 70 kg per resident. The residual 46% of food waste was dispersed among different phases of the food supply chain. It is noteworthy that the production of food and drink accounted for 21% of the trash, or 28 kg per person. Restaurants and food services contributed 9% to the overall food waste, equivalent to 12 kilograms per inhabitant. Primary production accounted for 9% of the waste, totalling 11 kilograms per person, while the retail sector contributed 7% with 9 kilograms per inhabitant.

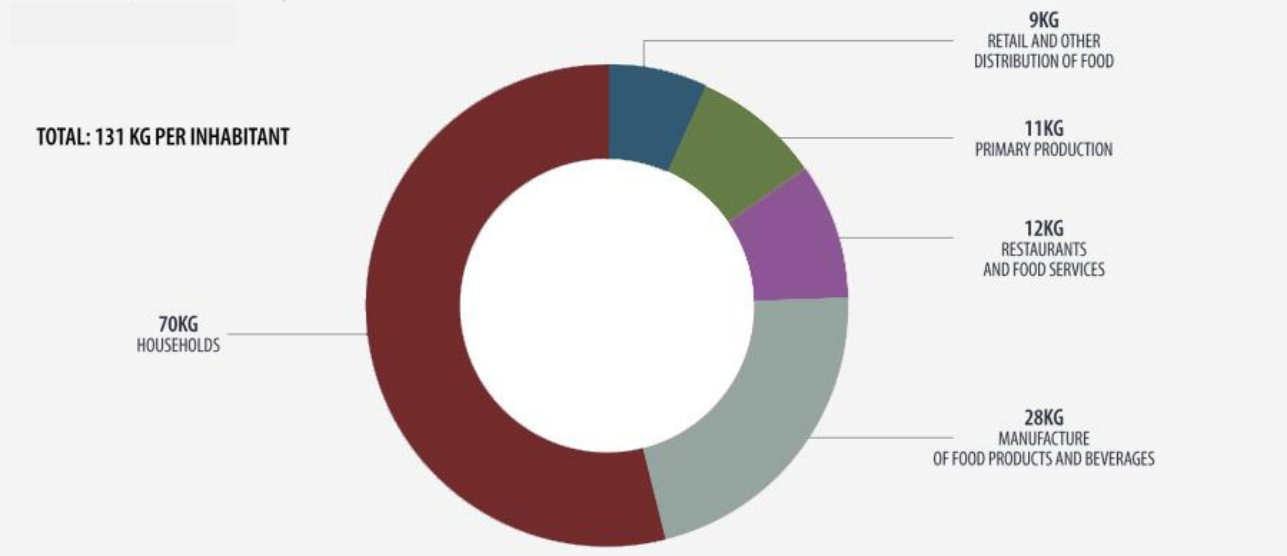


Figure 3: Food waste in EU in 2021 (Kg per inhabitant). Source: (2023)

1.2.1 Food waste in Italian context

Recent findings from a survey conducted by the Italian government underscore the magnitude of food waste within the country (win, 2018). The data reveals that, on average, each family in Italy discards approximately 85 kg of food annually, totalling a staggering 8.5 billion euros ($10.49 billion) which could amount to more than 1% of annual GDP in wasted resources. Shockingly, the survey highlights that Italy annually wastes 1.3 tons of food, equivalent to one-third of the total food production intended for human consumption. The economic repercussions are substantial, amounting to approximately 13 billion Euros each year, with an alarming average of 140 kg of food wasted per person.

The lack of clarity regarding the extent of food wastage, coupled with Italy's significant agricultural production and a growing societal awareness of food waste, renders it an intriguing subject for examination.

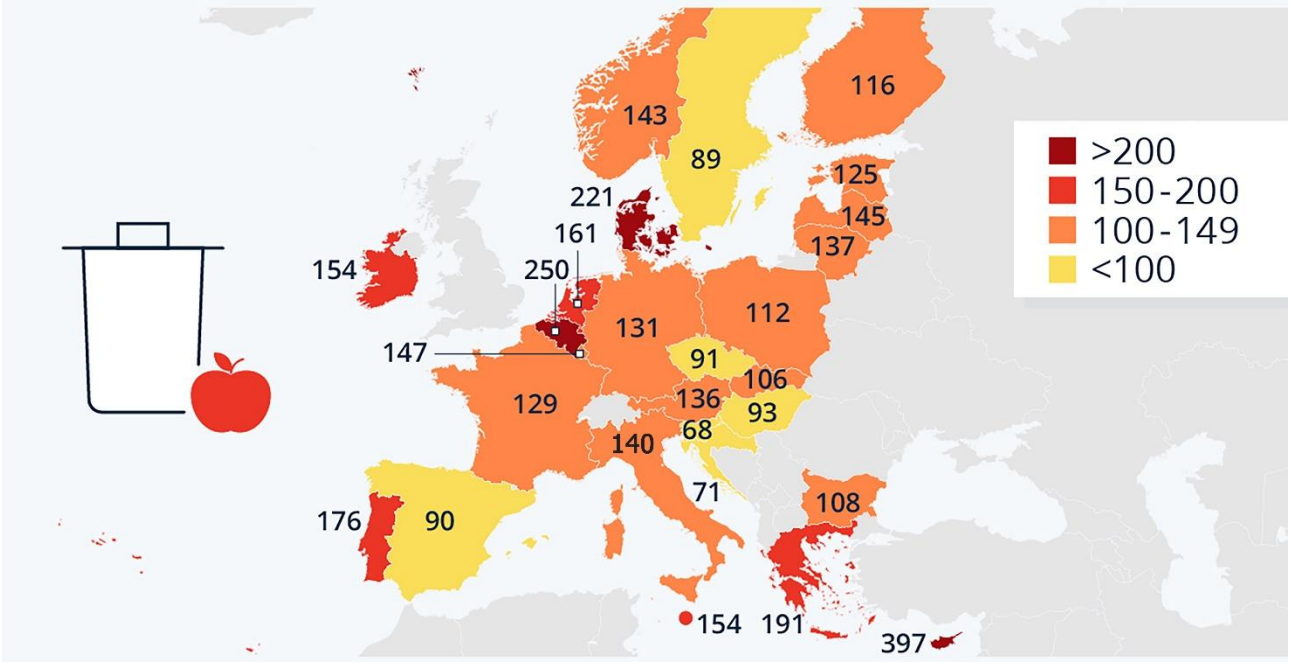


Figure 4: Estimated food wasted per capita in 2021. Source: (Eur)

1.3 Impact of food waste

The relationship between climate change and food waste is twofold: On the one hand, food waste is responsible for 6% of the global GHG emissions. On the other hand, climate change has a significant impact on landscapes and agriculture, thus the reduction of food waste and its related emissions automatically reduces the pressure on resource availability (Hamish Forbes (WRAP), 2021; Ritchie, 2020). The Paris Climate Agreement of 2015 also highlighted and addressed food waste as a critical issue.
Recent studies, such as Poore and Nemecek's 2018 (J.Poore, 2018), have brought attention to the enormous impact of greenhouse gas emissions from rotting food wastes. Surprisingly, these emissions outweigh the emissions of the entire global aviation industry, highlighting the urgent need to address the environmental consequences of food waste.

1.3.1 Direct and Indirect emissions

When food is wasted, it's not just the immediate CO2 emissions that pose a problem. The resources and energy invested in the entire process of food production go to waste as well.

This encompasses the labour, water, and land required for cultivation, as well as the fossil fuels essential for processing, distribution, and packaging. Essentially, the impact of food waste extends beyond the visible rotting of produce and contributes significantly to the overall carbon footprint.

Indirect emissions stem from the entire life cycle of food production and distribution. For instance, a single spoiled tomato at the harvesting stage may have a lower direct carbon footprint than tomato sauce wasted at the retail store. This is because the latter involves additional greenhouse gas emissions accumulated throughout the supply chain.

To visually represent this startling statistic, *Figure 1* illustrates Europe's substantial contribution to CO2 emissions resulting from food waste. This graph sheds light on the need for targeted interventions and sustainable practices in the region to mitigate its impact on climate change.

Figure 5: The countries contributing to carbon emissions. Source: (2015)

1.3.2 Impact of Landfills

The disposal of food waste in landfills contributes to environmental harm through the generation of methane gas, a potent greenhouse gas. When organic matter, such as food waste, decomposes in an environment without oxygen (anaerobic conditions), it produces methane. Methane is approximately 25 times more effective at trapping heat in the atmosphere than carbon dioxide over a 100-year period (2015). This makes it a significant contributor to global warming and climate change. The environmental impact of methane emissions is particularly concerning, given its relatively short atmospheric lifetime compared to carbon dioxide, meaning it has a more immediate and intense warming effect.

Furthermore, the disposal of food waste in landfills represents a missed opportunity to harness its potential value. If food loss and waste constituted a separate nation, it's emissions from landfills, will represent the world's third-largest emitter, surpassed only by China and the United States.

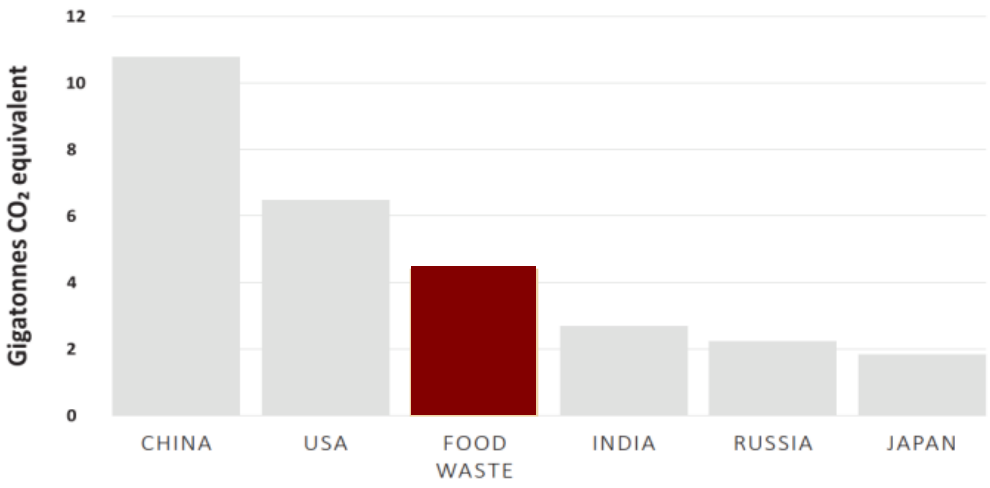


Figure 6: Food waste's position if Measured as a country. Source: (2015)

1.4 Global perspective and Sustainable development Goals (SDGs)

The Sustainable Development Goals (SDGs) of the United Nations provide a comprehensive framework on a global scale to tackle urgent issues and advance sustainable development. SDG 12 holds a significant position among these objectives, with a particular emphasis on promoting responsible patterns of consumption and production. This objective includes a wide range of programs, metrics, and benchmarks intended to direct countries toward more sustainable practices in several areas, such as the prudent use of natural resources, the decrease in food waste, the efficient handling of chemicals, and the reduction in waste production.

The need of developing a global mindset that prioritizes resource conservation, reduces environmental impact, and promotes equitable economic growth is highlighted by SDG 12. The objective highlights the necessity for countries to enact policies that support responsible manufacturing methods and sustainable consumption patterns. Reevaluating and optimizing resource consumption across industries is required for this, with a special emphasis on waste reduction and the mitigation of harmful environmental effects.

Moreover, it is evident that SDGs 11 and 8 are interrelated goals that tackle crucial facets of urban development and economic expansion concerning environmental sustainability. SDG11, which recognizes the growing issues caused by increased urbanization, focuses notably on reducing waste output and pollution in cities. It asks for coordinated actions to reduce trash creation, improve waste management

infrastructure, and lessen urban settlements' ecological impact to build more sustainable urban settings.

SDG8, however, focuses on separating resource consumption and related effects from economic expansion. This objective encourages countries to pursue economic development in a way that is less resource-intensive and environmentally damaging, acknowledging the inherent link between economic activity and environmental repercussions. SDG8 seeks to promote a more sustainable global economy by separating economic growth from excessive resource consumption and striking a balance between ecological protection and prosperity.

Figure 7: The inter-related SDGs

1.5 Aim & Research Objective

The contribution of research work starts from a comprehensive exploration of global food waste, concentrating on the economic landscapes of countries to identify the intricate patterns influencing waste generation. The objective of this study delves into university food waste, aligning with the principles advocated by *Rete delle Università per lo Sviluppo Sostenibile* (RUS). This investigation seeks to underscore the significance of institutional food waste within the broader spectrum of global sustainability initiatives. The research aims to discern the environmental, economic, and social impacts of food waste on a global scale. Moreover, the observation of the pattern at a local institutional scale offers a unique perspective how efforts at local level can contribute to broader sustainability goals.

Additionally, the research has been directed towards a few literatures and best-practices identified around the world to study the existing policies and technology to discern effective tools and strategies for mitigating food waste within university settings. This analysis establishes a baseline understanding of the current state of the art, identifying successful practices while uncovering challenges and gaps within the existing framework. Also, by drawing insights from best practices and lessons learned globally, the research aims to propose contextually relevant and effective strategies tailored to the unique characteristics of the university environment.

Through the research done, the thesis aims to investigate the root causes of food waste at university campuses through a qualitative survey involving students, and tailored interviews conducted with the faculty, and staff. By understanding the specific factors contributing to food waste, I would recommend policies as an urban planner that can be utilized to analyze large-scale data, including consumption patterns, inventory levels, and environmental conditions, to optimize food production, distribution, and waste management processes which of them cannot be only managed by mankind. Ultimately, the successful integration of technology in food waste management relies on collaborative efforts between humans and technology to develop the city of the future. Having in mind this gap lying between - The reason of food waste - the developments so far and the quick implementation strategies, the question of the research is –

Sub question:1
Why an institutional based analysis and what connection it has with the past and future city?

What are the underlying causes of food waste in a university and what policies can support the modern technologies to empower the food circularity in an Institutional scale

Sub question:2
How technology can be used for the pre-consumption and post-consumption food waste optimization and empower circularity?

Sub question:3
What strategies and policies can be developed as an urban planner to ensure food security in the face of urban transformations and uncertainties?

1.6 Methodological framework

Phase 1: Literature Review and Gap analysis

In the initial phase of the research, the groundwork begins with identifying past practices of preservation and disposal performing a gap analysis. This is done through analysing various literature studies and state-of art on existing technologies that has transformed these techniques for a global impact of reducing food waste. The missing middle of this phase has helped to frame the research question with three sub-questions to reduce food waste happening at an institutional level can help to reduce a global impact.

Phase 2: Best practices analysis at EU & International level

Building on the defined research questions, the second phase involves meticulous planning and a comprehensive review of the best-practices that has been implemented around the world and identifying stakeholders, initiatives existing in the city level. Employing a single-case study approach, the aim is to adopt and implement these best-practices and bring-in the contribution of stakeholders at city level to support the implementation of policies. This phase includes designing interviews and surveys for the chosen area to gather insights from students, canteen workers and stakeholders, ensuring a holistic understanding of perspectives. This dual approach enriches the research by incorporating diverse viewpoints and aligning the study with real-world experiences.

Phase 3: Qualitative analysis of Turin canteen

The third phase focuses on case-study which is the Castelfidardo canteen of Politecnico di torino executing the designed surveys and systematically analysing the gathered data using a robust sampling method is carried out. This involves selecting a representative sample from the target population, ensuring the reliability and validity of the collected information. Through statistical analysis and interpretation, this phase aims to extract meaningful insights, patterns, and correlations from the survey responses and therefore create a SWOT analysis. The survey analysis contributes empirical evidence to address the research questions and informs the development of practical recommendations.

Phase 4: Project proposal

In the concluding phase, survey findings are synthesized, and certain technologies from the best-practice analysis are chosen for implementing on the chosen site considering the challenges it might face. Utilizing empirical data, this stage proposes policies aligning with the proposal and tackling identified research questions. A thoughtful consideration of practical implications aims to bridge theory and practice, ensuring transparency by acknowledging limitations. This conclusive step not only sets the stage for future research but also provides valuable insights for practical implementation in the relevant context.

This image illustrates the four methodology phase carried out for the formulation of this thesis explaining the goals achieved at each phase and the methodological approach that was carried out to achieve the goals/aim of the research.

LITERATURE REVIEW AND GAP ANALYSIS

GOALS

Identify past practices of preservation and disposal.
Analysis of the research gap.
Framing the research questions and sub-questions.

APPROACH

The above objectives can be done respectively through-
Literature Review
State-of Art on existing technologies

BEST PRACTICE ANALYSIS AT EU & INTERNATIONAL LEVEL

GOALS

Identifying effective best-practices implemented in European institutions.
Identifying the stakeholders at Various authority levels to implement supporting policies

APPROACH

Selecting a single case-study location.
Designing surveys and interviews
Analysing existing Initiatives at various authority levels.

QUALITATIVE ANALYSIS OF TURIN CANTEEN

GOALS

Gathering insights from execu -tion of the designed survey
Performing a SWOT analysis based on survey findings
Carrying out a Robust sampling method for systematic data analysis.

APPROACH

On-site survey at the chosen case study area.
Extract insights from survey responses to address resear -ch questions and inform practical recommendations.

PROJECT PROPOSAL

GOALS

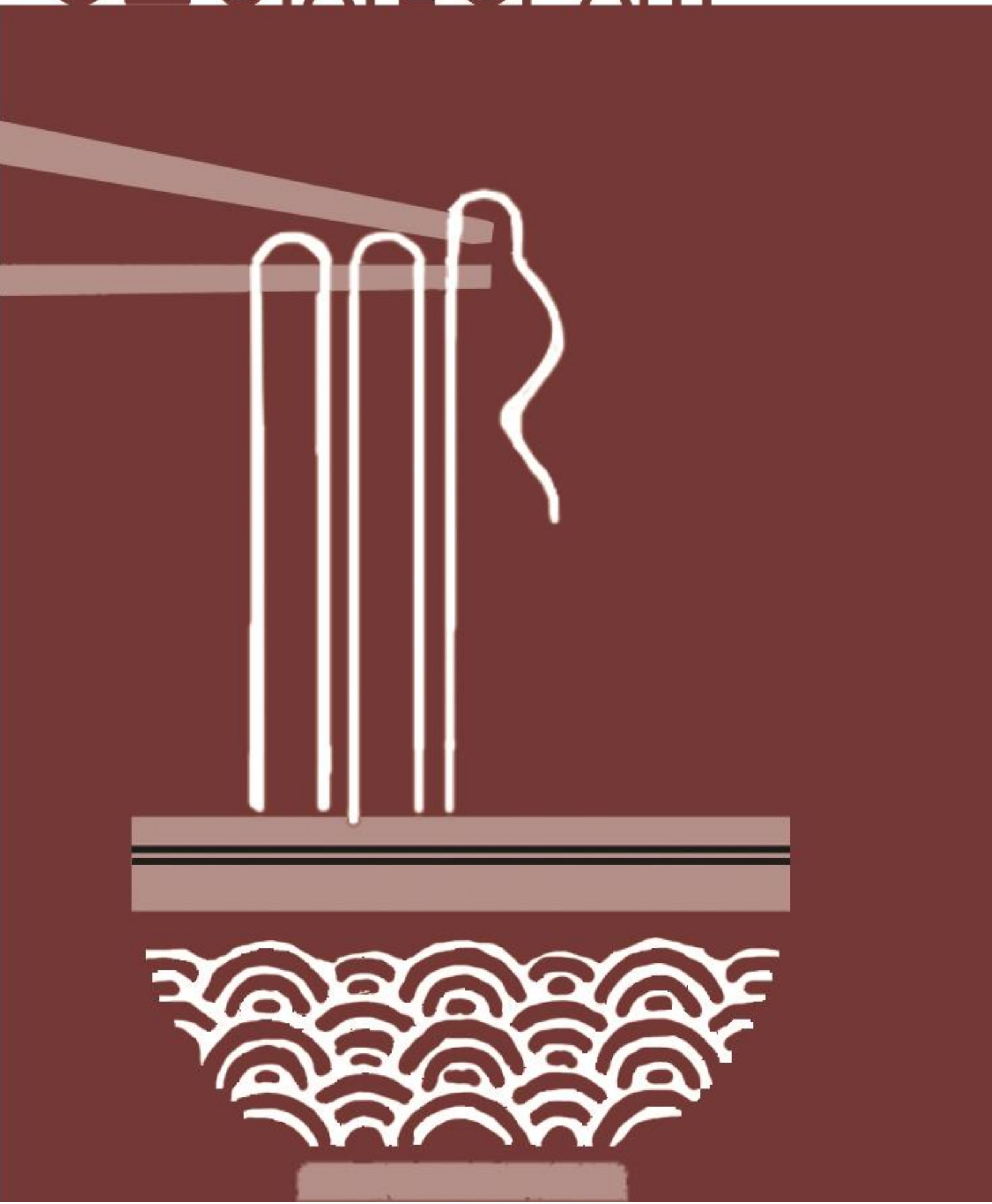
Identify specific technologies from best-practices to implement at chosen area.

Finding the challenges faced for implementation

APPROACH

Creating perspectives of technological intervention.
Generating policies aligning with stakeholders and EU initiatives

02 STATE OF ART



2.1 A memory exercise of food waste management

Prehistoric humans seem to have been mostly hunters in the early phases of human society, especially during the Palaeolithic era, when they produced very little trash. Most of the debris was made up of the remains that had been hunted for food. Notably, every component of the hunted animals—from skins to bones—served vital functions, therefore the amount of trash produced at this time was comparatively minimal. Very little of these materials was wasted because they might be used to make different kinds of tools or clothes. The absence of a disposability culture also contributed to the lack of garbage accumulation. Nothing was thrown out carelessly in this prehistoric human culture; instead, different animal parts were employed for necessary and useful functions (Zora, 2018).

The archaeological discoveries in Dolnì Vestonice, Czechoslovakia, around 1945, led by palaeontologist Absolon (Absolon, 1945), provided significant insights into a crucial Palaeolithic settlement in Central Europe. Among the findings were stone huts and a primitive landfill constructed from mammoth bones, offering early evidence of waste accumulation practices during the Palaeolithic era.

With the introduction of agriculture, human societies underwent a dramatic transformation that made waste management more difficult. The necessity to grow and tend to plants led to sedentary living as humans moved from nomadic to permanent agricultural groups (Zora, 2018) . Waste production and disposal procedures changed because of this transition and the planting of crops.
As agricultural cultures discovered ways to reuse and recycle what may otherwise be considered waste, the idea of waste disposal changed. Byproducts and leftover plant materials were frequently recycled and used sustainably. Feeding the food waste to animals that the community raised was one popular activity. This led to a symbiotic interaction between agriculture and animal husbandry by lowering waste levels while also assisting in the domestication and care of animals for a variety of uses.

Analysis of Pompeii's garbage shows that the ancient romans recycled too, according to Prof. Emmerson in *Life and Death in the Roman Suburb* (Emmerson, 2020) rubbish was not just haphazardly dumped but was systematically piled up along almost the entire external wall on Pompeii's northern side, among other locations.

The piles of rubbish discovered were not mere refuse meant for disposal; rather, they were carefully curated and sorted. This intentional sorting of waste materials suggests a sophisticated system of waste management and recycling within the city. The sorted-out waste, in fact had a potential reuse and resale within the city's confines.

> **They're outside the walls being collected and sorted to be resold inside the walls.**
>
> *- Steven Ellis and Kevin Dicus (archaeologists) working on the University of Cincinnati's excavation.*

2.1.1 The 19th century food waste disposal

In the 19th century, waste was regarded as a valuable resource, and a system of self-regulation and recycling was predominant. Organic waste was recycled during this time and used as animal feed for pigs and chickens, fertilizer in agriculture, and occasionally in industrial processes like papermaking and dyeing. However, waste management did not become a significant issue until the 20th century. Waste changed from being primarily organic to becoming diversified as cities became larger and less dependent on agriculture. This change required new challenges to be addressed by municipal administration and public policies due to the increasing variety and volume of waste (Benoit Daviron, 2019).

Growing concern was raised about the waste problem in ancient Greece and Rome. Slave street cleaners oversaw maintaining the streets as part of the urban sanitation system that Athenians established. The first sewage systems and public restrooms were built in Rome to centralize the disposal of human waste and prevent epidemics caused by unsanitary city conditions (Zora, 2018). Additionally, the city promoted a culture of spa visits. Still, only the wealthiest 1/10 of the population had access to such amenities as the oldest sewer pipe, the Cloaca Maxima. Slaves and peasants were kept out, and waste was frequently thrown out of windows in structures up to ten stories high (His).

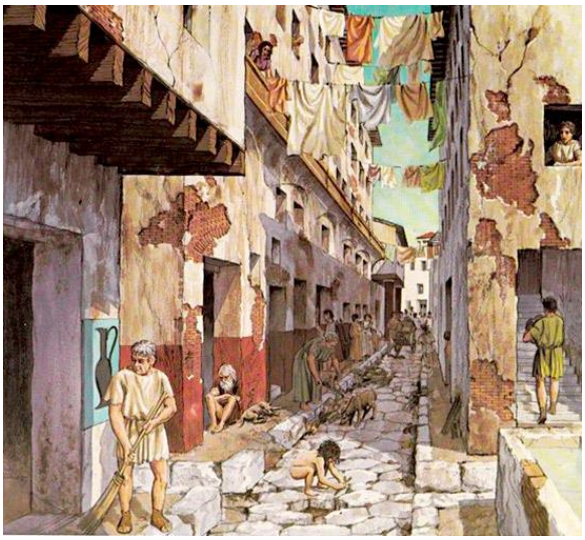


Figure 8: *Ancient Rome depicting waste thrown on streets to animals. Source (2021) .*

At the time, no one seemed to care about the problem of garbage in the streets. The situation remained practically unchanged until the appearance of the most important innovations and technological inventions that occurred during the "Industrial Revolution", which accompanied a large demographic increase and the birth of important cities. Therefore, more and more people began to move away from the countryside to move to cities which soon filled with inhabitants and therefore also with waste.

The first written regulations for a public urban cleaning service were created by the Greeks in ancient Greece, which is where the idea of cleanliness in cities originated. Ten city supervisors were assigned responsibilities, including supervising the work of street cleaners, as specified in the "Constitution of the Athenians". These labourers, who were probably slaves, were assigned to clean up the streets and remove dead people that were discovered there among other waste materials. In addition, the city's street cleaning operations were placed under the supervision of elected officials. The "*ruee*," who carried panniers, brooms, and shovels, were the main people who helped collect household waste. They would meticulously sweep the corners of courtyards where trash from the home gathered.

Figure 9: Waste and manure collector (Ruee). Source: (Lapini)

In 1903, there was a discernible shift in Favour of municipalizing public utility services, which included the Municipality directly assuming control of the urban cleaning service. Under an economic system, contractors supplied the horses and drivers, and the Municipality supplied the staff and equipment.

Six hundred street cleaners were managed by the Municipal Technical Office, which employed a director, two assistants (technical and accounting), fifteen assistants, and fifteen supervisors to oversee the service. In comparison to earlier decades, this represented a significant increase in staffing, indicating the service's expansion outside the city limits to encompass the entire rapidly expanding urban area.

Figure 10: Photograph of waste collectors in 1903. Source: (Lapini)

2.1.2 The Italian food waste in the 19th century

In 1929, private companies showed interest in the concession as the Municipalities in Italy aimed to update its waste management system. In Milan specifically, one of the northern Italian cities of that time despite the cooperative "*Società Anonima Cooperativa Consorzio Fascista Spazzini Privati,*" - SPAI was eventually granted the concession by the Municipality for waste collection, while "Duomo" was given the concession for sorting. When a sorting plant was built in 1929, conveyor belts were used to automate the handling of waste, but manual selection was still common.

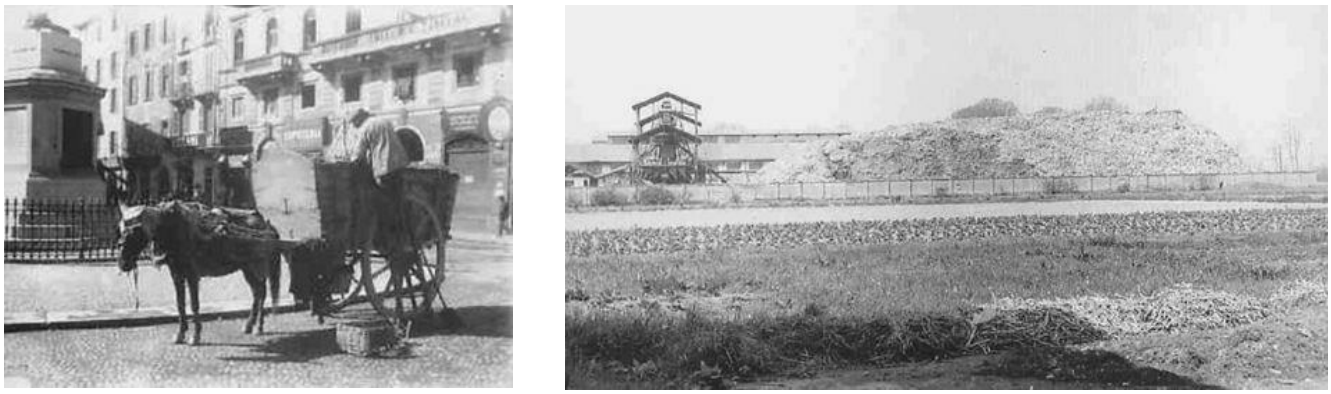


Figure 11: Municipality waste collection (Left) and Sorting Area (Right). Source: (Lapini)

The waste management service underwent a gradual modernization between 1929 and 1952, which included a transition to mechanized collection methods. The OTSU *(Organizzazione Techniche Servizi Urbani)* company came up with creative ideas that smaller cities adopted, like closed metal containers. Waste collection was handled by SPAI until 1952, when it was taken over by GSI *(Gestione Servizi Igienici)* in 1954.

Figure 12: Modernization of waste collection in Closed metal bins and Automated Trucks. Source: (Lapini)

In 1970, AMNU *(Azienda Municipale Navigazione Urbana*) was established, and the area became municipalized. Disposable polythene bags were first introduced in 1968 because of a noticeable increase in the number of employees and waste collected after the shift. After the service was made municipal in 1970, more development was spurred, and in 1985 the AMSA (Azienda Milanese Servizi Ambientali) was established.

Figure 13 :*Current Waste collection and Incineration Technology. Source: (Lapini)*

AMSA concentrated on a comprehensive "environmental policy," emphasizing can, paper, and glass recycling techniques, under the new management regulations. AMSA provided evidence of its dedication to environmental sustainability through its diverse approaches to waste management. AMSA was divided into four functional divisions.

2.1.3 Timeline of techniques in food Preservation

The intriguing thing about food preservation is how widely it has been used throughout history and across cultural boundaries. Ancient people used nature as their advantage to survive, whether they were in tropical areas where sun-drying was used or freezing climates where seal meat was preserved on ice. Harvested food spoils quickly, but preservation made it possible for early communities to congregate in one location, which promoted the development of societies. Ancient societies employed comparable preservation techniques, despite cultural disparities, to store and eat food later (Nummer, 2022).

Agrarian societies in medieval Europe realized how important it was to stockpile food to protect against natural disasters like hunger, drought, and conflict. Fear of calamity was not the only reason for preservation; it also improved Flavors, turning foods that were salted, dried, smoked, pickled, or honeyed into delectable treats. Additionally, preservation made it easier for pilgrims, traders, sailors, and soldiers to travel. Almost any kind of food could be preserved, using techniques specific to the food's nature, and intended results, whether it's for consumption during off-peak times or to experience a particular food item in its preserved state (Snell, 2019).

Figure 14: Timeline of historical origins to modernization in food preservation. Image translated by the author. Source: (Nummer, 2022)

These technological advancements, from storing and preserving techniques to refrigerators in modern-day, have collectively contributed to minimizing food waste and enhancing food security. As technology continues to evolve, there are promising opportunities to further improve resource efficiency, reduce waste, and create a more sustainable and food-secure future.

2.2 The Technological Innovations: A path forward

The urgent challenges posed by food waste present a compelling opportunity for technological innovations that span every stage of the food value chain. Acknowledged as a critical aspect receiving increased attention, these innovations aim to foster vertical collaboration among technology adopters and other stakeholders in the value chain to curtail food waste (Federica Ciccullo, 2021) . Technological solutions contribute to waste prevention, re-use, and the valorisation of unavoidable food waste through recycling or recovery. At the consumer level, technologies target various objectives, such as extending the shelf life of food products, reducing surplus generation in retail and households, and enhancing the redistribution of surplus food. This includes innovations in food preservation, packaging, smart labelling, and consumer-oriented applications like food-sharing apps (Federica Ciccullo, 2021) .

While many of these technologies are still in early stages of development, characterized by experimentation, prototyping, or limited rollouts, their potential impact is significant. However, adopting and implementing these technologies often require collaboration with technology providers and adjustments to existing business models, as competencies and technical expertise may lie outside the traditional food supply chain (Federica Ciccullo, 2021) . Despite promising results, there is a lack of comprehensive data on the economic, environmental, and social benefits of adopting Sustainability Oriented innovations (SOI) and digital technologies in relation to food waste. Notably, research by the World Business Council for Sustainable Development (WBCSD) reveals that companies across various sectors could save US$14 in operating costs for every US$1 invested in food loss and waste reduction (2017). This information could strengthen the business case for adopting SOI and digital technologies, potentially leading to significant household savings.

Perceived as costly and risky for individual companies, the uptake of new technologies, while promising, cannot stand alone in addressing food waste. An enabling environment is crucial, connecting policy, infrastructure, finance, and behavioural changes among consumers to reduce risks associated with technology adoption. Food waste-reduction technologies encompass both SOI and digital technologies, ranging from simple devices like fridges and shopping apps to sophisticated solutions like integrated supply-chain infrastructure, cold chains, and

advanced food preservation and packaging technologies. A 2020-22 inventory of ICT tools and smart technologies related to food waste includes 77 such tools or technologies, signalling a growing landscape of innovative solutions. Furthermore, advancements in digitalization, sensors, and the Internet of Things (IoT) in recent decades have opened new avenues for handling perishable food items. Breakthrough technologies such as smart packaging, labelling, and storage hold promise for future projections in mitigating food waste along the entire food supply chain (Federica Ciccullo, 2021).

PREVENTION		
Type	Function	Description
Eco-Friendly	Thermal prevention	Refrigeration and cold chains.
	Biological and bio-chemical preservation	Use of essential oils and natural extracts in active packaging
SOI + Digital	Smart phone apps: Food planning, shopping, storage & cooking	Guide, track and inform consumers in reduce food waste.
SOI + Digital + IoT	Smart packaging	Use of sensors and data carriers to monitor food Quality.
	Smart Labelling	Use of data embedded barcodes to improve information about food quality.
	Smart storage and disposal	Wi-Fi connected fridges and bins equipped with cameras and sensors to monitor food quality and quantity.
RE-USE		
SOI + Digital	Smart phone apps: Food sharing and redistribution	Different types of food sharing apps: Sharing for money, sharing for charity, or sharing for community

Table 2:Overview of the SOI and digital technologies addressing food surpluses. Source: (programme, 2022)

2.3 Food waste in Canteens

Institutional canteen services, encompassing facilities such as canteens, cafeterias, bars, and occasionally extending to night catering services like pubs and discotheques, typically employ a self-service model. This approach involves patrons serving themselves without the assistance of table service. These services are commonly overseen and managed by collective catering service providers, distinguishing them from both commercial and social service providers. Collective catering providers specialize in the administration of university canteens, where their primary objective is to offer quick, affordable, and nutritionally dense meals tailored to the individual needs and preferences of each student. This approach ensures that the diverse student population is catered to effectively, providing a range of food options that align with various dietary requirements and tastes.

However, a notable challenge faced by collective catering services is the relatively higher occurrence of food waste. This can be attributed to factors such as the self-service model leading to potentially larger portion sizes, limited timeframes for food turnover, and the diverse dietary preferences of students, resulting in a broader range of menu items and potential unsold or leftover food (Veronica Novelli, 2019).
To start with, students are an interesting and relevant case for this study, as they constitute a large part of society, and they are normally well educated. This contradiction between their higher food waste and their higher education status makes them an important and relevant group to study, since it can be assumed that higher educated people are more aware of environmental impacts of food waste. Universities, which may be comparable to mini-cities or large businesses, are places where FW remains a significant problem (Iazell, 2016), (Walter Leal Filho, 2021).

From the viewpoint of the community, campus sustainability as a field of sustainability research is essential to conveying how campus communities are forming a sustainable future vision, considering the goals and ideals they stand for, and investigating possible avenues for realizing that vision (Rodrigo Lozano, 2015), (Ramos, 2015), (Sonetti, 2019). In line with this realization, several universities worldwide have been engaged in transforming their campuses to become more sustainability oriented. Based on past review papers by Lozano et al. (Rodrigo Lozano, 2015) , areas of transformation include education, research, community outreach, campus operations, assessment and reporting, institutional policy, and framework and on-campus experiences (Filho, 2000), (Arroyo, 2017), (Lombardi, 2017).

2.3.1 Drivers of institutional Food waste

Two perspectives can assess food waste at food service establishments in educational institutions: pre- and post-consumer waste (Prescott, 2019a) "Pre-consumer waste" is kitchen waste arising at the time of storage, preparation, and production, whereas "postconsumer waste" consists of leftovers or plate waste (Burton, 2016), (Bean, 2018b), (Zhao, 2019). Scholars have also used the term "serving waste" or "display waste" (especially regarding buffet meals) to represent waste at the point of consumption (Ali H. Abdelaal, 2019). Prior scholars examining institutional food waste levels have discussed uneaten meals, representing post-consumer waste, to a large extent (Smith SL, 2014), (Adams, 2016), (Zhao, 2019). Most studies focused on food waste measurement as a tool to assess the nutritional aspects of leftovers from meals consumed (Getts, 2017).

There hasn't been much research done on food waste in institutional food services, as can be seen in both the pre- and post-consumer realms. Even with the thorough classification of waste kinds, there is still a dearth of research on the behavioural factors that contribute to food waste. Studies conducted nowadays frequently focus only on norms and attitudes, ignoring important variables including preferences, readiness to take leftovers home, a propensity for placing excessive orders, shopping routines, and table etiquette. Food waste is largely evaluated as a measure of nutritional loss, which further marginalizes its significance in school food service studies that predominantly focus on the nutritional component of meal consumption. This viewpoint highlights the need for a more comprehensive comprehension of the elements causing food waste in educational settings.

The lack of information regarding the quantity and kinds of food service establishments found in educational institutions exacerbates these aspects and makes it more difficult to gain contextual understanding of the dynamics of food waste. Moreover, the critical role that parents have in managing young children's food waste in school environments is still relatively unexplored, which is another important area that needs more research. Among these factors, the four opposing forces—functional, behavioural, demographic, and contextual—emerge as significant catalysts driving the rise in food waste in food service facilities (Puneet Kaur, 2021).

Type	Stage	Driver(s)	Author (s)
Functional	Pre-consumer (production waste)	Menu composition, availability of competitive foods, substandard foods, meal plan, overproduction, food service quality, inadequate meal planning, regulatory requirements, contractual obligation, food service regime, serving style, meal presentation, procurement issues, perishability of certain food items, low attention to the dietary habits of consumers	Boschini et al; (Boschini, 2020),Templeton et al; (Templeton, 2005),Prescott et al; (Prescott, 2019a),Marais et al; (Marais, 2017), Derqui et al; (Derqui, 2018), Pinto et al; (Pinto, 2018), Falasconi et al; (Falasconi, 2015).
Behavioural	Pre-consumer (production waste) and post-consumer (consumption waste)	Self-efficacy, tendency to consume fast foods, attitude towards food waste, personal norms, social emotions of guilt and shame, staff's perceptions of keeping track of food wastage.	Baik and Lee (Baik, 2009); Knezevic et al (Knezevic, 2019); Visschers et al (Visschers, 2020); Jagau & Vyrastekova (Jagau, 2017); Burton et al. (Burton)
Contextual	Pre-consumer (production waste) and post-consumer (consumption waste)	Dining environment, duration of eating time, food quality and palatability, timing of recess, portion size	Steen et al (Steen); Cohn et al (Cohn); Zhao and Manning (Zhao, 2019)
Demographic	Post-consumer (consumption waste)	Child characteristics, age, gender, ethnicity	Niaki et al (Niaki); Huang et al (Huang, 2017); Zhao and Manning (Zhao, 2019)

Table 3 : Drivers of food waste in food service establishments.

2.3.1.1 Quantifying the type of food waste

Various studies have approached the measurement of food waste in different ways, with some encompassing all waste, including both edible or avoidable and inedible or unavoidable components (Joseph Langley, 2009), (Costello C, 2016).Others, however, focused specifically on quantifying only edible or avoidable food waste, narrowing their scope to items like meat protein, soy protein, fruits, rice, potatoes, bread, pies, juice, beverages, milk, vegetables, and salads (Whitehair, 2013), (Thorsen AV, 2015). The items considered edible or avoidable food wastes are meat protein, soy protein, fruits, rice, potatoes, bread, pies, juice, beverages, milk, vegetables, and salads (Joseph Langley, 2009), (Thiagarajah, 2013), (Blondin, 2017), (Eriksson, 2018). Conversely, the inedible or unavoidable food wastes are fruit or vegetable peels and spines, eggshells, bones and skins and seeds (Joseph Langley, 2009), (Whitehair, 2013), (Belén Derqui, 2017).

Studies have examined specific food types and waste during food service, e.g. fruit and vegetables to explain the differentiated nature of people's waste behaviour. Among all food waste, fruit and vegetables have the highest wastage rate of 45–51.4% (Byker), and in food service specifically, salad fruit and vegetables account for over 25% of waste (Silvennoinen, 2015), and in an institutional setting, this rises to 40% (Gase, 2014). Further, vegetables pose a challenge to reduction, reuse and recycling the waste due to their higher biodegradability representing a loss of nutrients, money, and biomass (Stella Plazzotta, 2017). In the wider context, potatoes, rice, and pasta account for 29% of food waste; salad vegetables and fruit 25%, bread and grains 14%; meat (for meat eaters) 9%; fish 5%; dairy products 3%; and the rest is classed as other products (Silvennoinen, 2015). Ferreira et al. (2013) (Ferreira, 2013) point out that food acceptability is positively related to energy and protein content of food. The changing behaviour of students into consuming less healthy food, may lead to more waste in the food service environment (Iazell, 2016).

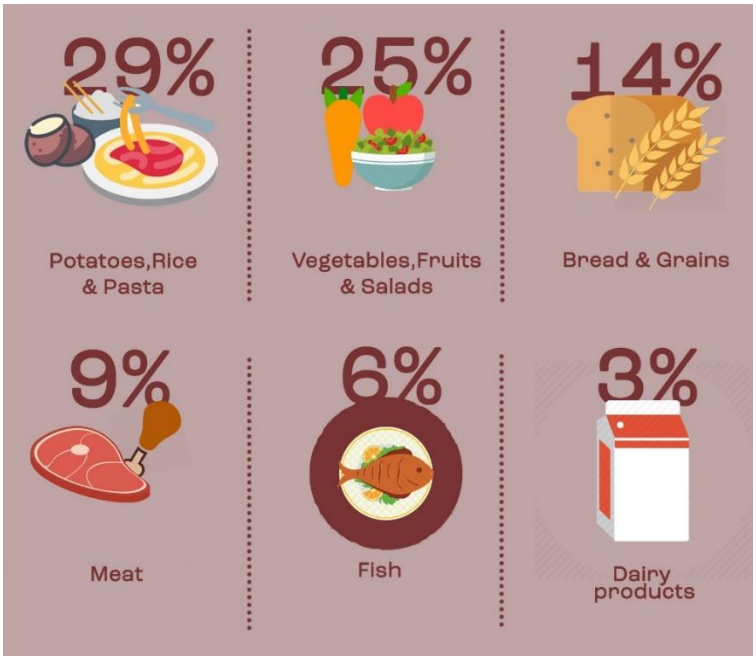


Figure 15*:* Quantifying the type of food wasted in universities. (Translated as image). Source: (Silvennoinen, 2015)

2.3.1.2 Method of Quantifying

Studies that have looked at food waste at university food service facilities have used a variety of methods to measure waste at different phases. The three main categories of serving waste, plate waste, and production waste have been the subject of research, and each has provided a distinct perspective on the dynamics of food waste formation (Gase, 2014), (Eriksson, 2018), (Boschini, 2020).It has been determined how much food waste is produced at every meal, including the total amount of food that is thrown out at the pantry, kitchen, service station, and plate levels (Painter), (Derqui, 2018), (Chapman, 2019).Plate waste is the most often used unit of measurement for the amount of edible food that is offered but not eaten (Huang, 2017), (Adams, 2016), (Capps, 2016). This is especially true in school settings where nutrition is a top priority. Various techniques have been used to measure plate waste, demonstrating the differences in methodological approaches amongst research projects. The gold standard, which provides exact measurements, is to weigh plate waste in grams each item served or as aggregate plate waste per meal (Eriksson, 2018a), (Eriksson, 2017). Aside from being more convenient, time-efficient, and able to use larger sample sizes, visual assessment methods like the quarter-waste method have also been found to be reliable and comparable to weighing (Belén Derqui, 2017), (Getts, 2017), (Niaki), (Hanks, 2014), (Liz Martins, 2014). Studies using photography to measure plate waste have shown that it is a popular visual tool (Smith, 2014), (Yoder, 2015), (Bean, 2018a), (Katare, 2019), (Prescott, 2019a), (Serebrennikov, 2020).

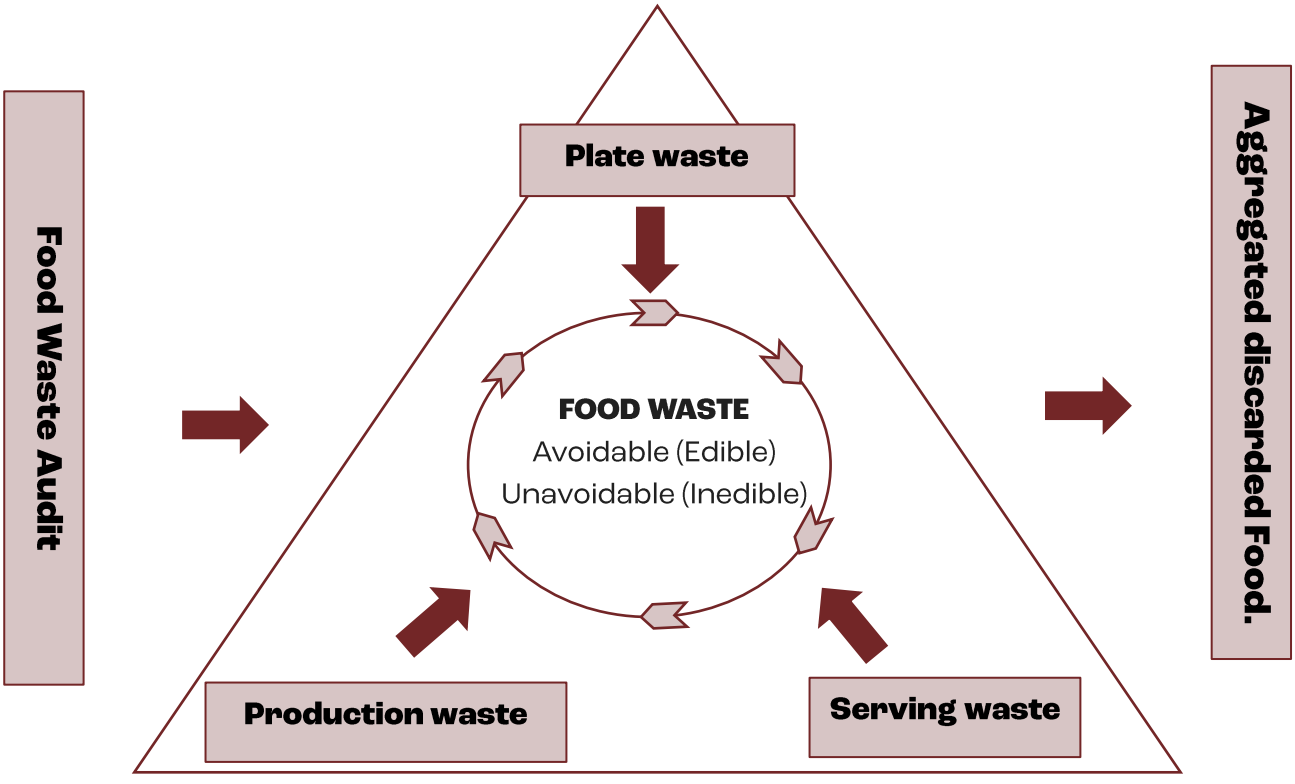


Figure 16: Method of food waste quantification. Source: (Puneet Kaur, 2021)

Furthermore, researchers have investigated using garbage analysis as a substitute method to measure food waste (Dresler-Hawke, 2009), (Belén Derqui, 2017).

Studies combining weighted methods with assessments based on digital imaging have been conducted to determine the effectiveness of various quantification techniques. For example, Liz Martins et al. (2014) (Liz Martins, 2014) highlighted the greater accuracy of weighing methods in assessing nonselective aggregated plate waste, whereas Bean et al. (2018a) (Bean, 2018a) verified the accuracy of digital imagery-based assessment. To measure the quantity and kind of food waste produced, food waste audits have also been used, which has expanded the methodological toolkit for comprehending the complexities of food waste in academic settings (Wilkie), (Costello C, 2016), (Belén Derqui, 2017), (Derqui, 2018), (Schupp, 2018), (Prescott, 2019a).

2.4 Role of universities and societal relevance

I think seeing Giancarlo De Carlo as a kind of translator helps to understand his sceptical position towards informal educational institutions and the interesting conundrum which De Carlo explores: the impossibility of containing educational experience whilst having, in some way, to realize places for education. De Carlo believed that formal education was too rigid and did not allow for creativity and innovation. He also believed that education should be accessible to everyone and that it should be a lifelong process (Charitonidou, 2021). He championed the idea of placing institutions at the core of city design, envisioning architecture as a catalyst for social interaction and informal education. In his influential book, "Architecture's Public" (1970), De Carlo articulated the transformative potential of architecture in fostering communal learning. He argued that institutions, particularly educational ones, should be thoughtfully integrated into the urban fabric to create spaces that actively encourage people to share knowledge and experiences. According to De Carlo, institutions serve as not just physical structures but as dynamic hubs where individuals converge, learn from one another, and collectively contribute to the cultural and intellectual richness of the city. His vision, rooted in participatory design principles, sees institutions as vital components shaping the character of a city, where architecture plays a pivotal role in facilitating informal education and fostering a sense of community.
This concept is vividly illustrated in his words:

> Architecture should be a means of communication, capable of changing the relationship between people. A place is not just a place; it's a chance for people to meet and learn from each other.
>
> - *Giancarlo de Carlo, Architecture's Public (1970).*

Like De Carlo's concept of the institution as a vital element in society, Lewis Mumford's echoes profound insights in "The Culture of Cities" (Wood, 2019) .Mumford, a pioneering urbanist, emphasized the city as a complex organism deeply intertwined with cultural and educational functions. In his work, Mumford argued for the city as a dynamic centre for cultural exchange, intellectual growth, and social interaction. Institutions, according to Mumford, play a pivotal role in shaping the character and vitality of a city, serving as both repositories of knowledge and catalysts for social progress. Mumford's theories had an impact on De Carlo, who expanded and used them in the fields of urban planning and architecture. His translation of Mumford's work on school architecture for a Domus special edition emphasizes the importance of institutions—especially educational ones—in a city's cultural fabric. Mumford argues that institutions are living things that add to the intellectual and social diversity of urban life, and De Carlo's perspective is in line with this idea. His idea of the city as a hub of culture is in line with his views that institutions should be an essential part of the urban fabric and that architecture has the power to influence people's behaviour. Both authors contend that institutions are linked nodes that contribute to a city's larger intellectual and cultural ecology rather than being separate entities. Mumford's theories are applied by De Carlo in a way that highlights the institutions' capacity to change society as it exists today. De Carlo bolsters the idea that institutions are not just places for formal education but also dynamic centres that foster a feeling of community, promote communication, and add to the city's overall cultural vibrancy by converting Mumford's ideas into workable architectural and urban planning guidelines. De Carlo's art essentially reflects Mumford's view that institutions play a crucial role in building a vibrant and culturally diverse cityscape when they are carefully woven into the urban fabric. Their emphasis on integrating institutions to urban design aligns with the thesis's exploration of how technological interventions in the spaces of canteen can foster sustainable urban environments through communal learning and social interaction.

2.4.1 The Institutional Grammar

Sue E. S. Crawford, & Ostrom, E (1995) proposed a grammatical syntax for examining institutional statements as part of the institutional analysis and development framework. They categorize institutions within three approaches -

Institution as Equilibria –

The institutions-as-equilibria approach is based on the stability that can arise from mutually understood actor preferences and optimizing behaviour (Ostrom, 1995). In this framework, societal institutions operate as stabilizing forces, aligning individual preferences

through common understandings and facilitating optimized behaviours. This approach recognizes that stability in human interactions can arise from shared expectations and agreements, creating equilibrium. In the context of societal change, the institution-as-equilibria perspective implies that shifts in societal institutions can be achieved by influencing and reshaping actor preferences and optimizing behaviours through fostering a collective understanding. The framework provides a theoretical lens through which this thesis examines how societal norms, rules, and equilibrium within educational institutions can be harnessed to promote sustainable practices and community engagement in urban settings.

Institution as Norms –

These norms are unwritten rules, whether prescriptive, indicating desirable actions, or proscriptive, outlining actions to avoid, are enforced through social pressure. The potency of the institution-as-norms approach lies in its recognition of social norms as powerful instruments for promoting positive societal change.

In the context of societal dynamics, the institution-as-norms perspective serves as a mechanism for establishing and reinforcing behavioural patterns. Social norms act as a shared framework that guides individuals toward actions aligned with collective expectations (2023). Harnessing social norms becomes a strategic tool for steering societal behaviours in a desired direction. For instance, this approach has been effectively employed to encourage environmentally friendly practices, discourage harmful behaviours, and promote healthy lifestyle choices.

By understanding and utilizing the institution-as-norms approach, society can deliberately shape its norms to foster positive changes. This may involve initiatives to cultivate and strengthen norms that support sustainability, ethical conduct, and well-being (Kirti, 2021). As individuals confirm to established social norms, a collective influence is exerted, contributing to a harmonious and positively oriented societal structure. The institution-as-norms perspective thus emerges as a valuable aspect of institutional grammar, offering insights into how societal norms can be intentionally moulded to propel constructive societal transformations.

Institution as Rules –

The institutions-as-rules approach focuses on the role of formal rules and regulations in shaping human behaviour and society. Formal rules are written laws, regulations, and policies that are enforced by the state or other governing bodies (HINDRIKS FRANK, 2015). According to this concept, regulations are institutional declarations that outline what is necessary, forbidden, or allowed in specific circumstances. These laws provide as a framework for regulations, offering a formalized set of standards

that direct people's actions within a community. The institution-as-rules perspective is important to society because it provides a defined framework for governance that guarantees predictability, consistency, and order. Societies can handle shared difficulties, promote cooperation, and lessen uncertainty by instituting a system of rules. Since following clear guidelines helps to establish mutual understanding and uphold social order, this strategy becomes very effective in promoting social cohesion. Fundamentally, institutional grammar's institution-as-rules method serves as a stabilizing influence, establishing a foundation for orderly and cooperative human.

2.5 Aligning the university engagement with Sustainable development Goals (SDGs).

Universities play a pivotal and multifaceted role in the global pursuit of the Sustainable Development Goals (SDGs), given their unique position as hubs for knowledge creation, dissemination, and societal influence (CROW, 2014), (Boulton). The SDGs encompass a broad spectrum of interconnected challenges, spanning social, economic, and environmental dimensions, and universities are recognized as critical drivers for addressing these complexities. The necessity for university engagement with the SDGs is underscored by the expansive reach and impact of tertiary education and scientific research, explicitly acknowledged in several SDGs. However, the imperative for universities extends beyond specific SDGs, as they are essential contributors to achieving the entirety of this ambitious agenda.

The primary roles that universities play in the context of the SDGs can be categorized into four key areas (Australia/Pacific, 2017) . Firstly, universities serve as knowledge hubs, generating the expertise and solutions necessary for SDG implementation. Through research, innovation, and talent cultivation, they contribute to technological advancements and societal progress, providing critical insights into the challenges and interactions between the SDGs. Universities are instrumental in developing and accessing policy options, transformation pathways, and monitoring progress, laying the groundwork for informed decision-making.

Secondly, universities are key contributors to shaping future leaders and SDG implementers. With access to diverse, passionate, and creative young minds, universities have a responsibility to equip current and future decision-makers, innovators, teachers, and citizens with the knowledge, skills, and motivation to actively contribute to achieving the SDGs. The global influence of universities through international students, alumni, and campuses further amplifies their impact on global development.

Thirdly, universities, as complex institutions, can directly contribute to the SDGs by embodying their principles in organizational governance, operations, and culture. By aligning their activities with the SDGs, universities can reduce their social, economic,

and environmental footprints, promoting sustainable practices within their spheres of influence.

Lastly, universities hold a distinctive position as neutral and trusted stakeholders in society, allowing them to provide cross-sectoral leadership in SDG implementation. Through partnerships, dialogues, and advocacy efforts, universities can guide responses to the SDGs at local, national, and international levels, leveraging their influence to educate the public and other sectors about the importance of the SDGs.

In essence, the active involvement of universities is not just beneficial but imperative for the successful realization of the SDGs. Their contributions extend beyond traditional academic roles, encompassing knowledge creation, talent development, sustainable practices, and cross-sectoral leadership, making universities indispensable partners in the collective journey towards a more sustainable and equitable world.

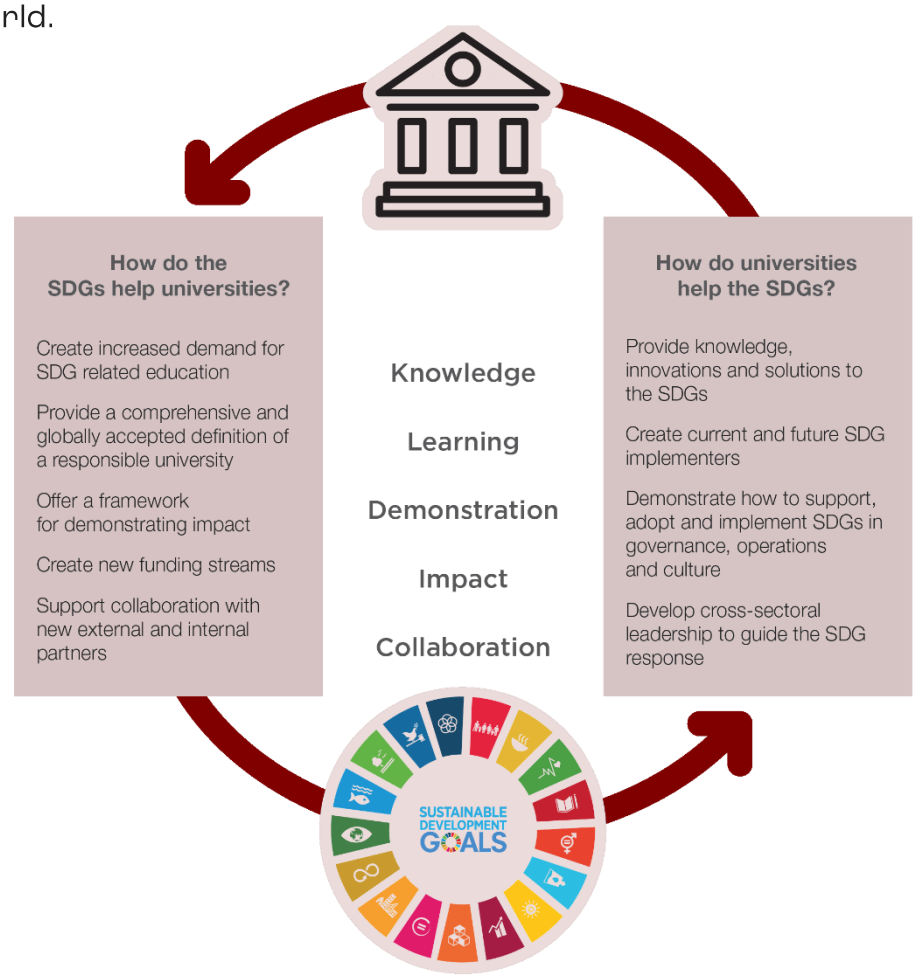


Figure 17: The case for university engagement in SDGs. Source: (Australia/Pacific, 2017).

2.5.1 RUS: Providing support and guidance

The *Rete delle Università per lo Sviluppo Sostenibile* (RUS) was officially established in 2016 by the *Conferenza dei Rettori delle Università italiane* (CRUI). However, its roots can be traced back to a bottom-up approach that began in November 2013 (RUS).This forward-thinking and collaborative initiative, predating the global pandemic, represents a significant milestone in sustainable development. The RUS is a unique cooperation among Higher Education Institutions (HEIs) in Italy. As of December 2024, the RUS boasts active participation from 86 universities, encompassing approximately 96% of the national total. This cooperative effort underscores the commitment of Italian universities to advancing sustainability and fostering positive impacts on environmental, social, and economic fronts.

The primary objective of the RUS is to facilitate the exchange of policies, skills, and practices, fostering a culture of sustainability within and beyond universities. This collaborative effort aims to amplify the positive impacts of environmental, ethical, social, and economic actions undertaken by member institutions (Sonetti, et al., 2020).The overarching goal is to contribute to the achievement of the Sustainable Development Goals (SDGs) and elevate the international standing of Italy in sustainable practices. Likewise, this thesis in alignment with SDG goals support sustainability of universities.

Simultaneously, the RUS places significant emphasis on enhancing the transdisciplinary educational dimension within university programs. This involves training teachers, technical-administrative staff, and students across all Italian universities, fostering a sustainability culture and influencing the adoption of responsible lifestyles through innovative approaches and engagement initiatives (Smaniotto, et al., 2023).

In recent years, the RUS has expanded its impact by establishing regional sub-networks and intensifying efforts in educational initiatives, actively involving local communities. The RUS Working Groups, namely RUS WG Resources and Waste work network developed an initial census on waste management.74% of universities who have joined the RUS WG resources and waste work group, shows that a quarter must implement sustainable practices to comply with RUS goals (Rada, 2020) (Perotto).

Secondly, The RUS Food (CIBO) group launched in the year, is actively conducting surveys on food consumption within universities to assess sustainability and waste management practices, with ongoing initiatives and mapping activities to track progress. So far 40 Italian universities have been a part of this network and have been planning for future strategies (Egidio Dansero, 2019).

Within the realm of standards and guidelines, the RUS Working Groups have focused on creating a shared framework of metrics for monitoring environmental, social, and economic performance. Two key tools highlighted are the Standard for Sustainability Reports and the Guidelines for Net-Zero Emissions Targets.

2.5.1.1 Standards for sustainability Reports

The collaboration between RUS and the Study Group for the Social Report (GBS) resulted in a standard for universities' Sustainability Reports (Di Tullio, et al., 2021) . This tool addresses the need for universities to account for their activities based on social and environmental responsibility, aligning with the pursuit of SDGs and pro-active visions. The Sustainability Report serves as an instrument for transparency, accountability, and performance measurement at both individual and aggregate levels. The RUS-GBS document provides qualitative and quantitative indicators for monitoring environmental, social, and economic impacts, encouraging validation by an independent third party and involvement of territorial stakeholders in the assessment process (Leal Filho, et al., 2022) .

2.5.1.2 Guidelines for net-zero emissions

Recognizing the importance of 'net-zero emissions' targets, the RUS developed guidelines to prompt Italian universities to achieve transparent, verifiable, and credible commitments (Joeri Rogelj, 2021). These guidelines, presented in 2021, focus on three main goals: a significant reduction in absolute terms of total energy requirements, an increase in the share of renewable sources covering energy needs, and a commitment to remove CO2 from the atmosphere. The guidelines emphasize clarity in expressing net-zero emissions commitments, specifying whether they relate to CO2 alone or other greenhouse gases, direct or indirect emissions, and the timeframe for achievement. Universities are encouraged to set intermediate goals, establish monitoring systems (2021) , and collaborate with energy technology experts. Notably, as of 2021, several Italian universities have declared net-zero emissions targets, reflecting varying timelines ranging from 2030 to 2050.

2.5.1.3 COP28 and Global initiatives

In a global context, COP28 in Dubai witnessed significant breakthroughs in the food sector, aligning with the goals of sustainable agriculture (2023), resilient food systems, and climate action. Notably, 159 countries, representing a substantial portion of the world's farmers, population, food production, arable land, emissions from the food system, and agricultural GDP, signed the COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action.

Several key initiatives were launched to transform agrifood systems into carbon sinks by 2050. The Food and Agriculture Organization (FAO), the Global Alliance for Climate-Smart Agriculture (GACSA), the World Resources Institute (WRI), the International Fund for Agricultural Development (IFAD), and the United Nations Environment Programme (UNEP) introduced plans and initiatives to reduce food waste. The FAO presented a comprehensive plan focusing on 10 priority areas, including livestock, soil and water, crops, diets, and fisheries, aiming to shift from a net emitter to a carbon sink by 2050 (2023). The COP28 UAE Declaration commits nations to scale up adaptation and resilience, promote food security and nutrition, and support inclusive, decent work in agriculture and food systems.
In summary, the collaborative efforts of Italian universities through the RUS and global initiatives like those emerging from COP28 underscore a commitment to sustainability.

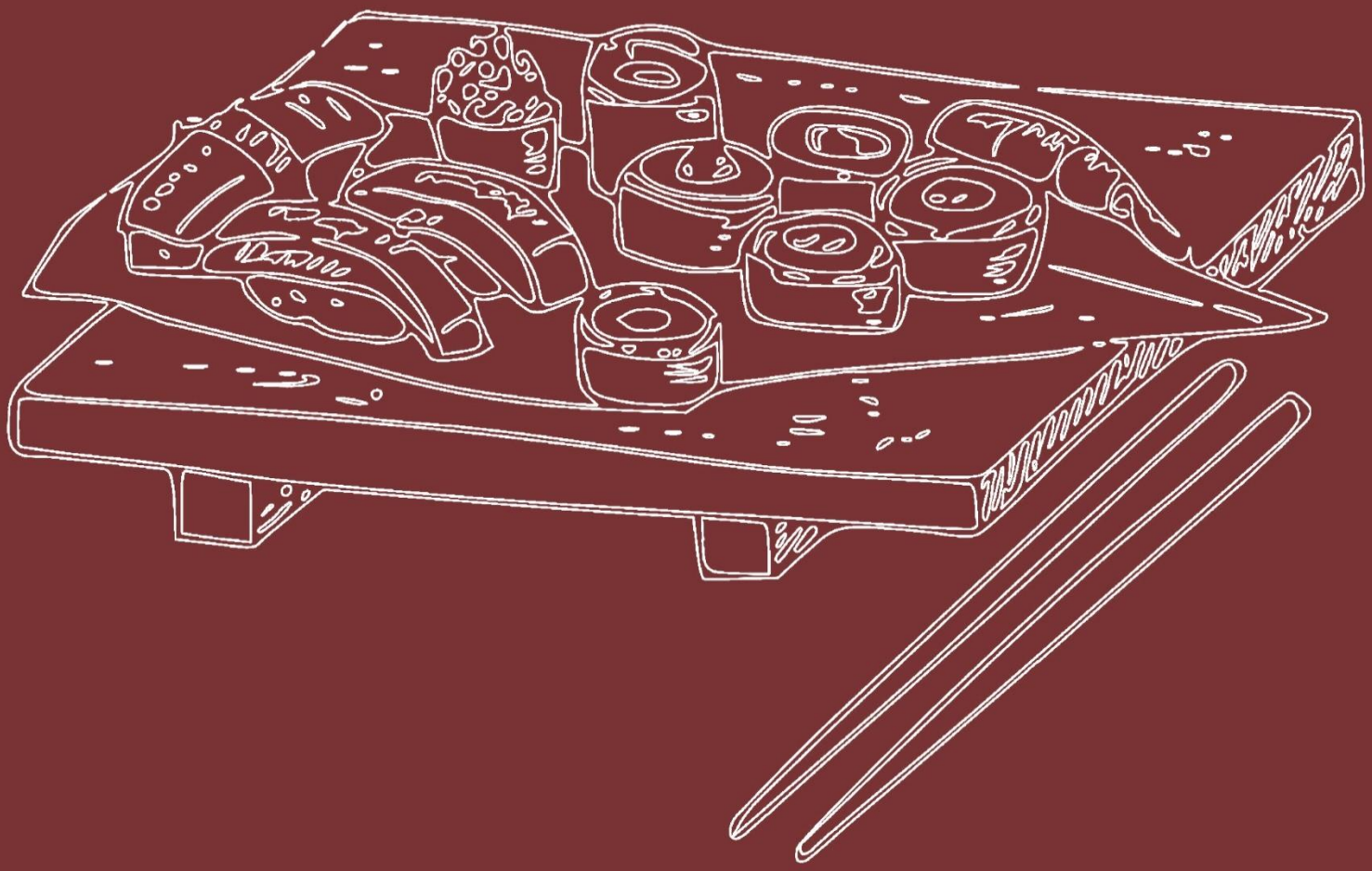
2.6 The missing middle

One of the genius abilities to convey a complex chronological order was Cedric Price's Egg model. Price condenses millennia of urban evolution into three types of egg: boiled, poached and scrambled – in that chronological order. It envisions a dynamic and adaptable urban structure capable of responding to changing needs and environmental pressures. While the concept emphasizes adaptability and resilience, there is a research gap in exploring how Ovo-Urban Analogy principles can be applied specifically to food waste circularity. Integrating advanced preservation techniques and technology within the Ovo-Urban Analogy framework could unlock innovative solutions to reduce food waste and foster a sustainable urban environment. The intriguing question would be -And what type of egg will the city of the future resemble? This will probably depend on the future technologies which are the boom in the modern world and on which we all are dependent.

Figure 18: The city as an egg. Source: (jacobs, 2011).

The research gap lies in the intersection between the increasing food waste of young generations, its implications on climate change, and the need for advanced preservation techniques and technology to empower food circularity. Despite the urgency to address the environmental impacts of food waste and enhance resource efficiency, there is limited research on how preservation techniques, technology, and circularity concepts that can be synergistically integrated on a large scale to combat food waste challenges effectively to create an egg recipe for the tomorrow.

03 Best-practice Analysis



3.1 Literature Study

In the realm of sustainable practices within educational institutions, university dining halls emerge as pivotal arenas necessitating immediate attention for waste mitigation strategies. Recognizing their potential impact on environmental conservation and the imperative role they play in shaping the ethos of future leaders, the implementation of effective Food Waste (FW) reduction approaches becomes paramount. In this context, the Green Restaurant Association's (GRA) comprehensive framework, introduced in 2020, outlines eight discerning standards tailored for environmentally conscious restaurants. These standards encompass a spectrum of sustainability facets, namely (a) water efficiency, (b) waste reduction and recycling, (c) sustainable food practices, (d) utilization of sustainable and durable goods along with eco-friendly building materials, (e) energy conservation, (f) promotion of reusable and environmentally preferable disposals, (g) strategies for chemical and pollution reduction, and (h) fostering transparency and educational initiatives. The applicability of these standards within university settings serves as a focal point for exploration, offering a promising avenue for the integration of comprehensive sustainability programs within campus dining facilities.

This literature review delves into two pivotal dimensions: firstly, an exploration of the underlying reasons and multifaceted factors contributing to the generation of food waste in these environments. Understanding the intricacies of waste generation is fundamental for developing targeted and effective mitigation strategies. Secondly, the review aims to scrutinize methodologies and studies dedicated to quantifying food waste specifically within university dining halls. Accurate quantification serves as a foundational step towards implementing informed interventions and fostering a culture of sustainability. Through a comprehensive analysis of existing literature on these intertwined topics, this review seeks to contribute insights that can inform and enhance sustainable practices in university dining settings.

3.1.1 Reasons and factors behind Food Waste (FW) Generation

According to Kasavan et al. (2021) (Kasavan), there is a high FW at the consumer level in developed countries due to over-purchasing of perishable foods, like fruits and vegetables, meats, and dairy products, whereas the post-harvest and production processes constitute major causes of FW in developing countries. Considering that at universities, FW occurs mainly from the cooking and preparation of dining halls and consumers' behaviour, Deliberador et al. (Deliberador, 2021) discussed the reasons for FW at campus eateries, such as food quality, portion size, satiety, time, and attitudes. Another factor to be considered is the seasonal influence on the characteristics and quantity of FW, which is not a common topic discussed within universities, nor is part of research agendas, or standard for urban land use (Afon,

2022). Qian et al. (Long Qian a, 2022) in their survey of 29 universities, which engaged 9,192 students, found some reasons related to generating FW, such as the mass of FW, gender, age, education, ethnicity, religious beliefs, being the only child in a family, daily waste habits, family origin (city, small town, or rural area), household size, family wealth, lunch or dinner, weekdays or weekends, presence of commercial canteens, time pressure, differences in how food is served, food expenditure, meal costs, food taste satisfaction, and awareness.

Also, Yoon et al. (Yoon B, 2023) pointed out that gender is another factor for variability in food consumption and sustainable behaviour. According to these authors, female consumers have a higher tendency to patronize environmentally friendly restaurants, are more likely to purchase sustainable products, hold stronger attitudes toward environmental issues, and pay more for sustainably produced foods when compared to their male counterparts. These gender differences and perceptions of sustainable practices are like those experienced by campus dining services at a large southeastern university in the USA.

Spatial characteristics affect FW. For example, in a survey at Chinese universities, Qian et al. (2022b) (LONG QIAN, 2022) discovered that regional economic development influences FW in China. The lower carbon food print regions are concentrated in Northeast and Northwest China, where rice and meat have less demand and wheat instead is the staple food. This may be because the south is more affluent and most people have a higher purchasing power that allow higher levels of consumption and waste (rice and meat), as substantiated by a previous study by Qian et al. (2022a) (Long Qian a, 2022).

Zhang et al. (Hui Zhang a, 2021) conceded that FW per meal, per capita, differs based on some factors such as personal attributes (age and gender), and additional reasons related to consuming behaviour (excessive purchasing, tasteless food, personal preference for gourmet, rather than staple food, undesired accompaniments, selection of disposable tableware, cheap food, and large-sized portions).

3.1.2 Quantifying the Food waste (FW) volume in universities

Accurate calculations of FW are necessary to identify waste hotspots and strategies for implementing effective waste reduction plans. To accomplish these computational tasks, employment of key performance indicators such as FW per capita (total FW generation divided by the total population in each school) and FW per portion (percentage of FW generated at the consumption level) is recommended (Kasavan) . In an international study with a sample of 52 higher education institutions, it discovered that more than half of the universities (60%) do not measure the amount of FW generated by their canteens (Walter Leal Filho, 2021). Hence, it is not possible to fully

understand to what extent FW is being generated and its impacts in terms of waste and related costs to dispose of it. Measurable indicators yield real numbers, and these data can encourage preventive FW measures, detect operational inefficiencies, and especially, establish realistic targets for improvement. An employment of the Material Flow Analysis (MFA) and System Dynamics (SD) approaches at the Ateneo de Manila University (Philippines) revealed that the total mass of rice waste was 49.48 kg/day and that large sources of waste originated in the cafeteria, involving the cooking, and serving of rice—the reason of this FW was the surplus of cooked rice that was not consumed (A. M. Favis, 2022).

A study at Obafemi Awolowo University (OAU) in Nigeria showed that the average solid waste generated per person per day is 0.042 kg., which cumulatively yields 2.98 tons/day (Afon, 2022).In a recent survey in a public North American university, it estimates that diners serving themselves once during lunch, on average leave on their plate 0.4 kg/day during a five-day week, leading to individual amounts of FW of 6.7 kg., during the typical sixteen-week semester period (Cavazos RL, 2023) . In a survey with 7000 students at a Portuguese university, 4,374 meals were prepared using 1599 kg of food during this study period (10 days). From this initial mass, 189.5 kg of food was wasted, 164.1 kg as plate waste (what is in the dishes), and 25.3 kg as leftovers. The high FW values (about 13.4%), determine a monthly economic loss of €3.080, an ecological footprint of 2.8 global hectares (Gha), and a total FW of 417 kg (Martinho N, 2022).

In another survey from Chinese universities, vegetables ranked first (46.80% of total plate waste) in FW, grain waste ranked second (36.23% of total plate waste), meat ranked third (13.91% of total plate waste), and the waste of eggs and aquatic products was the lowest (1.55 and 1.52% of the total FW, respectively (LONG QIAN, 2022) . At a university in Northern Portugal with 7000 students, Martinho et al. (Martinho N, 2022) compared the total FW from soup and main course options (meat, fish, pasta, and ovolactovegetarian meal) and found that FW was higher for meat (78.1 kg), whereas the lowest FW was measured for the ovolactovegetarian option. Considering daily meal prices and FW, researchers estimated that there is a daily economic loss of €140. Considering the length of the Portuguese academic year (200 days), this equates to almost €28,000/per year.

Tucho and Okoth (Gudina Terefe Tucho) found that leftovers (dominated by Injera, rice, and spaghetti), generated by students at an Ethiopian university accounted for 82% of the total FW in a oneyear timeframe, whereas onion counted for 10% and potato peels 6%, yielding cumulatively, 680 tons of FW.

In three canteens of a Chinese university, considering environmental and cost impacts, the total amount of FW with 22,000 students was 246.75 t/year, the carbon footprint caused by FW was 539.28 t CO2-eq, and the cost was €647,348.94 (Li J, 2021) . The staple food (cooked wheat-based foods and rice products) is the highest (46.14%) contributor to the FW in this sample, whereas the remainder consists of vegetables and soy products (28.34%). The authors explained that the carbon footprint of FW in university canteens in China derives mainly from the use of electricity and natural gas (68.71%) during the cooking phase. This requires the use of more energy-efficient electrical appliances in university canteens, attention to energy conservation, and considerations about sourcing renewable energies. The cost of FW in university canteens occurs primarily from the purchase of livestock and poultry meats in the procurement phase (26.04%), and labour costs in the cooking phase (38.17%). This calls on students to reduce meat consumption and waste and adopt a more balanced diet. Labor wages are stable and unlikely to change. In a national survey conducted among Chinese universities, the FW correlates with high carbon footprints, and that meat waste accounts for 13.91% of the total plate waste weight, which generates 46.28% of the total carbon footprint (LONG QIAN, 2022). On the contrary, vegetables account for 46.80% of the total plate waste, but only 10.65% of the total carbon footprint. Hence, reducing the FW of high-carbon-footprint foods like those derived from animals is effective for reducing carbon emissions.

3.1.3 Benefits of investing in FW reduction

When universities decrease FW, they gain economic benefits (tangible and intangible cost of waste management from purchase to disposal), social benefits (enhance food security), and environmental benefits (improve natural resource use efficiency, while reducing greenhouse gas emissions) (Kasavan). In a recent study in Indian and UK, university canteens, they found COVID-19-related changes, such as from self-service to table service, as well as reduced menu choices and improved estimation of the number of students requiring meals (Davison N, 2022). Surveys and focus groups were conducted with students to better understand their attitudes about FW, while interviews were carried out with university staff to better understand FW management. The study in the UK university canteen revealed that introducing table cards, posters, and signs led to food waste reductions of 13%. Meanwhile, the study in the Indian university canteen indicated that institutional interventions and COVID-19 impacts led to food waste reductions of 50%. Concerning food waste-related differences between the UK and India, culture and food preferences were key reasons for FW in India, with 40.5% more participants stating that they wasted food because the ‘food didn’t taste good’.

Constructs	Sources	Summary
3.1.1 Reason behind food waste generation	Deliberador et al. (2021)	Quality, portion size, satiety, time, and emotion.
	Adeniyi and Afon (2022)	The seasonal influence in the characteristic and quantity of FW
	Qian et al. (2022a)	The weight of FW, education, ethnicity, religious belief, the only child of a family, daily waste habits, family origin (city or town or rural area), household size, family wealth, lunch or dinner, weekdays or weekends, presence of others eating, time pressure, differences in how food is served, food expenditure, the cost of this meal, food taste satisfaction, and awareness campaign.
3.1.2. Quantifying food waste volume	Qian et al. (2022a) and Zhang et al. (2021)	Age
	Yoon et al. (2023), Qian et al. (2022a) and Zhang et al. (2021)	Gender
	Qian et al. (2022b)	Spatial characteristics
	Zhang et al. (2021)	Consuming behaviour
	Favis et al. (2022)	Ateneo de manila University (Rice Waste)–49.48 kilos/day

	Adeniyi and Afon (2022)	Obafemi Awolowo University (OAU)—0.12 kilos/day/per capita
	Martinho et al. (2022)	Portuguese university—18.9/day
	Qian et al. (2022b)	Diverse Chinese universities—0.146 kilos/day/per capita
	Tucho and Okoth (2020)	Jimma University—0.115 kilos/day/per capita
	Li et al. (2021)	Taiyuan University of Technology—0.68 kilos
3.1.3. Benefits of investing in FW reduction	Musicus et al. (2022)	Barriers to FW donation and composting Benefits of investing in FW reduction
	Kasavan et al. (2021)	Economic, social, and environmental benefits
	Davison et al. (2022)	FW reductions from 13 to 50%

Table 4:Literature review: Constructs & Summary

3.2 Identified Best-practices in European Level

Europe, a region renowned for its diverse culinary heritage and robust food industry, has been at the forefront of adopting cutting-edge technologies to prevent and control food waste. This analysis delves into the multifaceted approach taken by European nations in leveraging technology to combat food waste at both pre- and post-consumption stages of the food supply chain.

The pre-consumption phase is often marred by inefficiencies in production, distribution, and retail, leading to substantial food losses. The exploration begins with a pioneering university that has seamlessly integrated technology into its operations to curtail pre-consumption food waste. This analysis unveils the university's comprehensive approach to sustainable food management.

Shifting the focus to the post-consumption landscape, the investigation extends to research hubs and institutes that have made significant strides in understanding and repurposing food waste. These institutions have not only published groundbreaking articles on innovative methods for reusing post-consumption waste but have also catalysed a paradigm shift in how we perceive food disposal. By examining these post-consumption case studies, we aim to uncover the potential of technological advancements in transforming food waste into valuable resources.

The exploration further encompasses grassroots initiatives within university hostels, where smart community fridges have been strategically placed to mitigate post-consumption food waste. These fridges leverage technology to connect students, fostering a sense of communal responsibility and enabling the redistribution of surplus food within the campus community. The best-practices illuminates the positive impact of these localized interventions in reducing food waste at the source.

Finally, the journey concludes with an in-depth analysis of an innovative app that has gained prominence across Europe for its role in redistributing surplus food from university canteen to those in need. This app seamlessly connects establishments with excess food to individuals seeking affordable, quality meals, thereby creating a bridge between surplus and scarcity.

3.2.1 Technology in the preparation area -Institut Paul bocus, France

One of the sectors that can play a key role in reducing food waste is the hospitality industry, which includes hotels, restaurants, and culinary arts. This sector is responsible for a large share of food waste, especially at the retail and consumer levels. Therefore, it is essential to train the future decision-makers and professionals in this sector to be aware of the problem and adopt innovative solutions to prevent and reduce food waste.

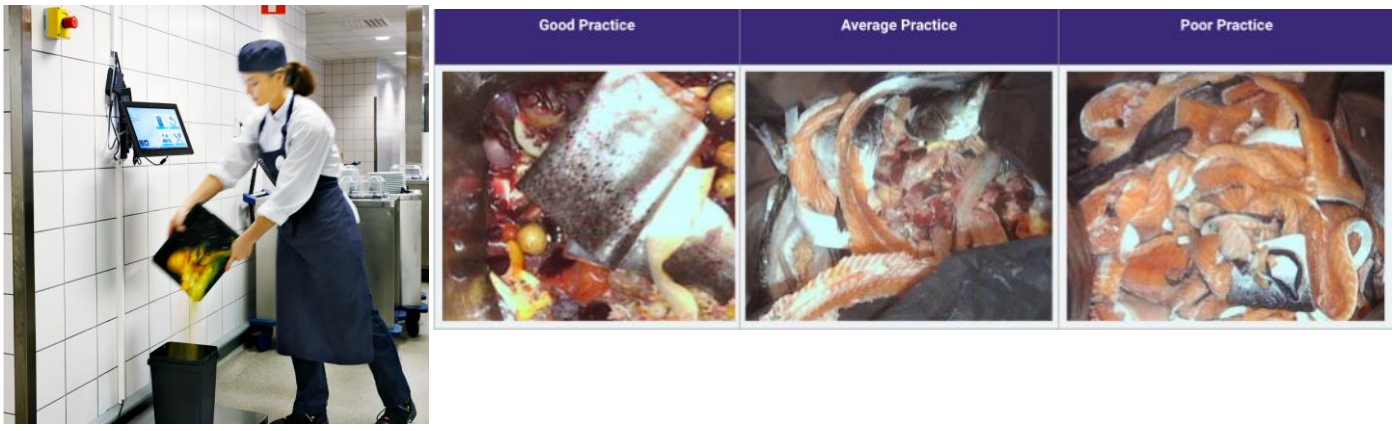


Figure 19: AI sensor detecting the best practice for students. Source: (2021)

Institut Paul Bocuse (IPB) is a leading French hospitality school that aims to prepare the makers of the industry of tomorrow by projecting itself into the future and in innovation. IPB has embraced AI technology for effective food waste management and reduction. A great school must project itself into the future and in innovation to prepare the makers of our industry of tomorrow.

The machine learning based technology scale up that helps chefs combat food waste with analytics. This culinary institute has adopted artificial intelligence in their kitchens to monitor and train the future chefs to be climate conscious. The A.I product, is attached to the bins and takes photos of waste food during the preparation stage as it's thrown away and, using the images, the machine recognizes what has been thrown in the bin. Computer Vision, the technology that enables the product, is like those used in autonomous vehicles (2021).

The teams receive daily reports which pinpoint wastage and highlight where operational improvements can be made. Typically, kitchens can expect to cut food waste in half while driving food cost reductions of between 2%-8%. Machine learning is the tool used to help the appliance recognize the foods being thrown away, with some assistance from kitchen staff during initial training to identify items from the menu. AI can recognize 65 unique trimmings items that include fruit and vegetable trimmings, meat and fish, and bakery items. As trimmings are discarded into the bin - often in a preparation area or separate kitchen - a photo is captured for each recording event. These images reveal where there are opportunities in the kitchen to increase product yield.

3.2.2 Technology in Cooking and serving area - Elior catering and gastronomy Research hub, Milan, Italy

Elior, a prominent catering company in Italy, has embarked on a groundbreaking initiative to combat food waste by integrating Artificial Intelligence (AI) into the kitchens of their restaurant Fourchette in Milan. This innovative solution, known as Winnow Vision, represents a pioneering effort to leverage technology in both the kitchen and dining area to address the pervasive issue of food waste.

In the canteen area, Winnow Vision is strategically installed to measure the amount of food left on diners' plates. This not only raises awareness among patrons about their own contribution to food waste but also provides valuable insights into customers' dining habits. By understanding how much food is being discarded, the kitchen team gains essential data that informs decision-making processes and aids in optimizing food production and serving sizes

Beyond the installation of AI technology, Elior is pushing the boundaries of culinary creativity to minimize food waste at its source. The publication of the article titled "Thrashed" underscores the company's commitment to reimagining traditional kitchen practices. The central idea is to transform kitchen by-products, such as peels and other cooking wastage, into recycled ingredients incorporated into the menu. This initiative aligns with Elior Group's broader ambition to reduce food waste by an ambitious 30% and decrease carbon emissions per meal by 12% by the year 2025.
As part of this initiative, Elior is not only addressing waste reduction but also fostering a culture of sustainability within its culinary operations. Chefs are being educated and encouraged to utilize every part of the food product, showcasing the potential of overlooked ingredients. For example, the company advocates for repurposing coffee grounds in creative ways, such as incorporating them into a chocolate brownie recipe to create a delicious chocolate-coffee brownie. This approach not only contributes to reducing food waste but also transforms discarded elements into valuable and flavourful components of the culinary repertoire.

Figure 20:Elior's kitchen re-using food peels to create AI generated recipes. Source: (2021)

Pushing creativity to the limit, they published an article “Thrashed” with the intention of using peels and other cooking wastage to be recycled in the menu. The basic idea is to teach the chefs how to use every part of the food product, for example. Instead of throwing coffee grounds away, you can use them in a chocolate brownie recipe to make a delicious chocolate/coffee brownie (2021).

3.2.3 Technology for Inventory - The University of Hertfordshire- Smart community fridge

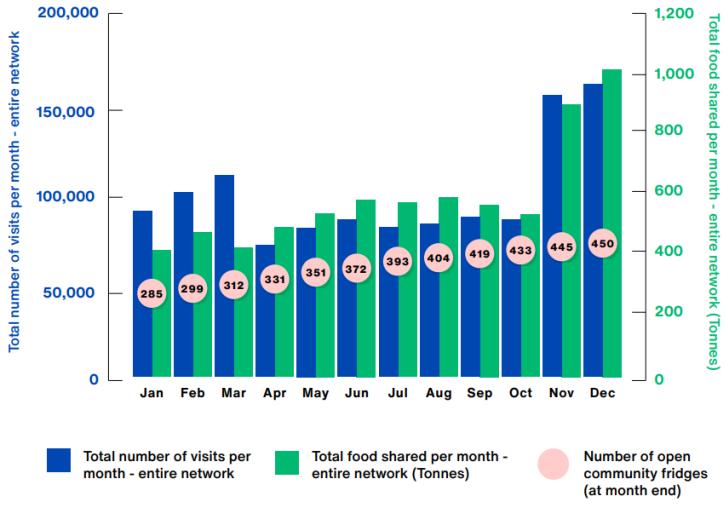
In the realm of food waste reduction, traditional community fridges have long served as beacons of communal goodwill, enabling the sharing of surplus food among community members. However, the efficacy of these fridges in reaching people before the food turns unfit for consumption has often been a concern in the modern world.

Addressing this challenge head-on, HUBBUB, a community-based organization in the UK, has ingeniously incorporated smart technology into the concept of community fridges, marking a significant leap forward in the fight against food waste.

Presently, there are 180 smart community fridges strategically positioned across the UK, each functioning not only as a sharing platform but also as a sophisticated inventory manager. These fridges utilize technology to provide real-time information on the available food items, ensuring that community members are not only aware of the offerings but also that the food is accessed before it reaches an undesirable state.

The smart community fridges, equipped with state-of-the-art technology, serve multiple purposes. They act as data hubs, collecting valuable information on the types of food present, generating recipes based on the available inventory, and meticulously tracking the activities occurring on-site. This data includes the volume of food being shared, the estimated number of visitors, and any challenges faced by coordinators or volunteers in managing the fridge. Such comprehensive data analysis contributes to a more nuanced understanding of the impact and efficiency of these smart community fridges.

The accompanying bar chart illustrates the aggregated data from the entire smart community fridge network across the UK for a full year. This data-driven approach allows for a detailed examination of trends, patterns, and the overall success of the initiative in reducing food waste. By leveraging technology in this manner, HUBBUB has not only elevated the traditional concept of community fridges but has also transformed them into powerful tools for waste reduction and community engagement.



Students feel that the running of this fridge is being an impact on cost-of-living crisis.

Figure 21:Aggregate data from smart fridges across UK. Source: (HUBBUB, 2022)

Implementing this innovative solution within the university setting has yielded remarkable results. The introduction of smart community fridges on campus has led to a significant reduction of 2.4 tonnes of food waste over the specified period.

3.2.4 A food redistribution using machine learning and Arc-GIS – Durham university, UK.

The University of Durham's catered colleges, like many institutions, grapples with the significant challenge of food waste generation. Annual statistics reveal that, on average, these colleges produce a substantial 266.8 tonnes of food waste annually. In response to this issue, the university has implemented several initiatives aimed at mitigating food waste, with a particular focus on both reducing surplus and adopting environmentally conscious disposal practices.

One noteworthy attempt to curb food waste involved offering second portions to students at the conclusion of each mealtime. This strategy aimed not only to minimize excess food production but also to ensure that surplus meals could find a purpose rather than being discarded. Concurrently, the introduction of food waste recycling bins strategically placed in corridors provided students with an environmentally friendly means of disposing of excess food, aligning with sustainability goals.

A second, technologically advanced approach involved leveraging artificial intelligence (AI) through the integration of the "Too Good to Go" app with arc-GIS mapping. This innovative solution serves as a platform to showcase the real-time availability of surplus meals, allowing students to purchase these meals at nearly half the price of standard college accommodation catering fees. At £83 per week for a maximum of 21 meals, each individually priced at just over £3.95, students can access affordable and nutritious meals through this app. The integration of GIS technology enhances the app's functionality by displaying the precise locations where surplus meals are available, facilitating seamless and efficient transactions.

Figure 22:The app using GIS to show the exact location in the university for food availability. Source: (whear, 2023)

Notably, the reduced price of these surplus meals through the "Too Good to Go" app equates to approximately £2490 per student per year, just under the government's recommended average cost for a whole-house energy bill. This not only offers a cost-effective dining option for students but also underscores the significant financial and environmental impact of repurposing surplus food.

3.3 Technology as the Social Innovative model

In the quest to combat food waste, a social innovation model emerges as a dynamic framework for catalysing change. This model intertwines technological advancements with innovative strategies to revolutionize food systems, particularly within university canteens. By leveraging technology as a cornerstone, this approach reimagines traditional food service operations, offering a pathway to enhance efficiency, minimize waste, and foster sustainability. At its core, the social innovation model integrates digital solutions, data analytics, and collaborative platforms to optimize resource utilization, streamline processes, and empower stakeholders. Through this lens, university canteens can transcend conventional practices, embarking on a journey towards a more sustainable future where technology serves as a catalyst for transformative change in food waste reduction efforts.
In this regard, Legislators from the European Union (EU) have held discussions.

The world's first waste management reference, the Waste Directive (WD) 2008/98/EC, which provided a pyramid of priorities for waste reduction, was released in 2008 (EUD) (Gesyeana Bazlyn Zamri, 2020). It urged member states to create targeted initiatives with an emphasis on (a) prevention; (b) reuse preparation; (c) recycling; (d) alternative recovery, like energy recovery; and (e) disposal (Claudia Giordano, 2020). However, this pyramid faced challenges, including overlap between measures like prevention and reduction, preparing for reuse, and reuse itself, which was part of the prevention definition. Few countries have adopted national plans focusing on food waste (FW) prevention and reduction, with more concentrating on single initiatives against FW (Mangesh Gharfalkar, 2015) (Matteo Vittuari).

In 2016, only two national regulations were issued in this direction, representing the current best-structured normative interventions: French Law number 138 (Sénat, 2016) and Italian Law number 166 (Repubblica., 2016). Both laws address only the first two levels of the FW pyramid with a strong emphasis on the second layer (e.g., re-use for human consumption). In both cases, prevention measures are weak and mainly related to communication and awareness-raising activities, not introducing any structural changes to the food system upstream to avoid the generation of FW (Claudia Giordano, 2020) (Gonzalez-Vaquè, 2017) (Costantino, 2018). In 2018, the WD was

amended by the new Directive (EU) 2018/851, which established a baseline to monitor the achievement of FW reduction goals (30% by 2025 and 50% by 2030) and to facilitate the identification of the main FW flows to be valorised in a circular economy perspective (J.Poore, 2018) (EU).

In 2019, proceeding in the same direction, the European Commission also provided a common methodology and set minimum quality requirements for the uniform measurement of FW levels (85, 2019) (Platform, 2019) followed by the UNEP, which, in 2021, published a methodology for countries to measure FW, at household, food service and retail level, to track national progress towards 2030 and to report on SDG 12.3 (UNEP, 2021).

In 2020, the European Commission finally launched, inside the bigger "European Green Deal", the "Farm to fork strategy", which proposes measures and targets for each stage of the FSC, from production to distribution to consumption, to make the European food systems more sustainable (European Commission, 2020). Hence, it has become critical to evaluate the different models that are used by each member state of the EU in applying an FW hierarchical framework. In some models, bottom-up approaches are being adopted. These approaches are intended to involve all actors of the FSC, emphasizing the importance of formal multistakeholder collaborations and focusing on the role of different relational forms in stakeholder networks (exchange of information, sharing of resources, and development of cooperative projects). They can be transformed into social innovation (SI) models, representing a valid alternative tool for ensuring sustainable production and consumption, i.e., FW and FL reduction. SI initiatives, indeed, might engage consumers more efficiently because, as is known, they can activate relations among them, creating or reconfiguring their social networks and introducing an innovative practice with a high possibility of acceptance (Lombardi, 2017) (M. Lombardi, 2020).

Teigiserova et al., 2020, proposed a new revision to earlier FW pyramids after the amendment of WD 2008 by the new Directive (EU) 2018/851 (Dominika Alexa Teigiserova, 2020). The reason for this revision was that the FLW and SF framework have continued to miss the adoption of a specific separated waste hierarchy, which is necessary for increasing the efficiency of prevention and reuse in a circular economy framework. They distinguished "surplus food and a new category for material recycling, in order to reflect the future food waste biorefineries in the circular bioeconomy." Thus, they separated the nutrient and energy recovery from FW into two categories and clarified the terms of recovery and recycling.
This latter change represents material recycling that does not include the total degradation of FW as it occurs in energy and nutrient recovery, so that the resulting products can be re-introduced into the market.

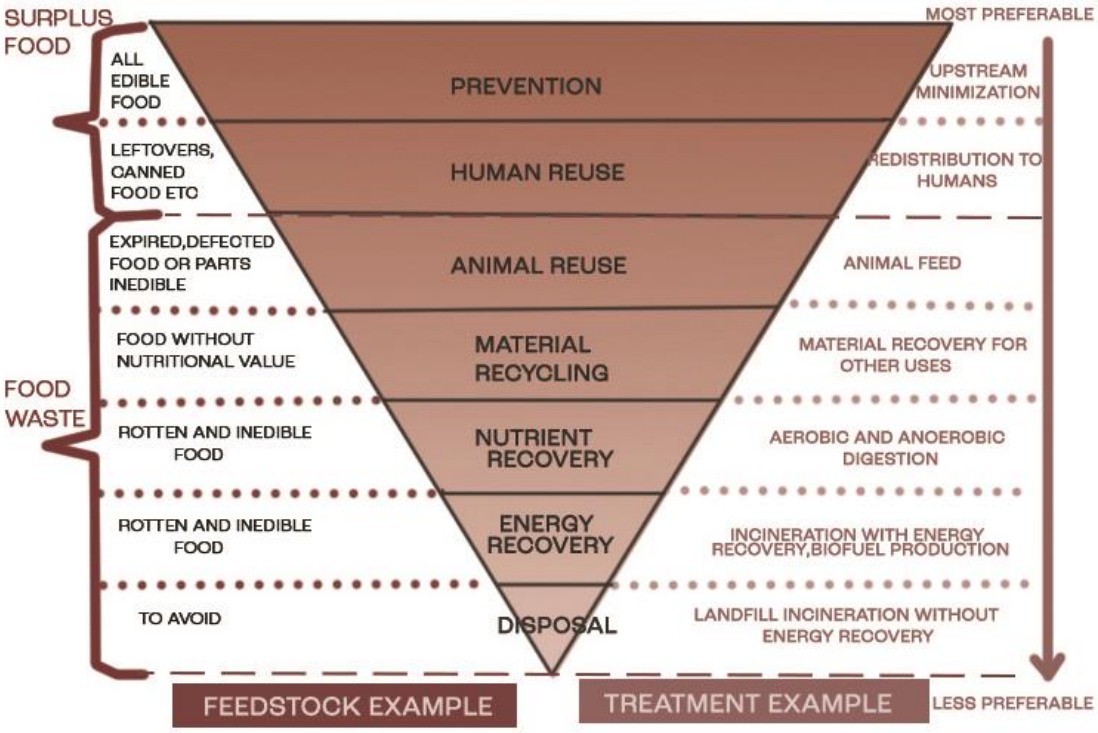


Figure 23. Last revision of an FW hierarchical pyramid. Re-drawn from: Source: (Dominika Alexa Teigiserova, 2020).

04 THE CASE STUDY: A QUALITATIVE ANALYSIS

4.1 Introduction of canteens in Italy.

The history of university cafeterias (Canteen) in Italy dates to the mid-20th century. After World War II, Italy experienced a period of reconstruction and economic development. During this time, there was an increasing demand for higher education, and universities started to expand. As student populations grew, the need for dining facilities became evident (Pagliarino).

In the 1960s and 1970s, universities across Italy began establishing their own cafeterias or dining halls to cater to the needs of students and staff. These facilities aimed to provide affordable and convenient meals for the university community.

Throughout the 1980s and 1990s, the concept of university dining facilities evolved. Many canteens expanded both in terms of capacity and the variety of food offerings. The focus shifted towards providing nutritious and diverse meal options to accommodate the diverse preferences and dietary needs of the students.

In the 2000s and 2010s, some universities in Italy started to privatize or outsource the management of their canteen services to external companies. This move aimed to improve efficiency and introduce innovations in menu planning, service delivery, and overall customer satisfaction. In recent years, many university cafeterias have embraced technology to enhance the dining experience. This includes online ordering systems, digital menu boards, and cashless payment options. The goal is to streamline operations and make the dining process more convenient for students.

Figure 24:Inaugration of a university canteen in Italy. Source: (Uni)

4.1.1 The case of Turin

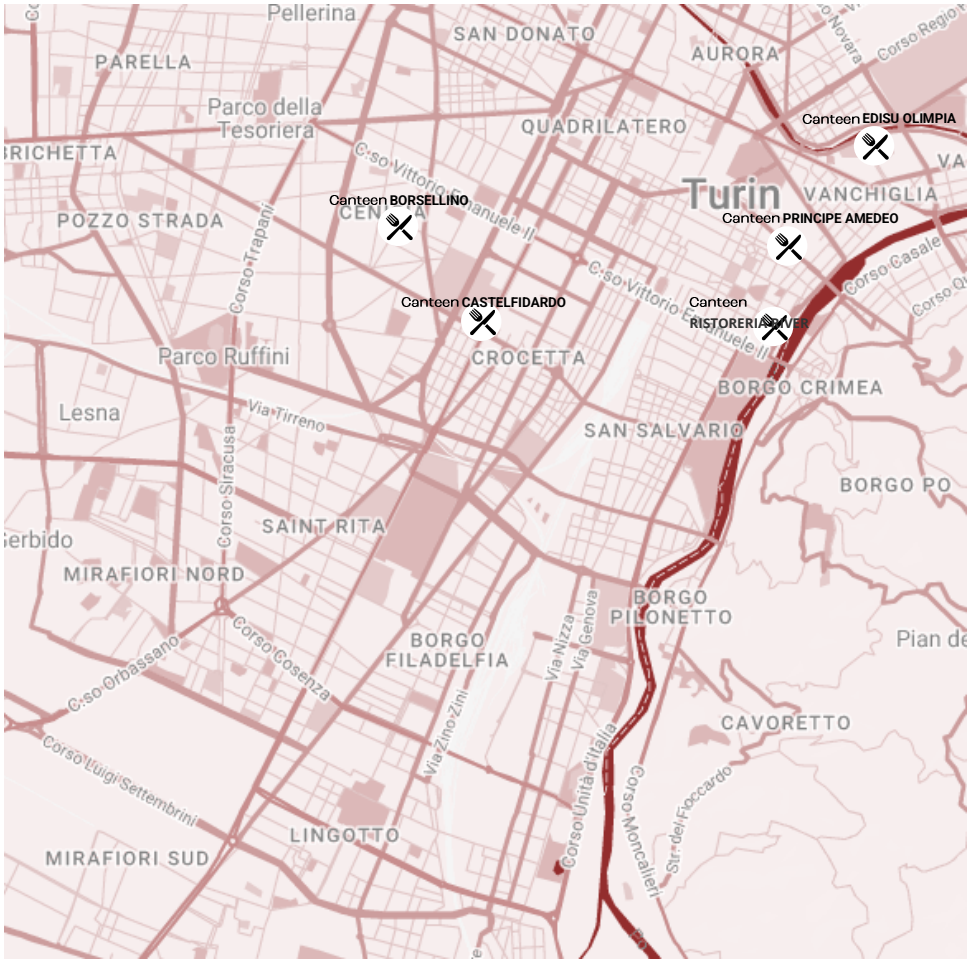


Figure 25: The CANTEENs situated in Torino. Source: (EDI)

The City of Turin represents one of modern Europe's most impressive stories of urban transformation. Situated in the Piedmont region in the north-west of the country, Turin is Italy's fourth largest city (Winkler, 2007). After the lowering of the population due to the industrial crisis, in the last ten years, the city of Turin has seen a demographic growth, reaching a peak of 901.556 inhabitants, where 140.138 of foreign nationalities. Former Italy's first capital, Turin is recognised as a capital of taste due to its local gastronomy, characterized by sobriety and refinement.

EDISU, short for *Ente per il Diritto allo Studio Universitario,* is an Italian regional agency responsible for supporting students in their academic pursuits. EDISU operates in the Piedmont region, including the city of Turin. Among its various services, EDISU manages university canteens, or "Canteens," in collaboration with local universities such as the Politecnico di Torino. These canteens play a crucial role in providing affordable and nutritious meals to the student community.

The institutional canteens in Turin provide more than 8 million meals per year; the seven university canteens provide up to 1.232 meals each day and more than 10 million of meals in peri-urban area.

4.1.2 Initiatives of Food waste management in project level.

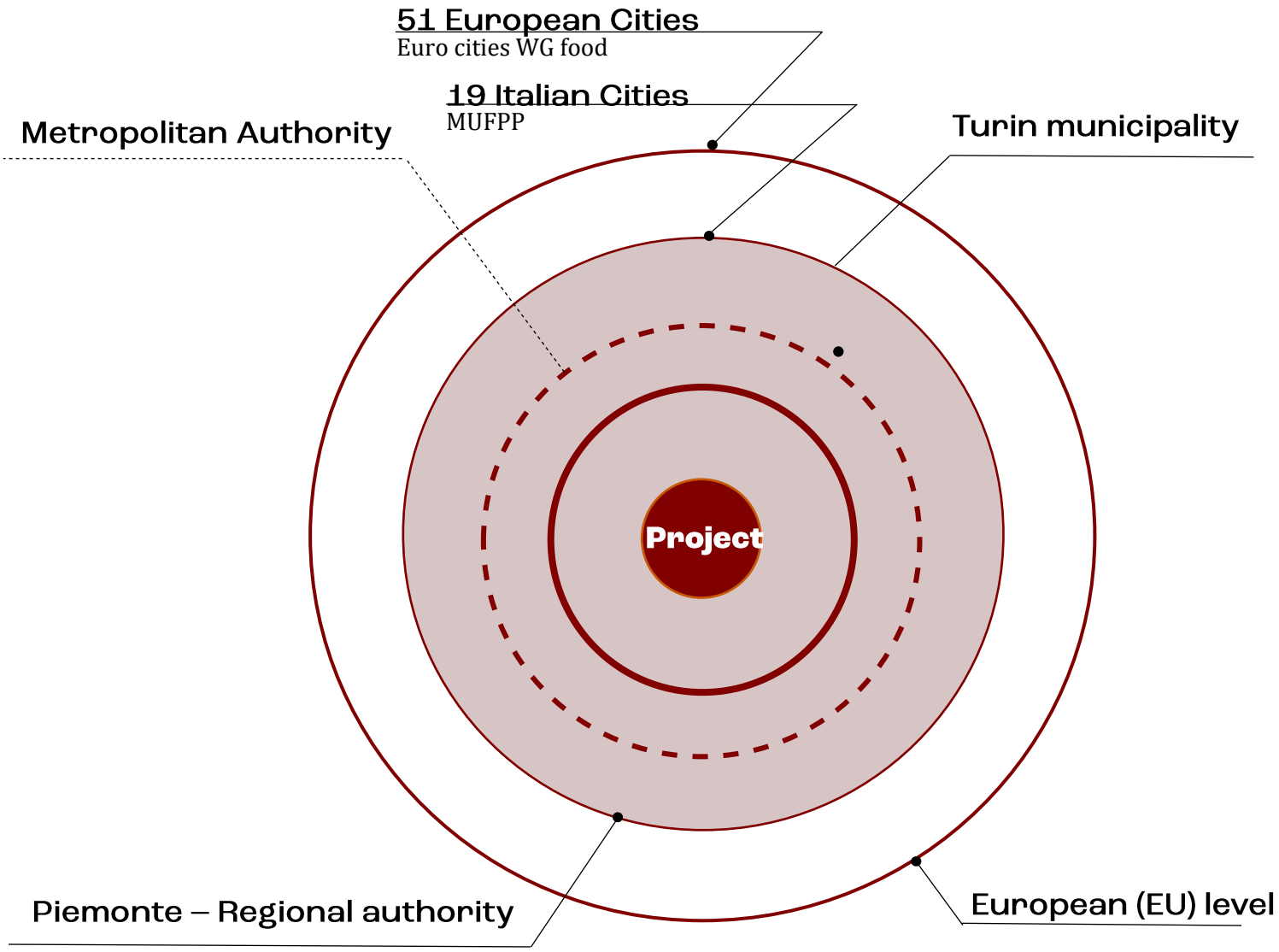


Figure 26:Integrated Governance Circles for resilient food systems

At the heart of our project lies a robust core, focused on enhancing sustainable urban development and fostering a resilient food system. This central initiative is fortified by concentric circles, each representing a distinct level of governance and collaboration. At the municipality level, local authorities engage in grassroots efforts to ensure food security, sustainable practices, and community involvement. Moving outward, the metropolitan authority envelops these endeavours, fostering cooperation among municipalities for a cohesive regional approach. The regional authority circle extends

the impact, orchestrating policies and initiatives that transcend individual municipalities to address food-related challenges on a broader scale. Stepping onto the European stage, our project resonates at the EU level, aligning with larger strategies for sustainable urban development and food policy.

Within this framework, our collaboration extends globally through active participation in the Euro Cities Working Group on Food Security, which includes 51 European cities. Moreover, at the national level, our engagement with the Italian network MUFPP (Milan Urban Food Policy Pact) involves 19 cities working collectively to achieve sustainable urban food systems.

By categorizing initiatives under each circle, it is possible to analyse the existing steps taken by each governing body.

4.1.2.1 European (EU) level-

- Slow food - influence food policies in the European Union, seeking to change the current food and farming systems
- Food Drink Europe-is committed to help Europe's food and drink sector in reducing food loss and waste and supports the European Commission's aspiration to hit the United Nations Sustainable Development Goal (UN SDG) target to halve food waste per capita by 2030.
-DEAR- European Commission's development, education and awareness raising program to create a coordinated urban food policy agenda and show the potential of the European Territorial Cooperation in fighting against poverty and hunger.

4.1.2.2 Piemonte-Regional authority

-Una buona occasione funded by the Piemonte region and the Italian Ministry for Economic Development to increase awareness on food labelling.
-Citta di Torino has signed the Milan food policy pact and is working towards the reduction of institutional food waste.

4.1.2.3 Metropolitan Authority

- **Fooding – Alimenta la solidarietà** Torino Solidale provides for the distribution of solidarity baskets through a dozen joints spread throughout the territory of Turin in collaboration with Arci Torino manages two hubs in the north of the city, with a total of about 1,400 households in charge.

-**Urban Lab Torino** - Atlante del Cibo is a join initiative with three universities in Torino to represent data about the food system of city-region scale coming both from official archives and from users and actors of the food system.

-Turin Smile project, to make the food-city relationship visible, establishing it as a challenge toward a territorial food system in the project of a technological and inclusive Smart City.

4.1.2.4 Turin Municipality

-Turin Food Bank network – La Rete di Torino Solidale:14 private and government solitary distributing 9000 families with food.
-Progetto RePoPP with an NGO Eco dalle Città, which involves the Waste Sentinels and the Ecomori (volunteers requesting asylum), in the recovery of food surpluses at the market stalls around Torino and redistributing it to the people in need
- Biova Circularity Project – to recover unsold bread at the end of the day - which is not always easy to redistribute to the needy to make it to beer significantly saving fresh produce of barley to 50%
-Fusilli – An urban food planning network creates awareness in institutional networks.

4.2 Analysis of Polito university

Figure 27: The Polito university and its food waste. Image by author.

To achieve the aim of the thesis to reduce the institutional food waste through technology, I am taking the Study site to be one of the canteens *(Mensa)* that runs under Politecnico di Torino.

The multitude of stakeholders involved, the various phases of the project and the tight relationship between the school and the local territory, it is deemed that a single case study was the right approach to study the phenomenon within its real-life context leveraging on multiple sources of evidence to understand its key success factors (Yin, 2003), (Greenbaum, 2018). Moreover, the single case study research method is particularly appropriate for exploratory studies discovering relevant constructs in areas where theory building is at the formative stages and for studies where the experiences of participants and context of actions are critical (Bhattacherjee) such as food waste management.

Like other methodologies, the analysis of a single case study has its limitations. In particular, single case study methodology is less generalizable, and it is more complex to verify the external validity than other methodologies, such as multiple case studies. However, these limitations are also positive factors because this methodology "sacrifices generalizability in favors of more in-depth analysis." (Stefan Hunziker, 2021)

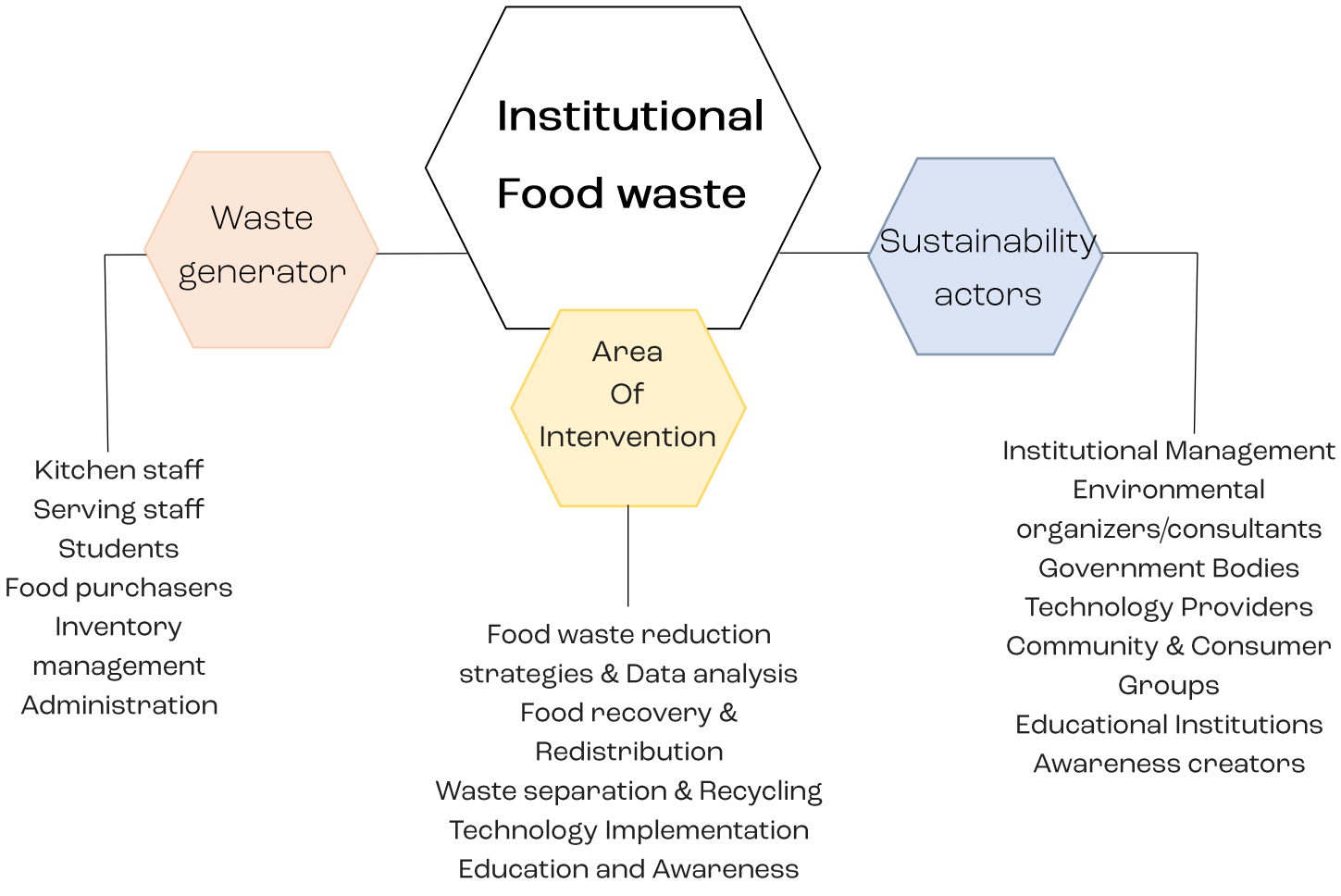
4.2.1 General information

The PoliTO is organized on a rather wide arrangement in distinct geographical locations with very different features from the architectural, urban, and functional points of view. The main site of *Corso Duca degli Abruzzi,* 144,000 sq.m, opened in November 1958 and was then extended in the 90s with the *Cittadella Politecnica.* The historic and representative base of PoliTO is in the city: the Valentino Castle, a seventeenth-century residence of the House of Savoy. It is the main teaching campus for Architecture and Design, with an area of 23,000 sq.m. The Cittadella Politecnica is a modern complex of 93,000 m2 adjacent to the main building, including areas set aside for students, research activities, technological transfers and services and potential expansion area of 75,000 sq.m. The newest campus is the Cittadella of Design and of Sustainable Mobility, in an area next to the manufacturing establishment of Mirafiori, the refurbished former FIAT manufacturing facility now mainly devoted to the Automotive degree and master's degree courses. Finally, the Lingotto, located in an old FIAT manufacturing complex, is currently hosting Masters and sites for the national public transport regulation authority. In 2017, more than 34,000 students were distributed along more than 90 courses and 25,500 m2 of classrooms. In total, 850,000 m2 for research activity is used every day by more than 1,700 employees, including 900 teachers and researchers (Chiara Genta, 2019).

This has been chosen as a case study since its strategic plan acknowledges since years the pivotal role that HEIs and scientific research organizations should play in supporting responsible development, both at global and local levels. With reference to what the Brundtland Commission defined as Sustainable development, as the one "that meets the needs of the present without compromising the ability of future generations to meet their own needs [...]", PoliTO encouraged several actions for current environmental, economic, and social challenges, to find solutions for reducing inequalities in the benefits distribution, and to protect the planet ensuring identity protection and prosperity for the widest. Also, a large amount of data made available from the living lab, the Masterplan team and the green team structures allowed a relatively easy data collection phase.

4.3 Stakeholder Analysis

For this research, we have followed the case study guidelines proposed by Eisenhardt (1989) (Eisenhardt, 1989). First, we defined the goal of the analysis: understanding how it has been possible to put in operation an effective food waste reduction involving all the stakeholders in the context. Second, respondents were selected to conduct several retrospective interviews with the institutional catering teams.



The stakeholders that are identified and clustered below are those within Turin city level who can contribute to mitigate the food wastage at the canteens of Politecnico di Torino. These stakeholders are categorized into four types based on their primary roles and possible contribution to the project ensuring comprehensive and cohesive strategy for policy formulation and implementation.

nº	Stakeholder	Level	Type of actor	Actor's resource	Objective
1	Region of Piedmont	Regional	Political	Political /Legal /Economical/ Social	Improvement of the condition of the regional territory and political consensus.
2	Municipality of Turin	Municipality	Political - Bureaucrat	Political /Legal /Economical/ Social	Improvement of the social, economic, and urban conditions through the implementation of the regeneration process
3	RUS Piemonte	Metropolitan	Educational services	Institutional / social	To share, develop, and implement regional policies for sustainable development of universities.
4	Banco alimentare	Regional	Political - CAAT	Social / Legal	Centro Agro alimentare Torino-CAAT is organizing this donation of unused products that are used in canteen food sectors as a circular food network.
5	Fondazione Compagnia di Sanpaolo	Regional	Private foundation	Public / Civil / economical	To foster the development of the communities in which it operates, pursuing objectives of public interest and social utility, Institutional purposes
6	RUS Cibo	Regional	Institutional model	Institutional / Social / Economical	To monitor the food consumption in universities to bring a sustainable network.
7	UNISG- University of Gastronomic sciences	Regional	Innovation	Institutional /Social / cognitive	To promote new modulated recipes to secure the food that is destined for dump.
8	EDISU canteens	Regional	Educational services	Cognitive / Social / Economical	To provide food to the students according to their economic value at discounted rates
9	ANCI Piemonte	National	Governance	Political / legal / cognitive	To raise voice for the people to greater administrators for

					valorizing the wealth of territories
10	University of Torino	Regional	Institutional model	Institutional / Social	To transfer technological research into the business world for benefit of the society
11	Politecnico di Torino	Regional	Educational services	Institutional / Social	To the development of a sustainable campus and the role of the University in the exchange of knowledge and technologies
12	Gruppo IREN	Metropolitan	Multi-Regional network	Economical / Cognitive	To disseminate environmental sustainability education in Turin university and proper differentiation of waste

Table 5:Identified stakeholders.

Clustering these stakeholders into four different category and utilizing the identified ones in the policy formulation of the project is vital to make our policies strong and promote circularity. The identified clusters are as follows –

Political & Legal

The Region of Piedmont is dedicated to improving the area's well-being and gaining political support by creating important legal structures and providing financial resources to back initiatives that reduce food waste. The Municipality of Turin works to better social, economic, and urban conditions through revitalization projects, offering essential political and bureaucratic support. ANCI Piemonte champions policy changes by voicing the needs of local communities to higher levels of government, promoting sustainable practices and better use of resources.

Institutional

RUS Piemonte aims to share, develop, and implement regional policies for sustainable development of universities. Moreover, it supplies institutional frameworks and encourages educational policies aimed at food waste reduction. At the same time, the University of Torino dispatches the outcomes of technological research to the business field which allows suggesting evidence-based policies and original strategies

to minimize food waste. Additionally, Politecnico di Torino is concentrated on the development of a sustainable campus and shares technologies and knowledge that can help in designing long-lasting and feasible policies. Finally, RUS cibo tracks food intake in universities and delivers data and institutional support structures necessary for the establishment of sustainable and responsible food networking.

Social & Voluntary

The Fondazione Compagnia di Sanpaolo contributes to the development of the community and enough information about the economic and social usefulness is provided to the authorities, to match policies to the public good. Banco Alimentare helps by setting up food redistribution networks, ensuring that unused food products are used effectively within circular food systems. EDISU canteens are examples of how it is possible to offer food at low prices aimed at guidelines to combat food waste based on both economic and socially sustainability criteria. These stakeholders make sure that the policies implemented are indeed socially appropriate and economically sustainable with support from the community.

Innovation & Technology

Gruppo IREN contribute technological expertise and cognitive resources to policy development, promoting initiatives against waste and providing innovative solutions for waste differentiation and reduction. The University of Gastronomic Sciences (UNISG) introduces innovative recipes and food management practices, offering cognitive and social resources that help shape effective and forward-thinking food waste policies. These stakeholders ensure that policies are technologically advanced, leveraging the latest innovations and practical solutions to achieve food waste reduction goals.

4.4 Data collection

To be able to get the necessary data, triangulation is used through literature research, a survey, and semi-structured interviews. Having a diverse and broad data basis on the one hand increases the research's reliability and provides a better overview about the institutional landscape of food waste. Semi-structured interviews are to be conducted with representatives of companies, initiatives, and university canteens to extrapolate the rules, norms and strategies needed for the subsequent analysis of the network organizational network. This method is generally chosen because they "have a fairly specific list of questions or topics to cover, [...] but the interviewee has a wide range of possibilities as to how to respond" (Costa Hofisi, 2014). Therefore, interviews

must be specific enough to get the necessary information from the interviewee, while leaving enough room for additional opinions.
To continue, the reason why interviews are used in combination with an institutional network analysis are on the one hand side that interviews are very useful for studying behavior of a small group of people.
Lastly, document research is the last data collection method, which helps collecting additional information on rules, norms, and strategies by technology.

4.4.1 Respondents Selection

A sampling method for the target population must be clarified. A **Purposive sampling strategy** was chosen to target majorly the students, representatives of food waste initiatives. According to Robinson (Robinson, 2014) the "rationale for employing a purposive strategy is that the researcher assumes, based on their a-priori theoretical understanding of the topic being studied that certain category of individuals may have a unique, different or important perspective on the phenomenon in question and their presence in the sample should be ensured" (p. 32).
More concretely **quota sampling**, as one of the purposive sampling methods has been chosen **to decide a quota for each of the actor categories**, such as companies, initiatives, retail, and canteens. The quota was set to minimum as actor per category, without an upper limit.

The **source sampling method in** the selection of actors was done after researching them, to assure that they can provide information on food waste.

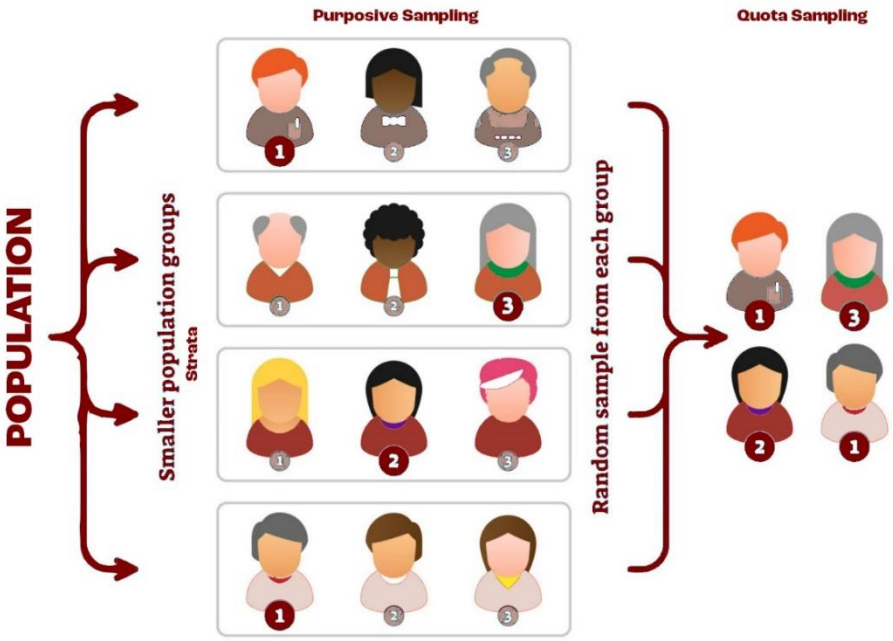


Figure 28:Defining the sampling method. Source: (Simkus, 2023)

4.4.2 The questionnaire

This forthcoming research study aims to investigate the role of technology and its impact on institutional with a primary focus on students aged 18 to 26. Employing a snowball sampling method, the research will utilize a question survey to gather valuable insights from this demographic. The study intends to analyse the preferences, attitudes, and expectations of young adults towards technology-driven urban planning initiatives, and how these insights can shape future policies. Ultimately, the research seeks to bridge the gap between traditional urban planning approaches and the transformative potential of technology, laying the foundation for more efficient and responsive urban development that meets the needs of both current and future generations. To briefly explain the questionnaire consists of four parts to extract comprehensive insights into food consumption behaviours and attitudes towards waste reduction among the surveyed population.

The initial part of the survey collects general demographic information to understand the characteristics of the surveyed population, aiming to provide insights into the demographic composition of canteen patrons. Following this, the second section investigates common practices and attitudes concerning food purchasing and waste disposal by exploring participants' grocery spending habits and attitudes toward food waste. The third segment focuses on individual-level activities, querying respondents about personal strategies employed to minimize food waste in their daily lives and within university canteens. Finally, the fourth section assesses attitudes and receptivity to technology-based approaches for reducing food waste, inviting feedback on potential technical innovations.

4.5 Introduction of the chosen area

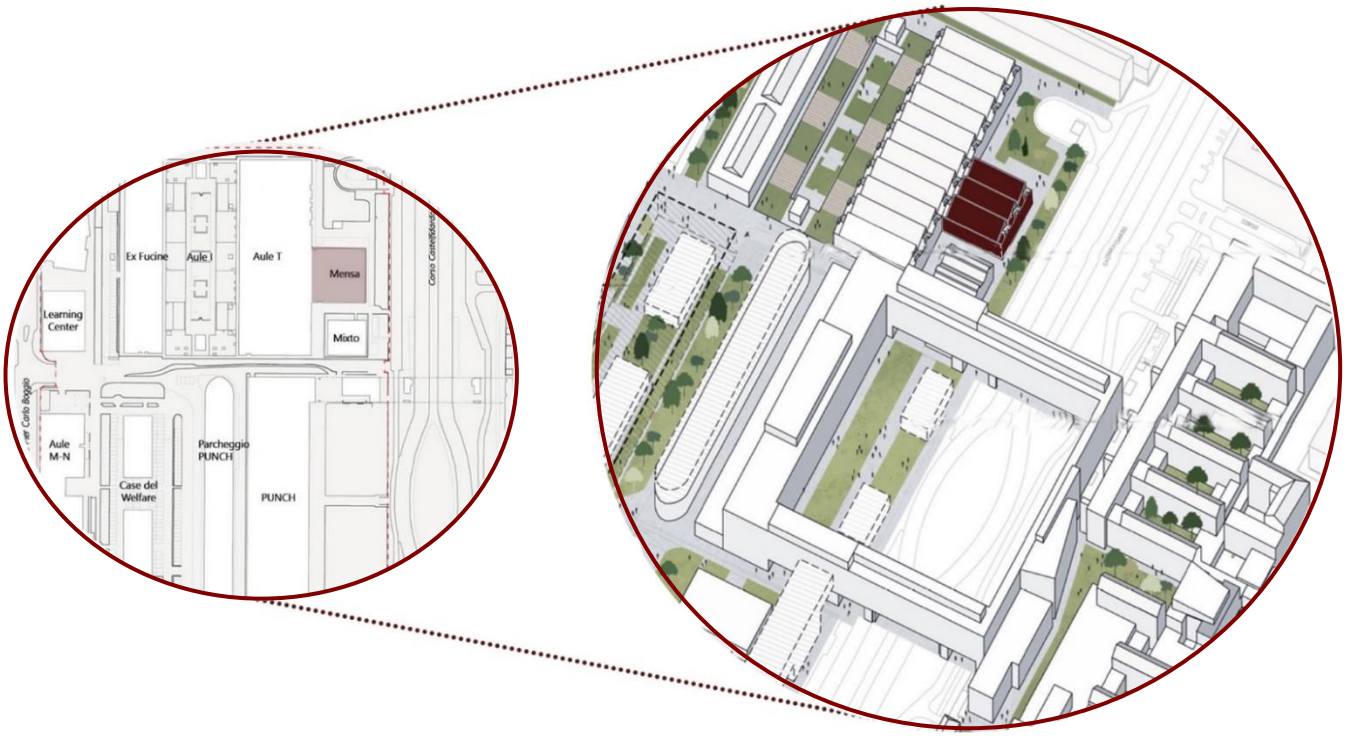


Figure 29: The location of canteen Castelfidardo at Sede centrale Citadella.Source: (2017), (Barioglio, et al., 2018).

The canteen Catelfidardo, located at Politecnico di Torino, is a significant dining facility catering to the needs of students on the main campus. With its sprawling 1440 sq. m structure, it stands as one of the largest canteens under Politecnico di Torino's. The strategic selection of this site ensures accessibility to a large student population.

The canteen offers two convenient mealtimes: from 11 am to 3 pm and from 7 pm to 8:30 pm. It is open from Monday through Friday. This extended service period makes it possible to adapt to the different schedules of the students. Canteen Catelfidardo can accommodate 400 people at a time and serves about 1000 students every day. With a wide range of options for primi piatti (first courses), secondo piatti (second courses), contorni (side dishes), and desserts, the menu guarantees guests a well-rounded and fulfilling dining experience. The canteen offers two mealtimes: from 11 am to 3 pm and from 7 pm to 8:30 pm open from Monday through Friday. They provide both Dine-in and take-away options for the students. The Canteen Catelfidardo can accommodate 400 people at a time and serves about 1000 students every day. With a wide range of options for primi piatti (first courses), secondo piatti (second courses), contorni (side dishes), and desserts, the menu guarantees guests a well-rounded and fulfilling dining experience. In terms of the menu, there are many options to suit various dietary needs and preferences. The menu, which primarily consists of traditional Italian food, with rotational seasonal dishes made with ingredients that are sourced locally. Also, there are vegetarian, vegan, and gluten-free options to accommodate a diverse student body.

AMIAT, an Italian company that specializes in waste collection and disposal, oversees managing Canteen Catelfidardo's waste management system. AMIAT oversees gathering the waste produced at the location and making sure that it is properly disposed of, recycled, and segregated in compliance with legal requirements. We had the opportunity to visit the site in the month of February through a virtual tour with the manager of the Mensa and conducted an interview with her. Below are some images and analysis from the survey.

4.6 Interview and On-site survey results

Figure 30 : Floor plan - Canteen

The floor plan of the university canteen is strategically organized into distinct zones to efficiently accommodate various functions. The students' zone encompasses areas dedicated to student access, including the entrance, serving station, billing section, and dining area, providing a seamless dining experience. Adjacent to this, the workers' access zone consists of dry and wet storage areas, a preparation area, and a cooking area, facilitating the efficient preparation and cooking of meals by kitchen staff. Additionally, the food waste disposal zone is designated for the segregation and disposal of waste generated during food preparation, ensuring responsible waste management practices. Each zone is thoughtfully designed to optimize workflow and enhance the overall dining experience within the canteen.

Entry kiosk

Figure 31:The entry kiosk of Canteen.

The entrance to the university canteen is equipped with student card recharging kiosks, facilitating seamless transactions, and providing a convenient point of access for students to enter the dining facilities.

Serving Station

The serving station is intelligently divided into dine-in and take-away sections, offering students flexibility in their dining preferences. This setup enables students to efficiently select their desired dining option, contributing to a smoother flow of service.

Figure 32:The serving station.

Billing Section:

Utilizing the recharged student cards for payment, the billing section ensures swift transactions and a streamlined checkout process. This not only enhances convenience for students but also minimizes waiting times, optimizing the overall dining experience.

Figure 33: The billing section.

Dining Section:

Designed to provide a comfortable and inviting space, the dining section of the canteen offers students a pleasant environment to enjoy their meals. This contributes to the overall satisfaction of the dining experience, encouraging students to frequent the canteen.

Figure 34:The dining hall.

Canteen workers contribute significantly to the overall hygiene and quality of the food served in the university canteen. Stringent regulations were followed to ensure the cleanliness and safety of this environment. Among these regulations, the use of hair masks, kitchen-appropriate footwear, and full-body robes to cover attire were enforced for all individuals entering the worker's area. After the students have been served in the canteen, the workers of the Canteen have the same meals. However, any leftover food is discarded, as it is ineligible for donation due to regulations forbidding the distribution of items containing condiments.

Dry Storage:

The dry storage area was found to be well-maintained and properly organized, with clearly labelled shelves and containers for each type of ingredient. Pasta, flour, oil and condiments were stored in separate sections, minimizing the risk of cross-contamination, and ensuring easy accessibility for staff members. Each compartment in the shelf can hold up to 10 kgs of weight. Furthermore, the storage conditions were optimal, with adequate ventilation and temperature control measures in place to preserve the quality and freshness of the stored items. Regular inventory checks were also noted, indicating a proactive approach to stock management and rotation.

Figure 35: The dry storage.

Wet Storage:

The wet storage zone equipped with walk-in fridge were meticulously organized, with separate sections designated for each type of perishable item, ensuring optimal freshness and ease of access.

A particularly commendable practice was the stocking of inventory once every two days. This proactive approach minimizes food waste by ensuring only necessary quantities of perishable items are stocked, reducing the risk of spoilage.

Figure 36: The wet storage.

Preparation Area:

The pantry area is equipped with dedicated stations for various food preparation tasks. This includes areas for chopping vegetables, slicing meats, portioning ingredients, and preparing sauces, dressings, and marinades. Each station is furnished with appropriate tools and equipment to facilitate efficient workflow. Adjacent to the prep and assembly areas, the pantry includes designated spaces for cleaning and sanitizing dishes, utensils, and equipment. This typically includes dishwashing sinks, drying racks, and storage shelves for clean supplies.

Figure 37:The preparation area.

The kitchen:

Large stoves meant for boiling pasta and vegetables were seen to be part of the well-maintained kitchen. Temperature indicator devices were installed on these stoves to guarantee exact cooking temperatures. Exhaust systems were also put in place above the stoves to keep the kitchen's ventilation and air quality intact. Information given by the culinary staff indicates that a large amount of pasta—roughly 2000 kg per week—is regularly prepared. It was observed, although, that no monitoring system is in place now to keep track of food waste that occurs throughout the preparation and cooking stages.

The manager said that the university canteen kitchen operates on an approximate portioning strategy, typically preparing meals for around 800 individuals each day. However, it was noted that accurately estimating the daily population can be challenging due to fluctuations, making it difficult for kitchen staff to adjust their cooking activities momentarily to accommodate increased demand.

Figure 38:The kitchen area.

The Clean-Up zone:

The university cafeteria kitchen's cleanup zone is a crucial location where trash management and food service finish meet. Food trays from the dining halls are effectively moved here on trolleys so they can be cleaned and sanitized. The culinary crew in this busy area carefully sorts waste into appropriate containers, making sure that it is properly separated for disposal. There are sinks close by where you may wash utensils and cutlery while paying close attention to hygienic practices. After cleaning, these objects are carefully placed on drying racks, ready to be used in the dining halls later. It was discovered during a conversation with the manager that the cleanup zone processes between 70 and 80 kg of waste every day on average, which is equal to 1.5 bags of organic waste.

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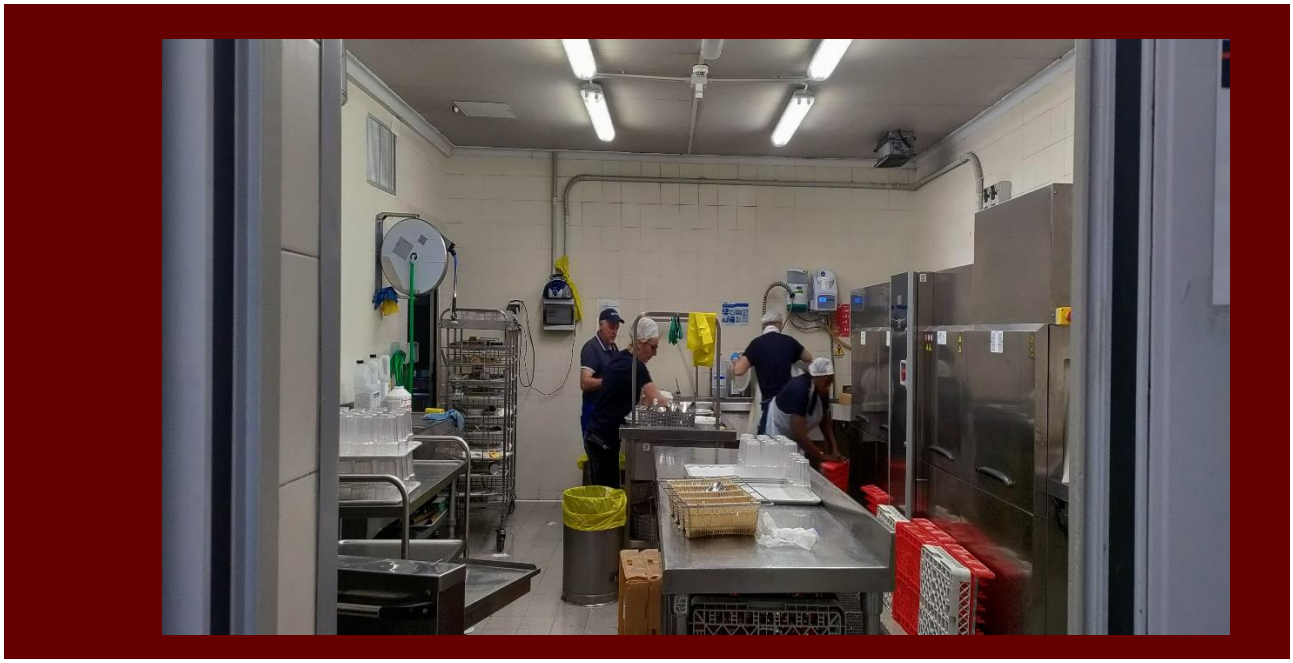


Figure 39:The cleaning area.

The Disposal area:

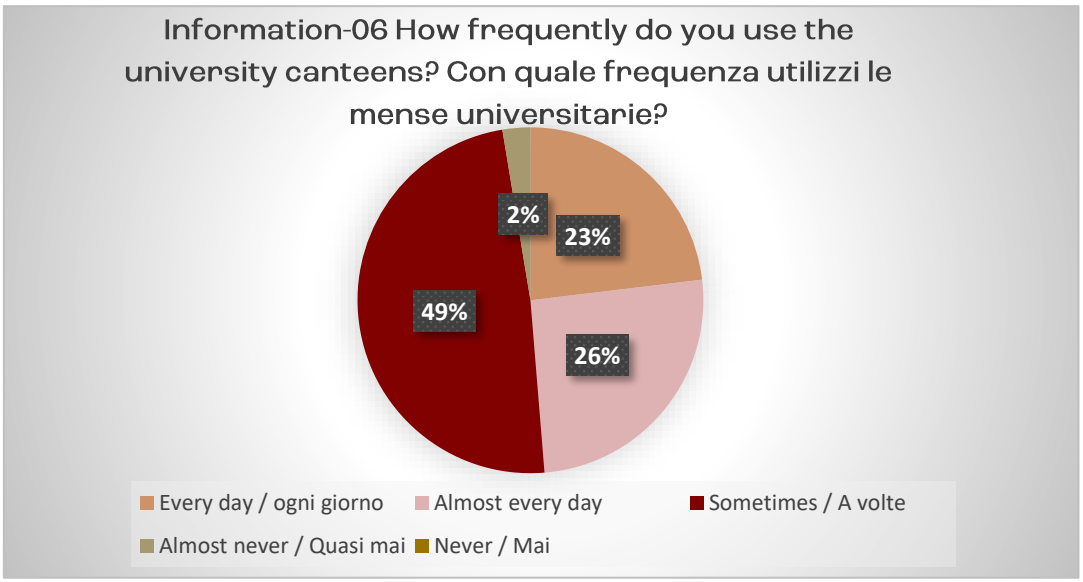
A designated area away from the Canteen has been allocated for the disposal of garbage, facilitating efficient waste management practices. Within this area, separate bins are provided for the segregation of waste into distinct categories, including paper, plastic, organic, and mixed waste. This meticulous sorting process ensures the optimization of recycling efforts and minimizes environmental impact. The disposal system operates in collaboration with the AMIAT organization, which collects specific types of waste on predetermined days according to a structured timetable.

Figure 40:The disposal area.

4.7 Questionnaire Results

The results part, which is presented in the following summarizes the most important findings from the survey conducted in the month of February through the help of Online platforms like WhatsApp, Instagram and Facebook. This study, which primarily analysed data from 86 students who participated in a survey out of 120 students whom it was shared to, provides a thorough investigation of food consumption habits within the Canteen at Politecnico. Through a thorough analysis of the gathered data, this research seeks to identify important patterns and actions that impact the production of food waste. We aim to offer significant insights that will direct the creation of focused initiatives for waste reduction in the canteen setting through a descriptive analysis of survey results. More results and graphics from the survey can be found in Annex A.

Starting with an analysis of the frequency of students using the canteen and their preferred canteen, it is evident that a significant portion of respondents visit the canteen regularly. Combined, those who reported visiting either "everyday" or "almost every day" account for 23% of the surveyed population, while those who visit "often" constitute 43%. Additionally, most participants, totalling 61%, indicated Catelfidardo as their preferred canteen, which aligns with our study focus, as it is our study site.



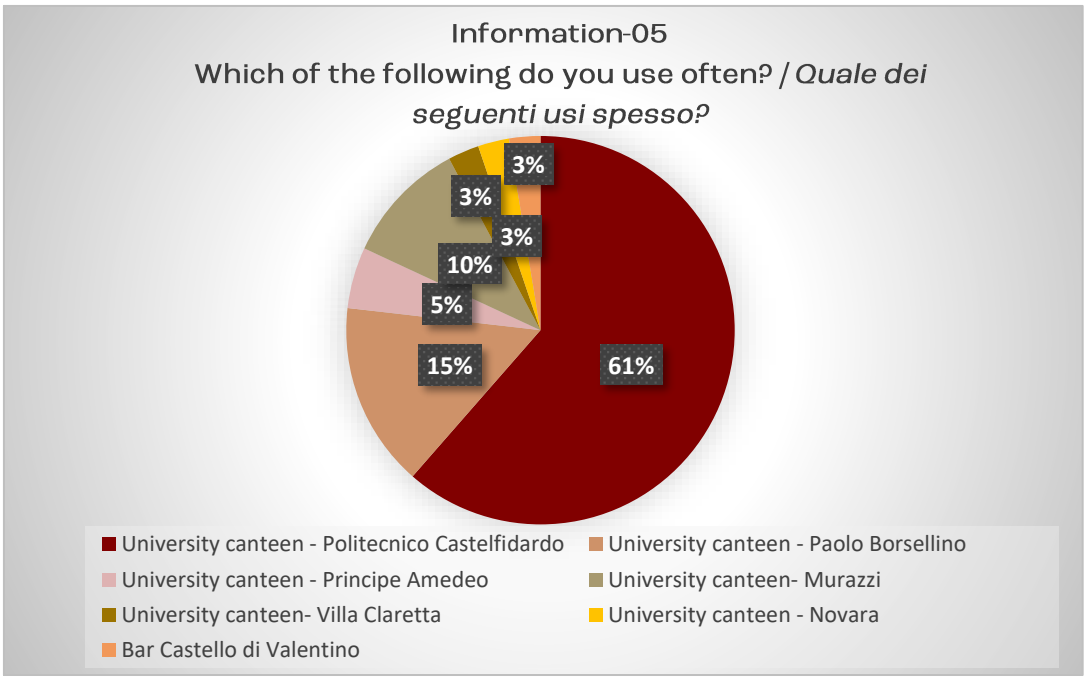


Figure 41:Frequency of using canteens and the most often used zone.

An insightful observation gleaned from the survey results is that a significant majority of students identified the condition of food as the primary reason for its disposal, particularly citing that it was not eatable or mouldy. This finding highlights the critical importance of food quality and preservation in reducing waste within university canteens. Moreover, the survey reveals other notable factors contributing to food wastage, including excessive portion sizes, lack of meal planning, unappealing leftovers, inadequate storage practices, and forgetfulness about stored food. Recognizing these multifaceted influences on food waste behaviour provides valuable insights for developing targeted interventions aimed at promoting sustainable consumption practices.

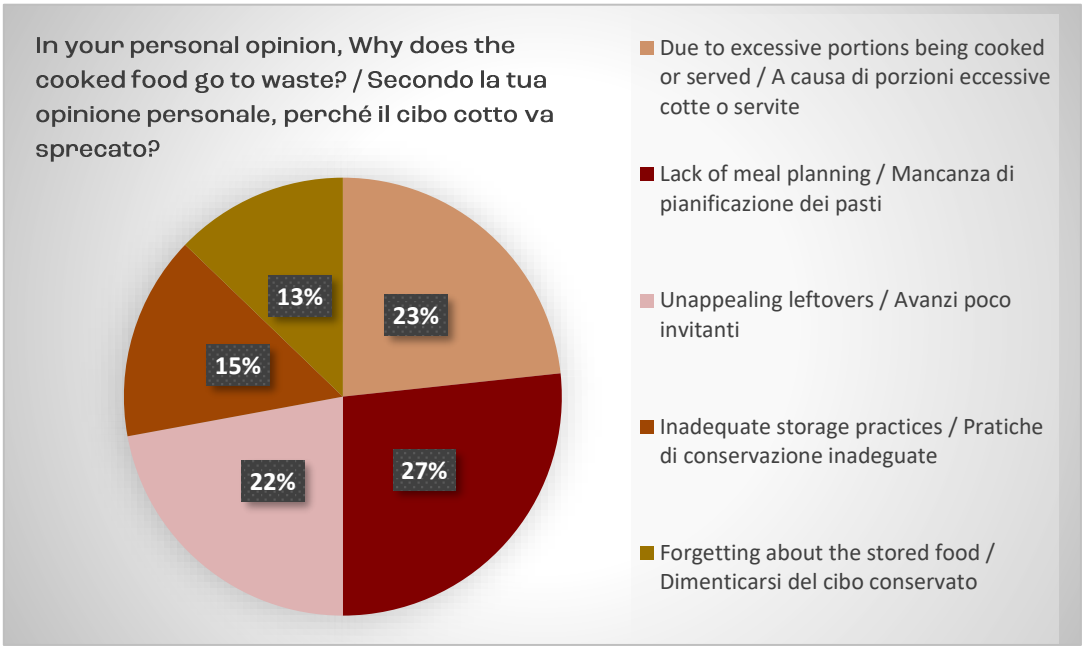


Figure 42: Reason to waste food.

Regarding monthly food budgets, the predominance of moderate to sufficient budgets among respondents, particularly within the ranges of 50-150 euros and 150-250 euros per month. While the exact distribution of budgetary values varies, these two categories collectively encompass most participants. This suggests that most students possess a reasonable number of financial resources allocated to food expenses. However, the implications of these budgets on food waste behaviour are multifaceted. While economic constraints may incentivize individuals to be more mindful of food usage, they can also drive reliance on cost-effective purchasing strategies, potentially leading to excess and subsequent waste. Understanding this interplay between budgetary constraints and waste generation presents an opportunity to design general food management habits.

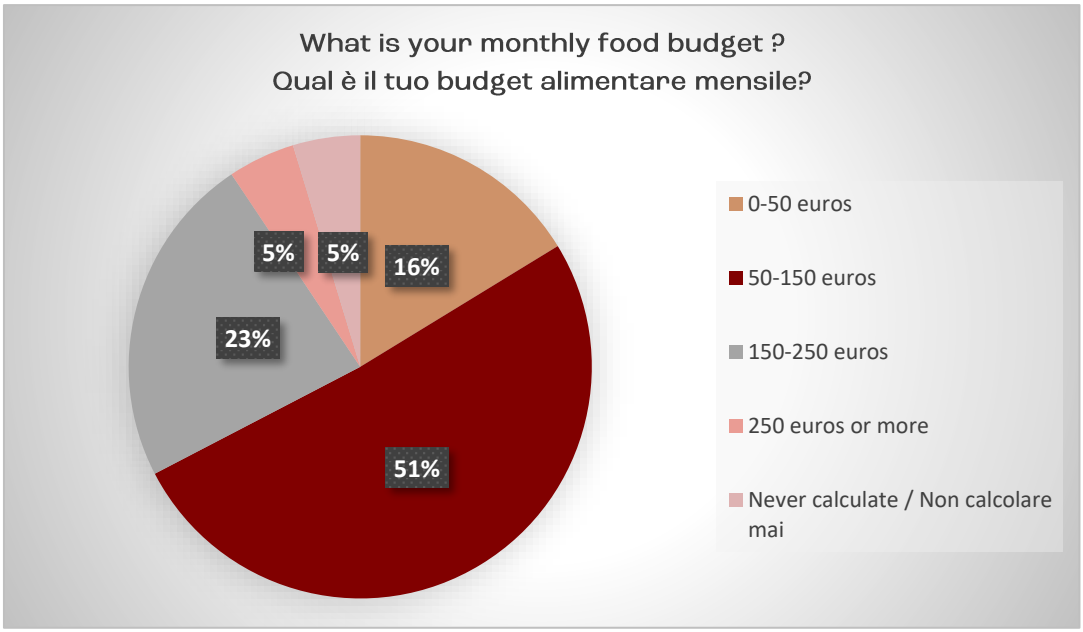


Figure 43:Monthly food budget.

A significant finding from the survey is the wide spectrum of consumer opinions regarding buying food items at a discount. A tendency to overbuy due to affordability was displayed by some respondents, while others prioritized food preservation even with discounts and only purchased what they needed. A segment also focused on mindful consumption, avoiding items that were almost expired or leftover. A smaller subset voiced doubts regarding deals that were discounted. Comprehending this heterogeneity is pivotal in formulating efficacious policies and interventions, customizing strategies to align with disparate consumer demographics. Some people might be influenced by food waste education campaigns, while others might be inspired by sales of eco-friendly goods.

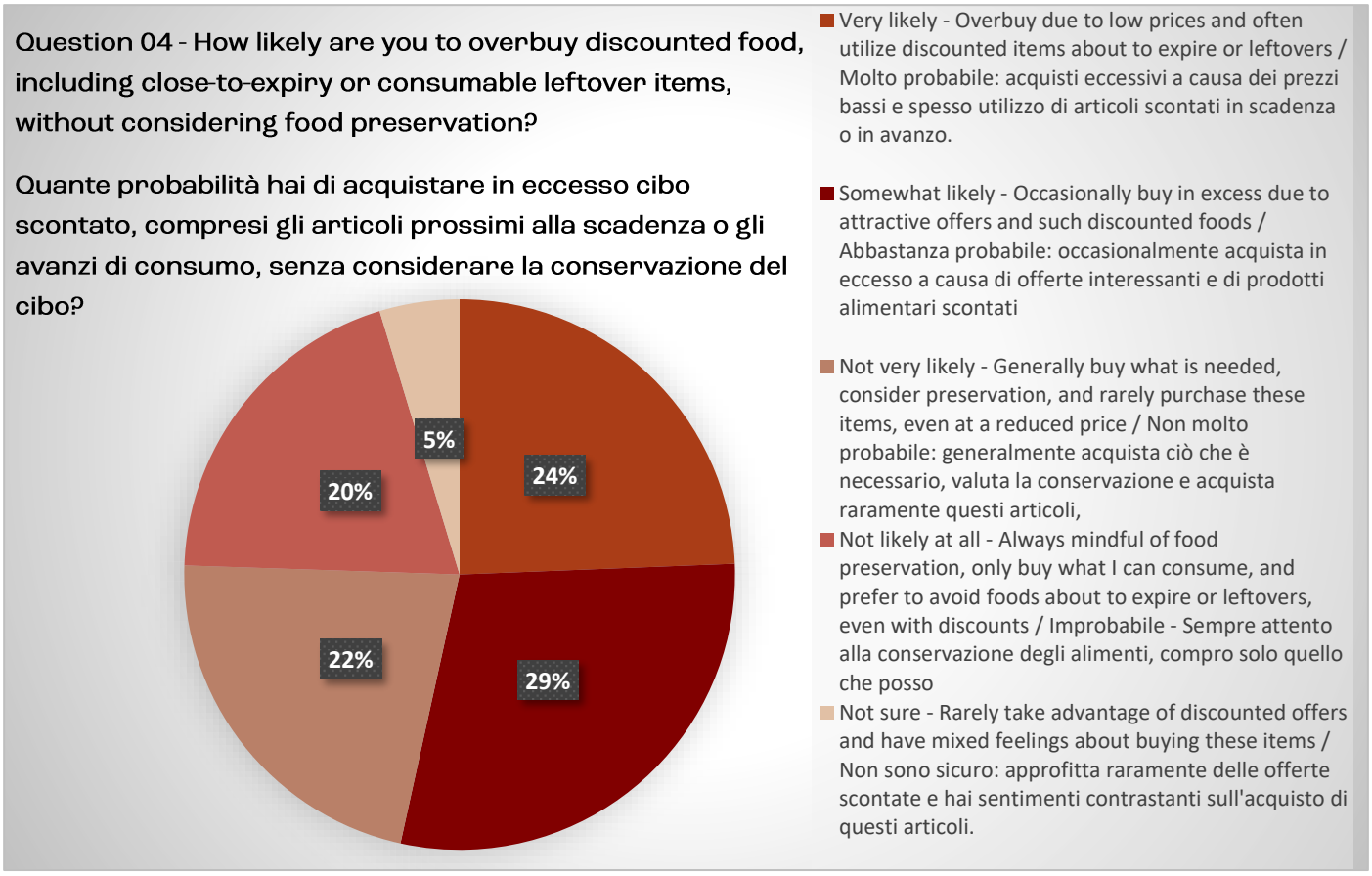


Figure 44:Overbuying discounted food.

The results of the survey illuminated several factors that lead to food waste in the pre-consumption environment of a canteen. The most important of them is the lack of tasty or healthful food options, which points to the urgent need for menu diversification and enhancements in the nutritional offerings. Furthermore, the participants indicated that excessive portioning by staff was a noteworthy issue, indicating possible avenues for training programs designed to encourage improved portion management techniques. In addition, issues with ineffective canteen design that result in long lines and hurried decision-making as well as inadequate food consumption monitoring were brought up. These findings highlight how critical it is to deal with these problems to reduce food waste and guarantee that meals are given in sufficient amounts, improving customer happiness and canteen operations' sustainability initiatives.

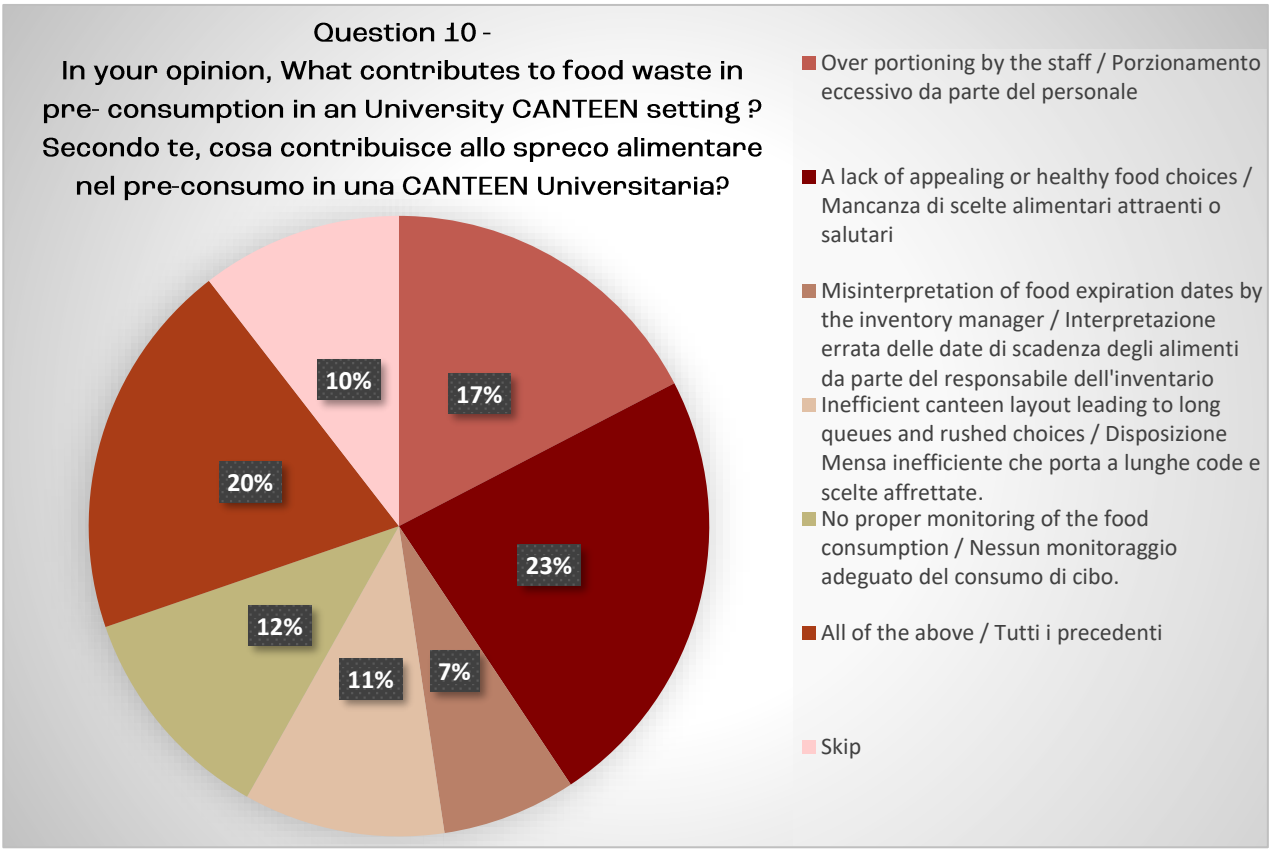


Figure 45:Reason for waste occurring in pre-consumption setting.

Building upon the previous explanation, Food left on plates is the most common type of waste found, suggesting that students are probably served more food than they can eat and discarding the remaining. Furthermore, a lot of fruits and vegetables are wasted, which could indicate problems with student preferences. Remarkably, dairy items and condiments/spices account for a decreased percentage of waste, suggesting that students are managing or using them more effectively. Notably, the least wasted foods are pasta and fish or meat, suggesting potential to maximize portion sizes and menu planning. This provides a clear indication of possible areas for portion planning optimization.

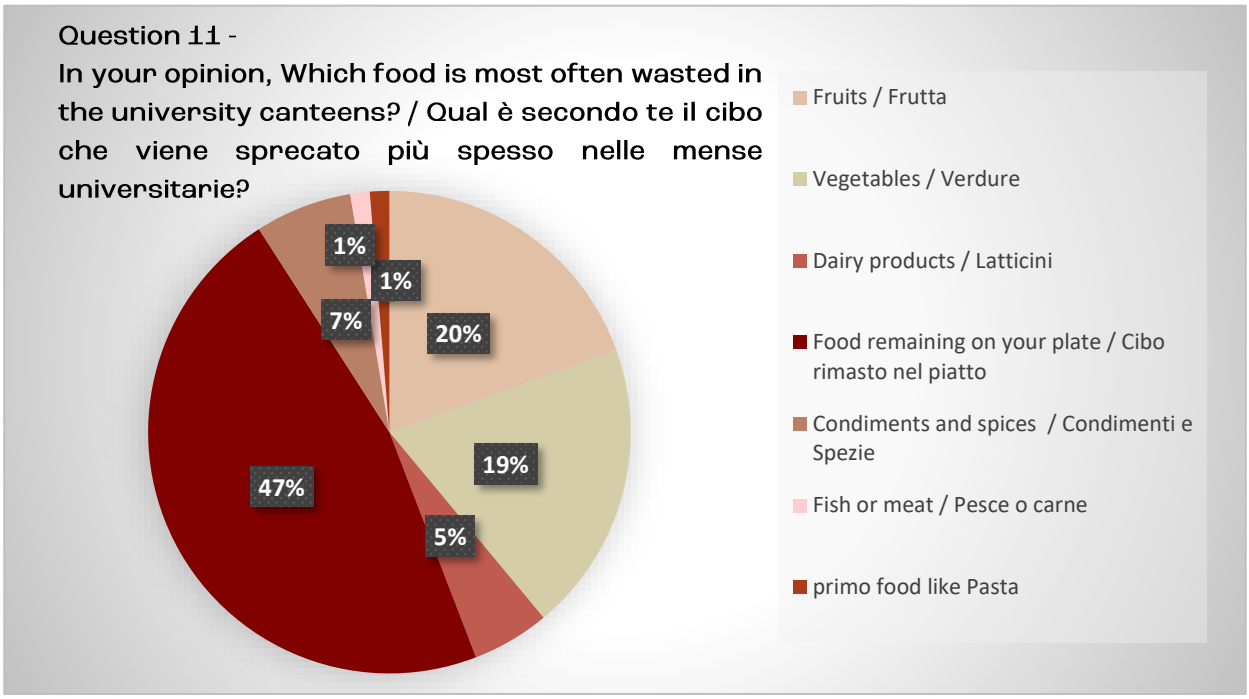


Figure 46:Most common food wasted in canteen.

Another prevalent issue highlighted is the tendency to discard leftovers rather than preserving or reusing them, indicating a lack of knowledge or resources for efficiently managing food surplus. Respondents also emphasized the ineffective tracking of food consumption patterns, suggesting a need for improved data analysis to inform menu planning decisions. Additionally, there is a notable deficiency in knowledge and instruction regarding food waste, underscoring the importance of educational programs to promote conscientious consumption practices among students. Time constraints during mealtimes were identified as a contributing factor to increased plate wastage, suggesting challenges in managing meal service efficiently. Lastly, the desire to try every dish on the menu but not being able to finish it all at once indicates a potential mismatch between students' expectations and consumption capacity, necessitating menu planning strategies that accommodate varied preferences and portion sizes.

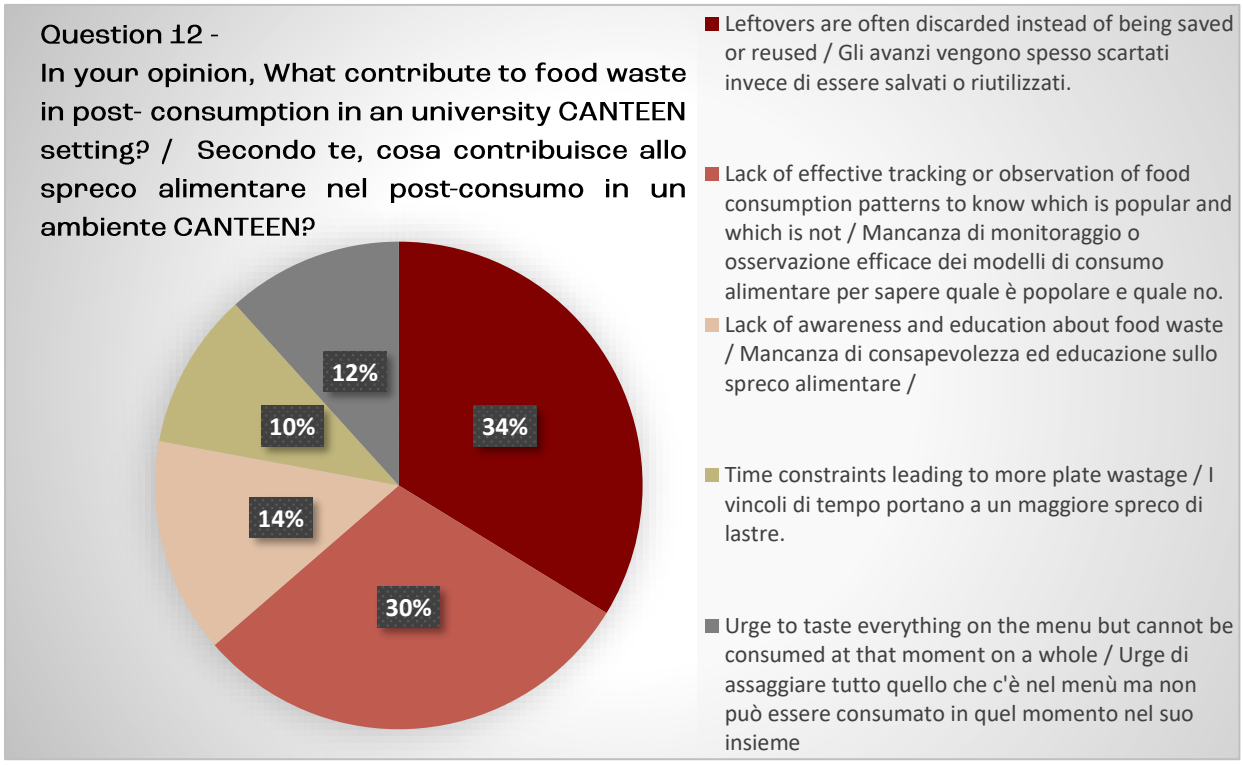


Figure 47:Reason for food waste in post-consumption setting.

Followed by this, several strategies were proposed by respondents to prevent food waste. One common suggestion was to utilize technology, such as smartphone reminders for expiry dates and smart labelling to track food expiration. Additionally, the idea of sharing food with others and utilizing smart fridges/freezers was mentioned. Another approach suggested was to buy less fresh food. A significant proportion of respondents favoured the idea of incorporating all the above strategies.

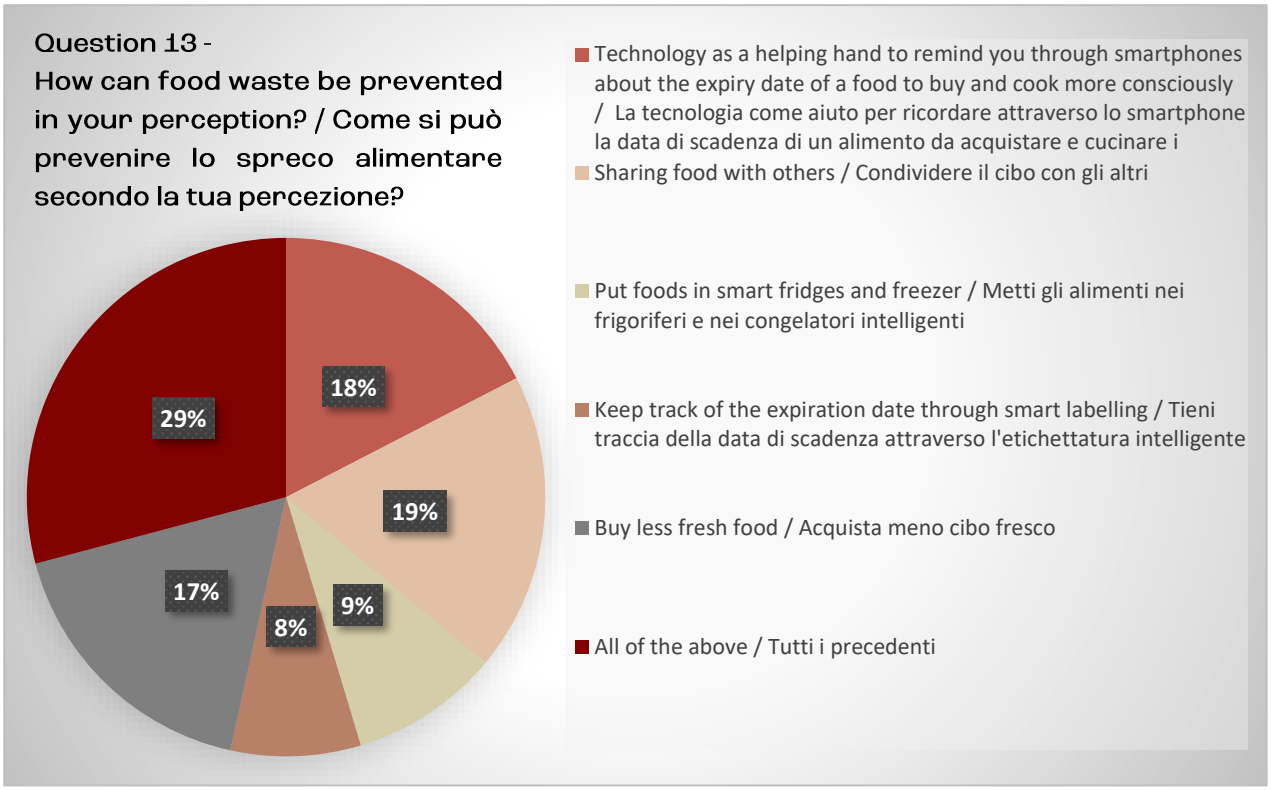


Figure 48:Perception of strategies for preventing food waste.

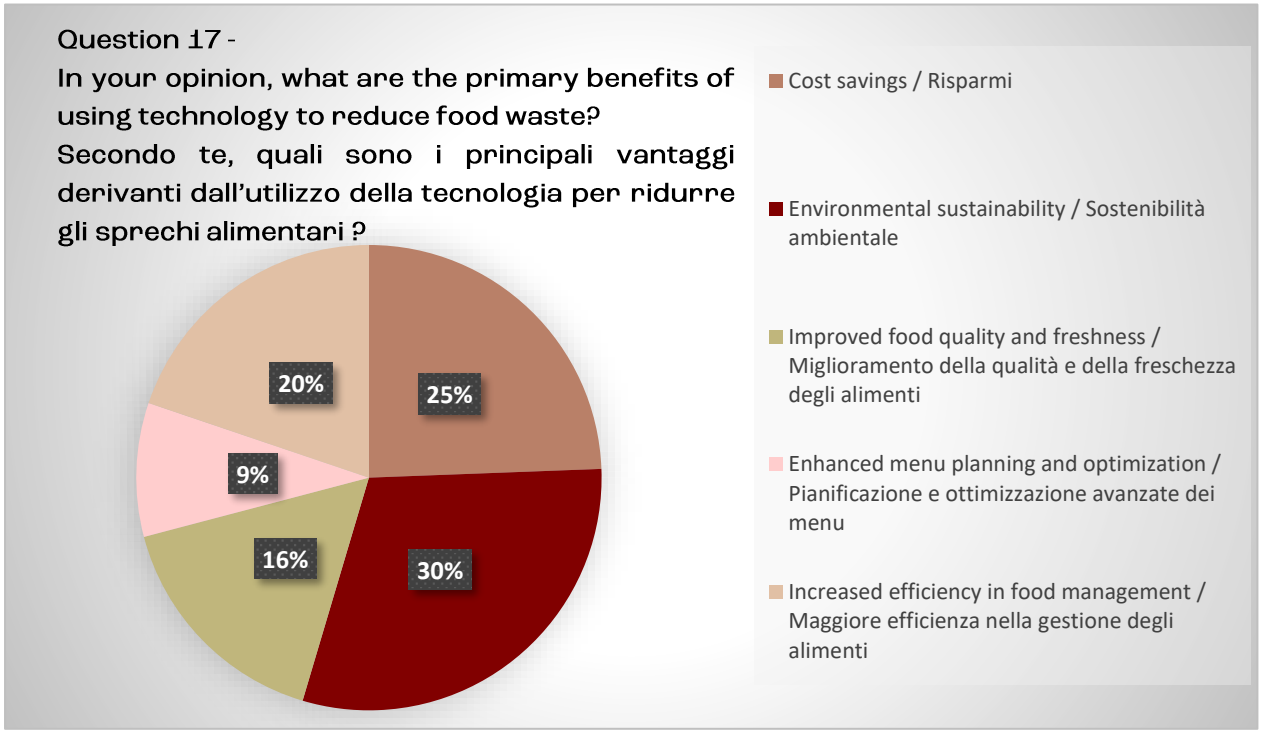


Figure 49: Benefits of using technology.

When considering the implementation of technology-driven solutions to address food waste, several challenges may arise. One significant hurdle is resistance to change in traditional food management practices. This resistance can stem from entrenched habits and cultural norms within food service operations. Privacy and data security concerns also pose a challenge, especially when implementing systems that involve the collection and management of sensitive information. Additionally, the high costs associated with technology implementation can present barriers, particularly for institutions with limited financial resources. A lack of technical expertise and infrastructure further complicates implementation efforts, as proper training and suitable technology infrastructure are necessary for successful deployment. Furthermore, potential conflicts with existing policies may hinder progress, requiring careful alignment and integration of new technology-driven approaches with established protocols.

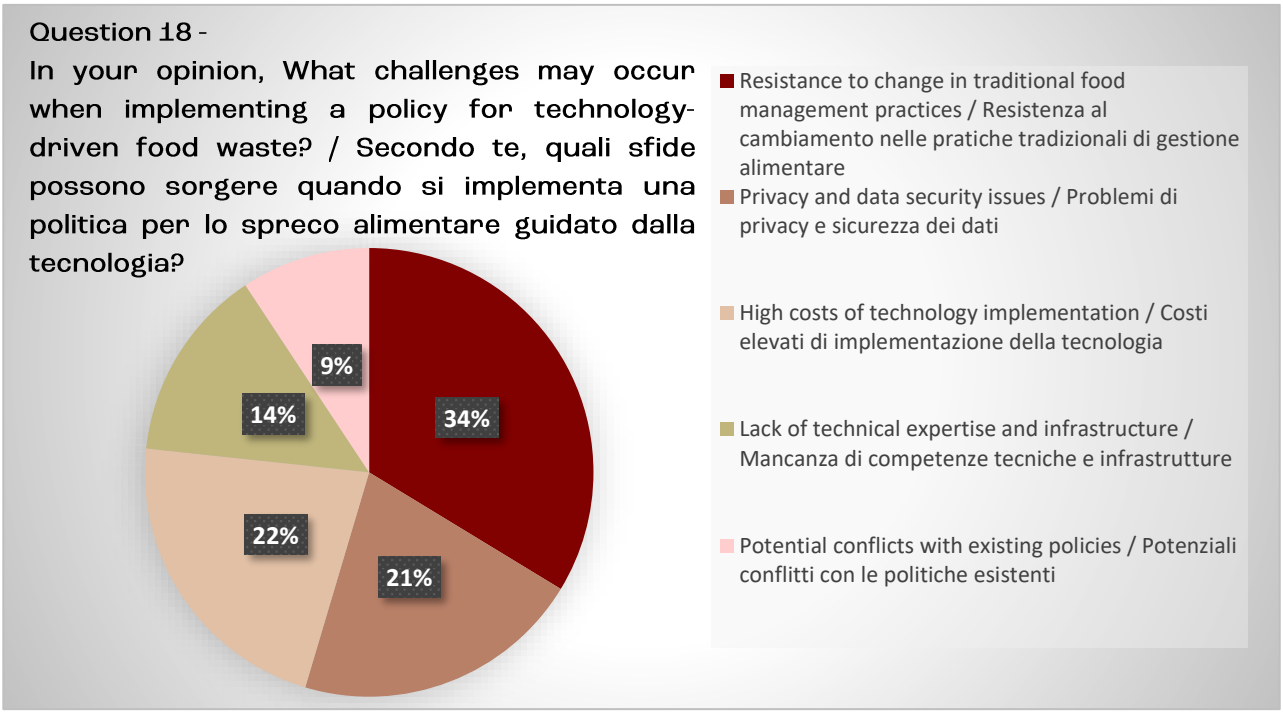


Figure 50:Challenges that might occur in implementing policies for tech-driven food waste reduction.

4.8 SWOT Analysis

This analysis draws data from the On-site survey evaluating the current spaces and the management of these spaces and a questionnaire survey among students to take insights of their practices and needs. By organizing the internal strength and weakness present alongside external opportunities and threats offers a comprehensive framework for strategic planning. It also ensures that proposed strategies are responsive to actual conditions and user feedback, facilitating the development of policies that enhance strengths, address weaknesses, capitalize on opportunities, and mitigate threats.

Strategic organization demonstrating thoughtful approach to space utilization & Customer satisfaction.

Student recharge and payment methods enabled with technology aligns with modern advancements in food service operations.

Involvement of the canteen workers and students in the survey demonstrates diverse perspectives considered and collaboration towards successful implementation.

The sustainable education initiatives such as the "Green food week" empower stakeholder empowerment.

The consideration of Budgetary constraints allows targeted intervention while promoting waste reduction strategies that are economical.

The absence of waste monitoring system throughout the preparation & cooking stages to address inefficiency in the processes.

Lack of a technical expertise to support in implementing & maintaining tech- driven solutions.

The observation of lack of tasty/ appealing food menus tells us there are no apps/website to meet the preference between liked and disliked food.

Lack of pre- booking software for the dining area leads to difficulty in estimating the number of diners per day.

Absence of necessary packing items to take-away the remaining leftover food on plate.

Innovative approach with tech tools to minimize the wastage from pre-consumption to post-consumption stages.

Collaborate with Tech companies, expertise to support implementation of innovative solution.

Implement more educational campaigns and workshops through social media apps for faster reach.

Conducting menu polls/audit based on consumer preference to satisfy diverse dietary.

Advocating policies, incentives for Tech adoption and regulatory support for waste prevention measures.

Implementing a culture of continuous monitoring & feedback mechanism for a Life cycle assessment ensuring the effectiveness and sustainability over time.

Economic availability might limit the usage of Technology.

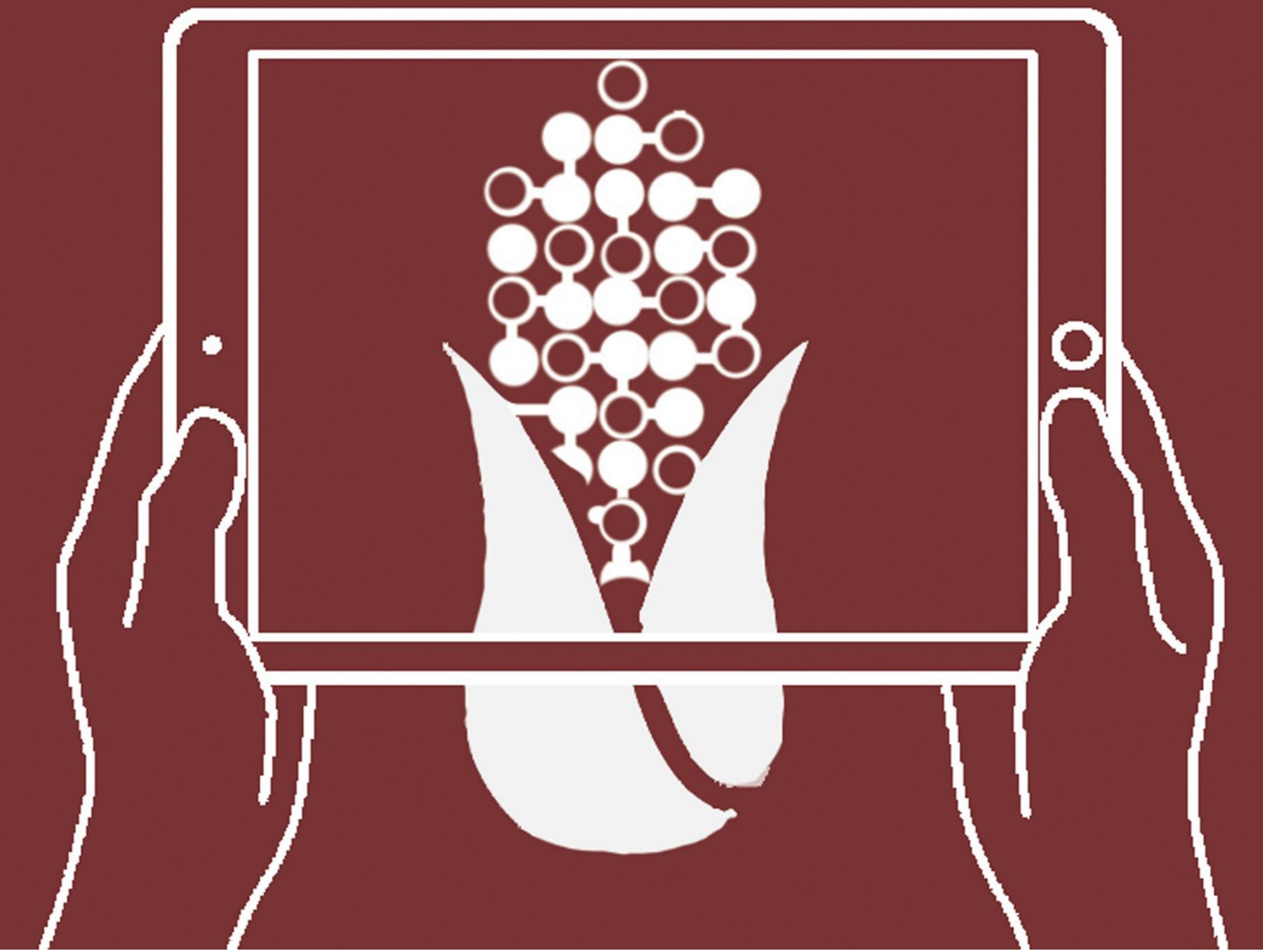
Changing of regulations & advancements might take time than expected for people to get adapted to it.

May render the implemented solution obsolete over time, requiring regular updates &

Deeply ingrained cultural norms & traditional practices hinder efforts to promote behavioural change.

External factors like stakeholder de-engagement, system failures and supply chain interruption can undermine the success.

05 PROJECT PROPOSAL



5.1 Harnessing digital solutions

Campuses are increasingly using digital solutions to address inefficiencies in the stages of the food supply chain as part of the ongoing fight against food waste. Campuses can employ creative approaches to reduce waste production, maximize resource use, and encourage sustainable consumption practices among employees and students by utilizing technology. In this brief, we examine how the use of digital tools can transform food management procedures, from purchasing to eating, ultimately resulting in a notable decrease in food waste on college campuses.

The challenge of feeding a growing population without destroying the planet's resources requires innovative solutions. Technology can play a crucial role in reducing food waste and ensuring a more sustainable food system.

– Ellen MacArthur

Technology presents a multitude of opportunities to stop food waste before it happens during the pre-consumption phase. Campus dining facilities can track food stocks in real-time with digital inventory management systems, which improves forecasting and lowers the risk of overordering or underusing ingredients. Furthermore, trends and patterns in food consumption can be found with the use of data analytics and predictive modelling, which makes menu planning and portion control techniques more intelligent and helps reduce food waste. Furthermore, by offering details on the origin of ingredients, nutritional value, and advice on meal preparation, mobile apps and digital platforms can enable students to make more environmentally friendly food choices.

Technology is essential in the post-consumption phase for removing excess food from the waste stream and giving it to people who are in need. Campus dining facilities can donate extra food that would otherwise be thrown away by connecting with nearby food banks, shelters, and community organizations through digital platforms and apps. Campuses can maximize the social impact of surplus food redistribution efforts by utilizing technology to streamline the donation process and ensure food safety compliance. Additionally, food waste produced during meal service can be tracked and monitored with the use of digital tools, which can offer insightful data that can be used to pinpoint problem areas and maximize operational effectiveness. For instance, real-time monitoring of food waste by smart waste tracking systems using sensors and IoT technology enables focused interventions and waste reduction. Campus dining can use data analytics to identify patterns, trends, and the underlying causes of food waste. This allows them to put effective solutions in place and keep improving their food management procedures.

5.1.1 The FW hierarchy changed with the SI model in canteen service.

In the context of canteen service sectors and the transformation of the food waste hierarchy (Refer 3.3) through social innovation (SI) initiatives, it's essential to consider the definitions provided by Teigiserova et al., 2020. They define food waste (FW) as surplus food (SF) that is not utilized for feeding people, highlighting the inefficiencies in food utilization (Paola Garrone, 2014). On the other hand, food loss (FL) specifically refers to the streams of food that are genuinely lost, whether due to unaccounted factors or disappearing from the accounting altogether (Dominika Alexa Teigiserova, 2020).

In the realm of SI initiatives within canteen service sectors, there is a notable emphasis on the central roles played by the community or individual, aspects often absent in traditional or top-down approaches. SI initiatives typically do not emerge when solutions are tied solely to regulatory interventions under public authority or purely technical and technological innovations. Consequently, SI initiatives are less prevalent or absent at the processing, packaging, and transportation levels of the Food Supply Chain (FSC), but are more concentrated at the extremities, particularly at the consumption level.

Here is a graph showing the possible technology intervention as the SI model in the transformation of food waste hierarchy pyramid.

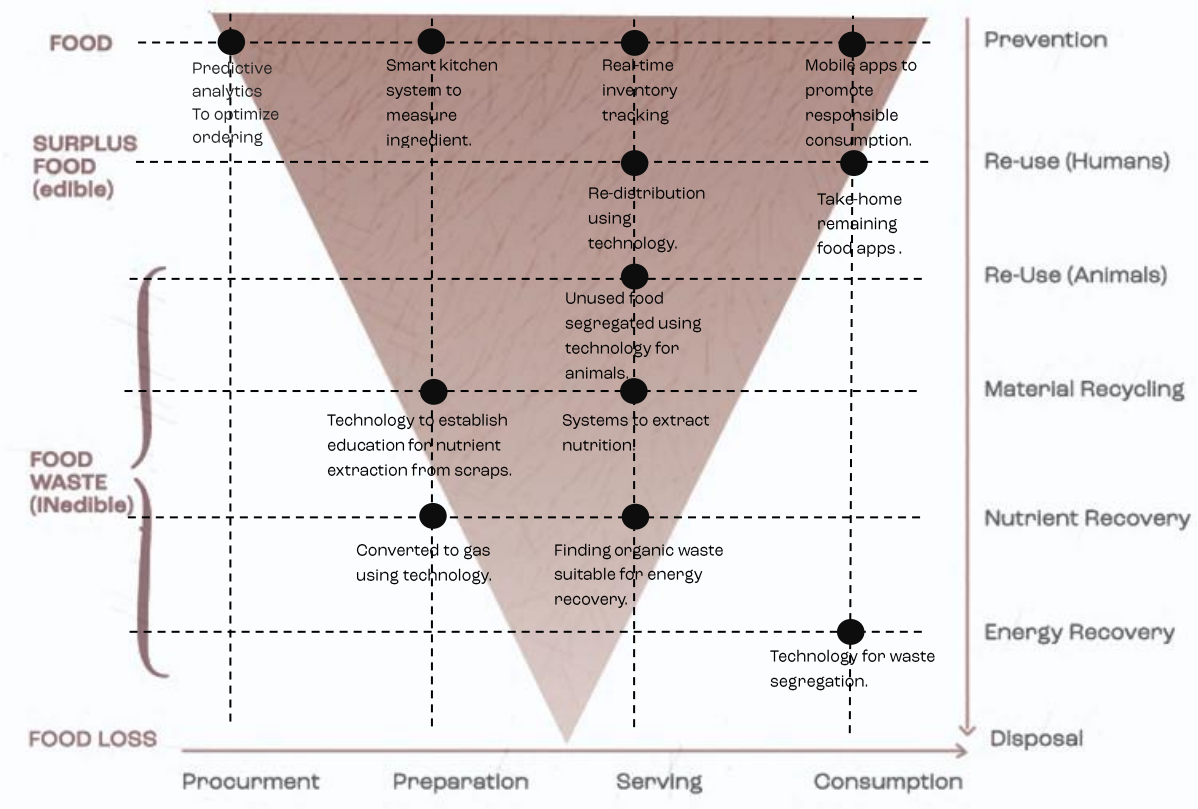


Figure 51:Intervening hierarchical model with Technology based solution. Source: by author.

Integrating technology as a Social Innovation (SI) tool within the food waste hierarchy in university canteens offers numerous opportunities to enhance community engagement, empower stakeholders, and drive sustainable practices. Therefore, the benefits of transforming the hierarchy with technological intervention as the SI model can be-

Community engagement and empowerment:

Technology-enabled platforms provide an avenue for students, faculty, and staff to actively participate in waste reduction initiatives. Through mobile apps or online portals, individuals can track their own food waste contributions, set goals for reduction, and collaborate with others in the community. This fosters a sense of ownership and responsibility, empowering stakeholders to take meaningful action towards sustainability.

Transcending traditional methods:

Unlike top-down approaches, which often rely on mandates or directives from higher authorities, technology-driven solutions encourage inclusive participation and collaboration. By democratizing the decision-making process, university canteens can harness the collective wisdom and creativity of their community members to develop innovative strategies for waste reduction.

Collaboration across the food supply chain (FSC):

Technology facilitates seamless communication and coordination among stakeholders across the FSC, including food suppliers, distributors, canteen operators, and consumers. Real-time tracking and reporting of food waste data enable stakeholders to identify inefficiencies, optimize inventory management, and implement targeted interventions to minimize waste at every stage of the supply chain.

Informed decision making:

By leveraging data analytics and predictive modelling, technological platforms provide insights into patterns and trends in food waste generation. This enables canteen managers to make data-driven decisions regarding menu planning, portion sizes, and inventory management, ultimately reducing waste and maximizing efficiency.

Policy implementation for sustainable practices:

Policies can play a crucial role in incentivizing waste reduction efforts within university canteens. Reward and recognition programs can recognize individuals or departments that excel in waste reduction, fostering a culture of sustainability. Educational campaigns leveraging technology, such as interactive workshops or online modules, can raise awareness about the environmental impact of food waste and promote behaviour change among students and staff.

€ Investment in infrastructure and Partnerships:

To support the implementation of technology-driven waste management solutions, investments in infrastructure are essential. This may include upgrading kitchen equipment, installing composting facilities, or implementing food donation programs. Partnerships with tech companies can also facilitate the development of tailored solutions that meet the unique needs and challenges of university canteens.

Cultural shift towards mindful consumption

Ultimately, the integration of technology as an SI tool in university canteens can catalyse a cultural shift towards mindful consumption and sustainable living. By embedding sustainability principles into everyday practices, university campuses can serve as living laboratories for innovation and inspire future generations to become stewards of the environment.

5.2 Possible technological solutions for the Polito canteen

Efficient food waste management within university canteens necessitates a comprehensive strategy that addresses multiple intervention areas. Drawing from insights gleaned from on-site surveys and descriptive survey analyses outlined in chapters 4.2 and 4.3, several potential intervention points have been identified for leveraging technology as a tool to reduce food waste.

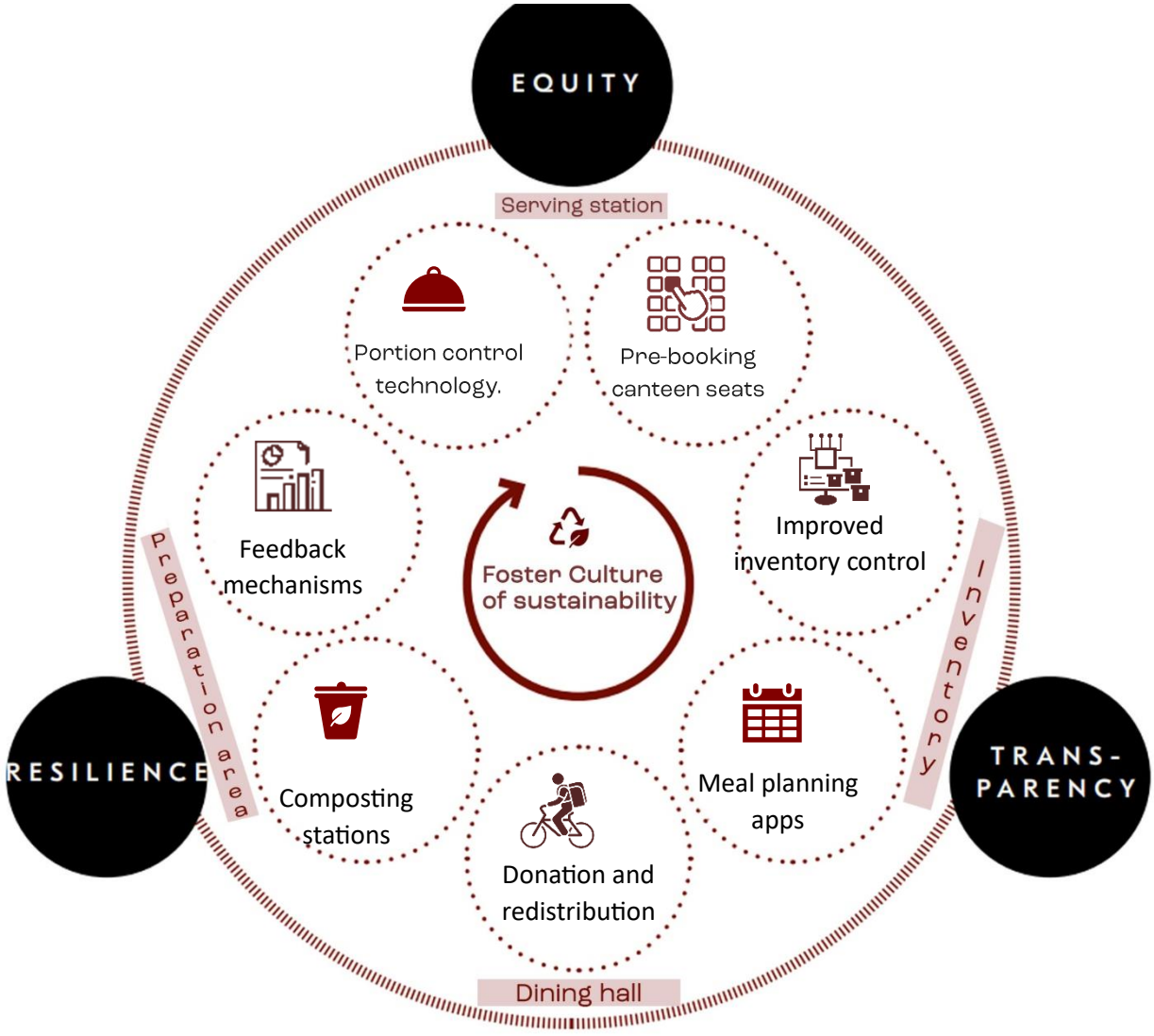


Figure 52:Possible intervention areas and Technologies.


Improved inventory management
Food waste analytics (Pre-consumption)
Pre-booking Apps
Food waste analytics (Post-consumption)
Donation & Redistribution apps

5.2.1 Technology interventions in serving station.

The foremost intervention with technology-based app is to implement pre-reservation system to book prior for the dining service. Implementing a technology app for pre-reserving seats in the canteen offers numerous benefits for both the university and its students. Firstly, it allows for better estimation of the number of persons eating per day, facilitating more accurate food preparation, and reducing food waste in the process. This intervention area directly addresses the challenge of portion control and waste reduction within the serving station, ensuring that food production aligns closely with actual demand (Mamaril, 2017).

Furthermore, the app streamlines the dining experience for students by allowing them to reserve seats in advance, minimizing waiting times and enhancing overall efficiency. This intervention area corresponds to the dining area space within the canteen, where the efficient allocation of seating contributes to a smoother flow of operations and improved customer satisfaction.

The integration of barcode technology within the canteen reservation app can be achieved using various methods. (Ess). One approach is to utilize barcode generation libraries or APIs (Application Programming Interfaces) within the app's backend infrastructure. These libraries can dynamically generate unique barcodes for each reservation, incorporating relevant information such as reservation ID, time slot, and seat number. Additionally, mobile barcode scanning technology can be integrated into the app's user interface, allowing students to access their reservations by simply scanning the barcode displayed on their smartphone screens. This seamless integration enhances user experience and ensures efficient access to canteen facilities. Real-time updates on seat availability and occupancy levels can be facilitated through cloud-based databases and synchronization mechanisms, enabling instant data updates, and ensuring accurate information for students making dining decisions.

Additionally, the app's ability to collect data on reservation patterns over consecutive years enables universities to conduct life cycle assessments and analyse day-to-day consumption patterns. This data-driven approach supports informed decision-making and allows for continuous optimization of food production and service operations.

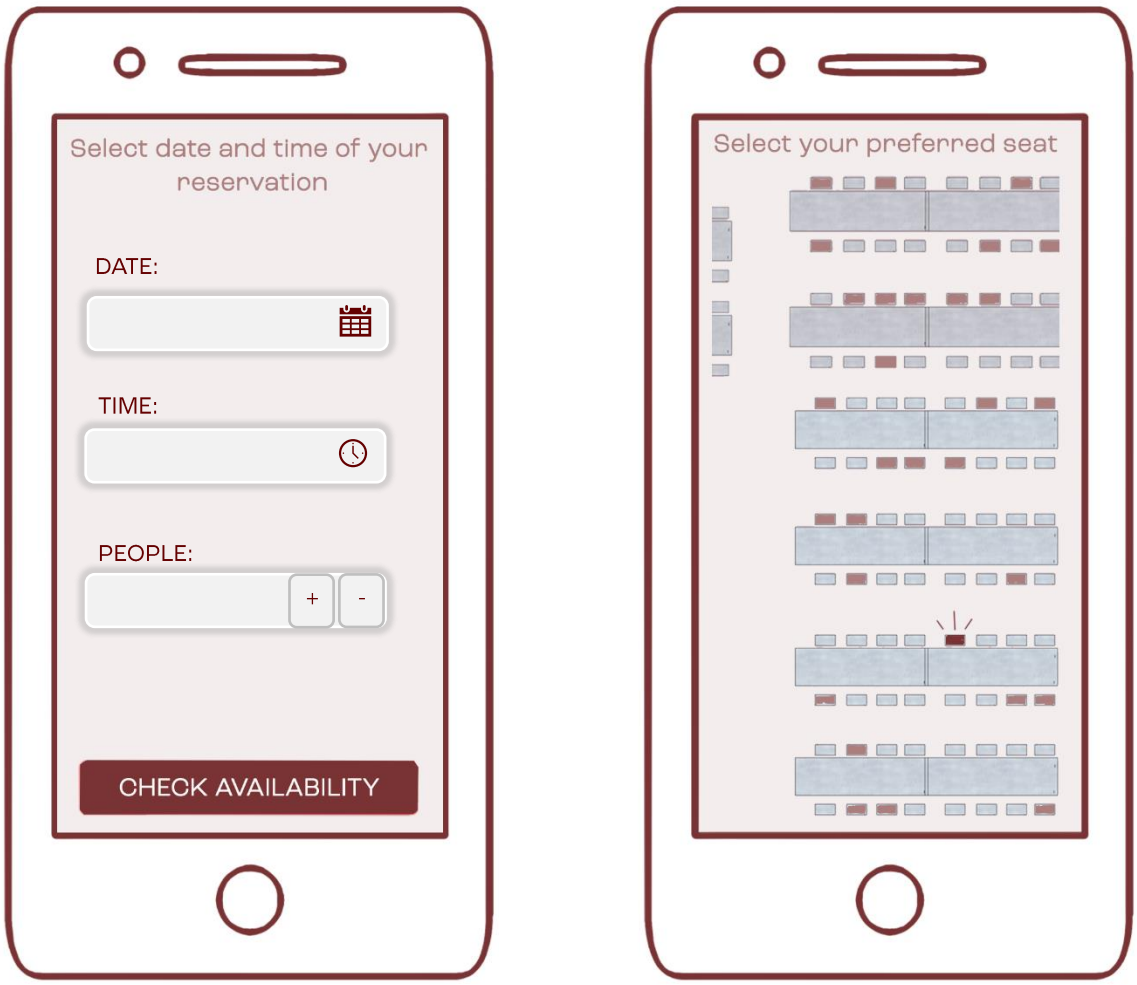


Figure 53: Module representation of pre-booking app.

One of the Best practices analysed from international level, Opera Universitaria, Trento has successfully implemented an app for reserving seats beforehand in their canteen facilities. The app allows students to make reservations directly from their smartphones, with a barcode provided for easy access. At the entrance to the restaurants, terminals display real-time information on seat availability, booked seats, and occupancy levels, enhancing transparency and efficiency in the dining process. Additionally, the app provides nutritional information for each menu item, allowing students to make informed choices based on their dietary preferences and requirements. Furthermore, the app collects data on reservation patterns over time, enabling Opera Universitaria to analyse day patterns and optimize food production quantities accordingly. This data-driven approach supports the canteen's efforts to minimize waste and enhance sustainability by aligning food preparation with actual demand and nutritional preferences of students (Ope).

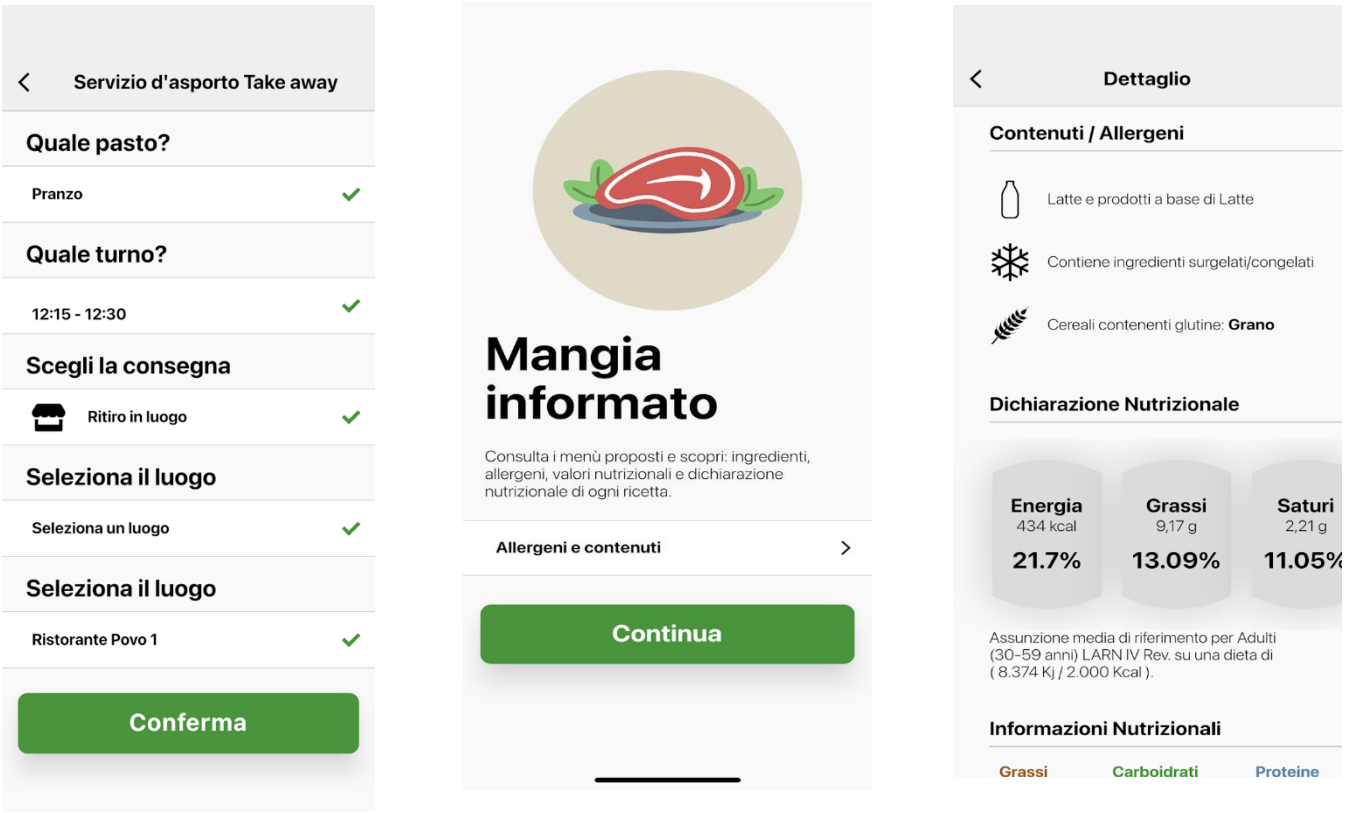


Figure 54: Opera4U app Interface. Source: Google Play store, Developer – Ristocloud group S.r.l

Secondly, the technology that we can implement in the serving station is the smart portion control technology. In the context of a student canteen, implementing a smart portion control technology centred around smart weighing systems offers a transformative solution to enhance efficiency, accuracy, and nutritional awareness. These systems can revolutionize the serving process by integrating advanced scanning and weighing capabilities to provide precise measurements of the food being served while simultaneously offering insights into its nutritional content.

At the core of this technology are sophisticated scanning systems equipped with sensors capable of identifying and analysing various food items placed on serving plates or trays. As students approach the serving station, they can place their plates or trays on the designated area equipped with these sensors. The scanning system then swiftly recognizes the contents of the plate, capturing detailed information such as weight, portion size, and even nutritional composition through advanced image recognition algorithms. Once the scanning process is complete, the collected data is seamlessly integrated into a centralized AI-powered platform. Here, sophisticated algorithms leverage the gathered information to calculate the nutritional content of the meal, considering factors such as calories, macronutrients, vitamins, and minerals. This real-time analysis enables students to make informed decisions about their food choices, promoting healthier eating habits and fostering nutritional awareness among the student community. Moreover, the smart weighing systems can be programmed to align with individual student preferences and dietary requirements (Celikcan, 2018).

By linking the scanning technology with personalized profiles stored in a central database, students can set their portion size preferences and nutritional goals beforehand. The system then adjusts the serving size, accordingly, ensuring that each student receives a meal tailored to their specific needs while minimizing food waste. Furthermore, implementing a pricing model tied to portion size encourages students to make more conscious decisions about their food choices. With the financial implications of their selections directly linked to portion size, students are motivated to select portion sizes that align with their hunger levels and preferences, minimizing the likelihood of over-ordering or leaving food uneaten.

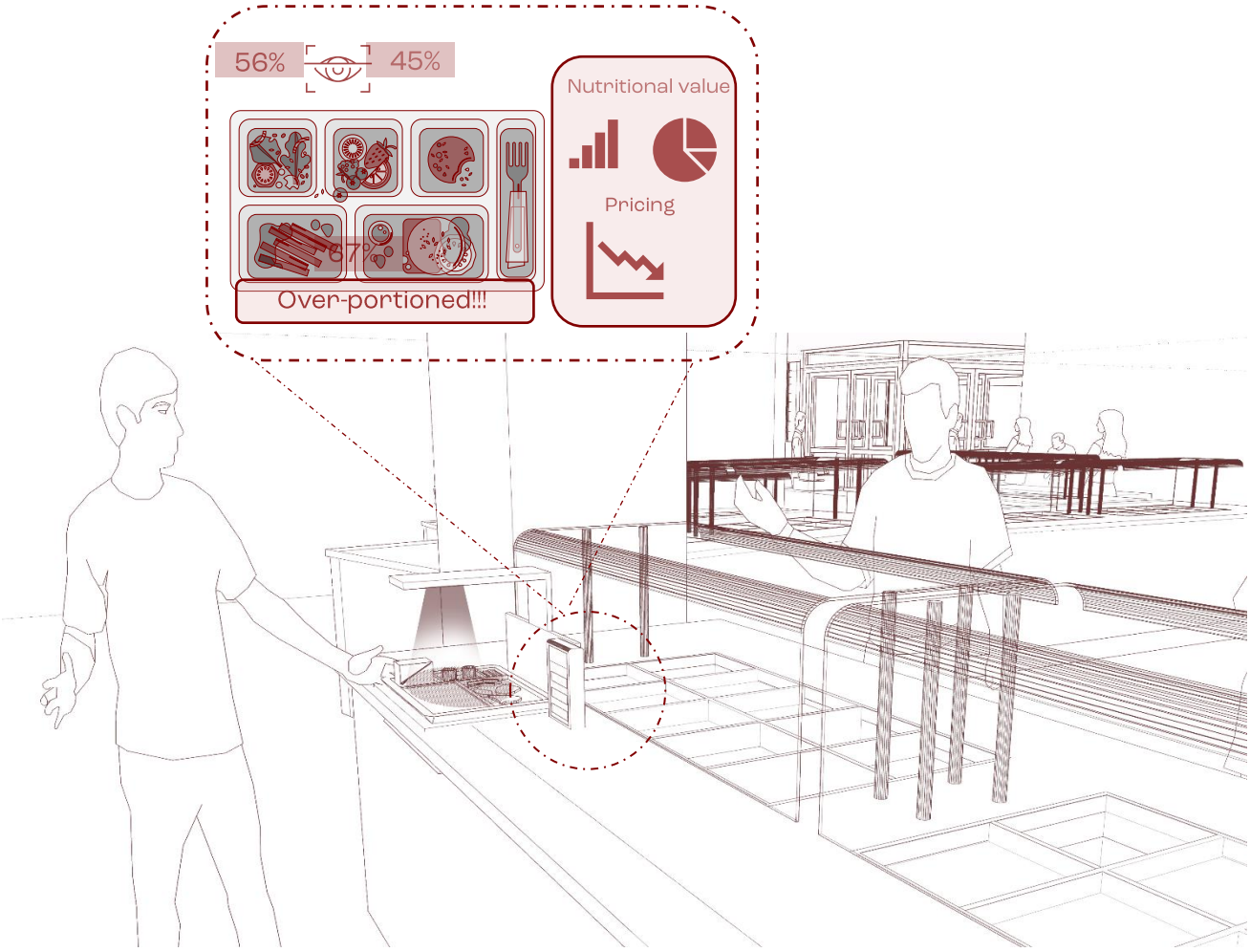


Figure 55: Visual representation of the portion-control technology.

The other best practice is a pioneering initiative at Zhejiang University in China, smart portion control technology was implemented in the university's student canteens to revolutionize the dining experience and tackle food waste. Leveraging advanced scanning and weighing systems, coupled with AI-driven nutritional analysis, the technology provided students with real-time insights into portion sizes and nutritional content while dynamically pricing meals based on weight consumed.

Figure 56:The buffet system of East China's Zhejiang university having the smart weighing technology. Source: (news).

5.2.1 Serving station. 5.2.2 Inventory. 5.2.3 Preparation area. 5.2.4 Dining hall

5.2.2 Technology interventions in Inventory Area.

In today's dynamic food service industry, effective inventory management is paramount to the success of student canteens. However, with limited space and resources in inventory and preparation areas, optimizing stock levels while minimizing waste presents a significant challenge. Traditional inventory management approaches often fall short in addressing the complexities of fluctuating demand and evolving consumer preferences. As such, there is a growing need for innovative solutions that leverage cutting-edge technologies to enhance efficiency and accuracy in inventory control. By integrating four key components given below enable caterers to enhance operational efficiency, reduce stockouts, and optimize resource utilization (Fostercapital, 2024).

Accurate demand forecasting

Efficient order management

Real – time inventory tracking

First-in & First-out inventory management

Figure 57: Inventory management with real-time tracking using technology.

Accurate Demand forecasting-
One of the key benefits of implementing an inventory management system is its ability to accurately forecast demand. By analysing historical data and trends, these systems can predict future demand patterns with a high degree of accuracy. This allows businesses to optimize their supply chains by stocking exactly the right amount of inventory at any given time, reducing the risk of overstocking or stockouts.

Efficient Order Management-
Inventory management systems also streamline the order management process, making it more efficient and reducing the risk of errors. These systems allow businesses to automate the ordering process, ensuring that orders are placed at the right time and in the right quantities. This not only reduces the administrative burden on staff but also minimizes the chances of overordering or underordering.

Real-time Inventory tracking-
Another significant advantage of inventory management systems is their ability to provide real-time inventory tracking. With these systems, businesses can monitor their inventory levels at any given time, enabling them to make informed decisions about stock replenishment and reducing the risk of stockouts.

FIFO (First In, First Out) Inventory Management-
Inventory management systems also support the implementation of the FIFO (First In, First Out) method, which is crucial in reducing waste, particularly for perishable goods. The FIFO method ensures that the oldest inventory is sold or used first, reducing the chances of spoilage or expiration.

The integration of inventory management with recipe suggestion technology in university canteens represents a forward-thinking solution that addresses multiple challenges in food service management. By integrating advanced inventory management systems with intelligent recipe recommendation algorithms, we can significantly optimize ingredient usage, reduce food waste, and improve menu variety. This technology will leverage real-time data from inventory systems to suggest recipes that align with current stock levels, ensuring that kitchen staff can prepare dishes using available resources. Furthermore, the system will adapt to fluctuating inventory levels, offering alternative recipes when certain ingredients run low, thereby ensuring continuous menu variety and minimizing disruptions. In addition to regular inventory utilization, the proposed technology will incorporate features to generate creative recipe suggestions using leftover food. This aspect of the system will transform potential waste into appealing meals, further supporting sustainability efforts within the university canteen. Adopting this method can streamline kitchen workflows, reduce operational costs, and contribute to environmental sustainability by minimizing food waste.

Figure 58: Representation of Technology integrating with the kitchen staffs.

Another best practice from international level is CIRFOOD - Società Cooperativa Italiana di Ristorazione is one of the leading Italian companies operating in the sectors of collective catering, commercial catering, and employee welfare services to business. To increase the level of sustainability and efficiency of CIRFOOD's processes, they have implemented a Demand forecasting and Inventory Optimization solution, based on artificial intelligence algorithms. They have developed an artificial intelligence system consisting of two phases: Demand Forecasting and Inventory Optimization. In the demand forecasting phase, the models predict future demand for products leaving the canteens and kitchens managed by CIRFOOD. In the Inventory Optimization phase, these predictions are made to suggest the best time to place orders with suppliers, minimizing overstock and reducing waste. All the choices made by the system are reported via the Web App to operators, who in this way can monitor and control the options suggested and choose the best one, based on personal experience (news, 2023).

Figure 59:Predictive analysis with AI by Amma gamma in CIRFOOD. (Amma Gamma by accenture, 2024).

5.2.1 Serving station. 5.2.2 Inventory. 5.2.3 Preparation area. 5.2.4 Dining hall

5.2.3 Technology interventions in Preparation Area.

To address food waste in university canteens, a technology-driven feedback mechanism integrated with a pre-booking app can be highly effective. This system allows students to pre-book their meals, enabling the canteen to predict demand accurately and reduce over-preparation. Additionally, the app includes a feedback feature where students can rate dishes and provide comments. Analysing this feedback helps identify unpopular dishes, ensuring they are not repeated, thus minimizing food waste. By leveraging real-time data and student preferences, the canteen can optimize its menu offerings, enhance meal satisfaction, and procurement.

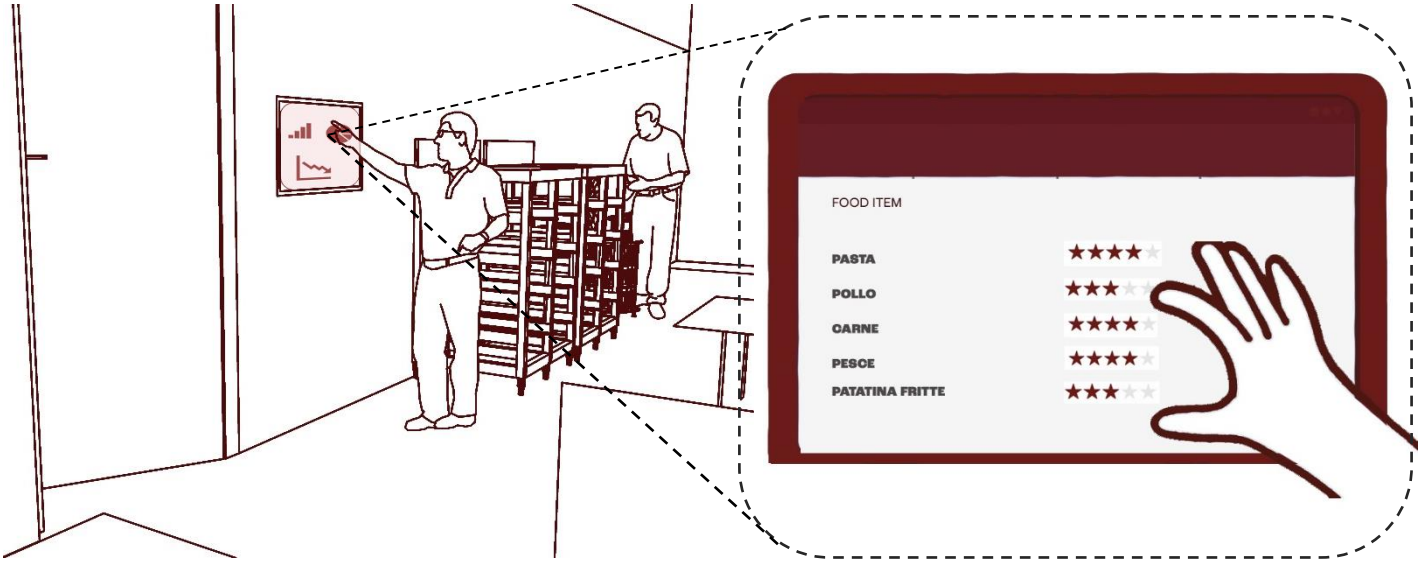


Figure 60: Representation of Feedback mechanism technology.

The best practice analysed in a Swedish case study, a feedback mechanism with a food waste tracker was implemented in school canteens to reduce food waste. The interface communicates the target that the canteen has set and shows how much plate waste was generated previously. The impact of the waste is shown in indicators that guests can relate to, such as “Yesterday we threw away 7.1 kg, which is roughly the same as 21 portions or 27 cinnamon buns”. The interface also allows guests to give feedback on why they wasted food, which helped identify discrepancies between staff perceptions and actual observations. Head chefs provided data on waste types, portion sizes, and guest numbers, allowing for accurate adjustments and effective waste reduction strategies (Christopher Malefors, 2022).

Figure 61:Plate waste tracker at the point where school canteen guests scrape their plates.

Implementing technology-incineration dustbins in the university's Canteen can significantly reduce food waste and promote sustainability. These advanced dustbins not only dispose of waste efficiently but also convert it into energy, thus minimizing landfill impact. By incinerating food waste, the Canteen can harness this energy to power kitchen appliances or heat the building, creating a closed-loop system that reduces the environmental footprint. Additionally, the byproducts from incineration can be used as fertilizer, further enhancing the sustainability efforts. This innovative approach ensures that food waste is not only managed effectively but also repurposed in a way that benefits the environment and the campus community promote sustainability through efficient food management practices.

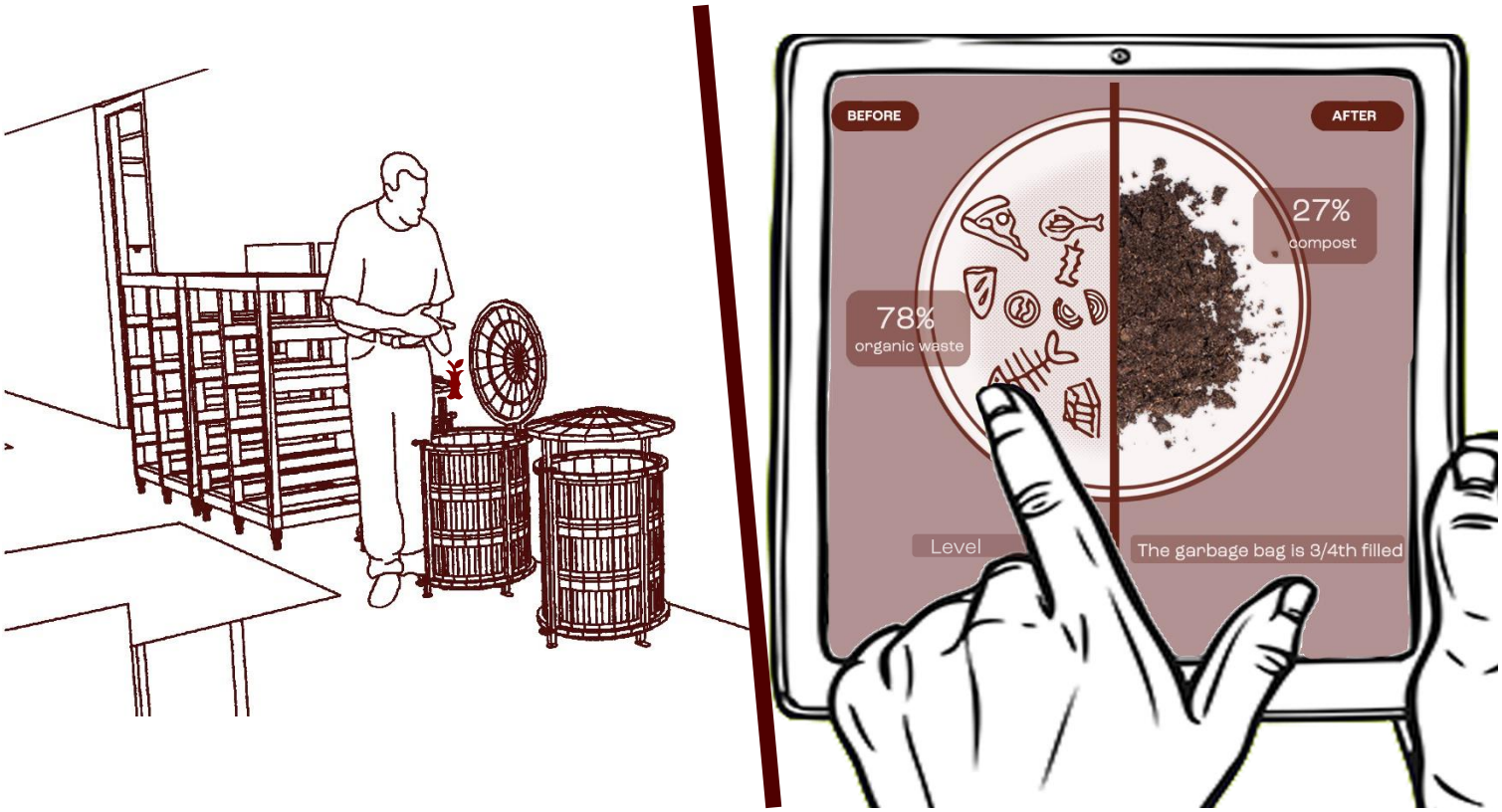
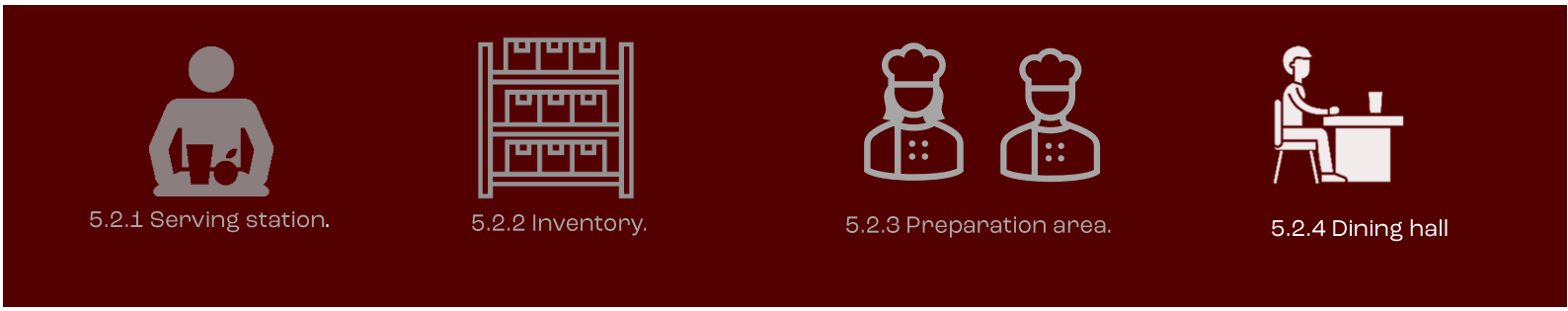


Figure 62: Implementation of tech- incineration dustbins.

At Princeton University, a comprehensive approach to food waste management combines the S.C.R.A.P. Lab and Trenton Biogas facility is a similar best-practice analysed. The S.C.R.A.P. Lab, a small-scale composting operation, processes 15 percent of campus food waste, transforming it into nutrient-rich compost for campus use.
This initiative, launched in 2018, temporarily halted during the COVID-19 pandemic but resumed in Fall 2022. Meanwhile, most of the waste, particularly from dining halls, is sent to Trenton Biogas, where it undergoes anaerobic digestion to produce methane biogas, powering the PSE&G grid and sequestering greenhouse gases. This dual strategy not only reduces landfill methane emissions but also fosters sustainability through student involvement and on-site composting, exemplifying effective waste-to-energy and composting practices in a university setting (The daily Princetonian).

Figure 63:The incineration dustbin in Princeton University. Source: (The daily Princetonian)



5.2.4 Technology interventions in Dining hall.

In Italy, where laws prohibit the donation of cooked food, canteens can implement a redistribution system by selling surplus food at lower prices and using ArcGIS technology. This system would map nearby communities and organizations in need, optimizing distribution routes and ensuring real-time tracking of available food. An associated app could show users where discounted food is available and detail the contents of each food bag. This approach reduces waste, supports local communities, and adheres to legal constraints, promoting sustainability and social responsibility.

Figure 64: Food re-distribution platform.

This perception of implementation is like the "Too Good to Go" collaboration with Durham University, as discussed in section 3.2.4. This case study exemplifies the use of technology to redistribute surplus food at reduced prices, leveraging ArcGIS (whear, 2023) .

Implementing these interventions do come with certain challenges such as consistent engagement of humans, user adoption and managing technical reliability. Added to this we have initial costs, complexity of logistics in re-distribution and community engagement to consider. However, some of these challenges can be mitigated with a robust policy framework, aligned with EU's existing policies and identified stakeholders for the project provides structural support and clear guidelines for successful transformation.

5.3 Policy Framework for implementing the proposed strategies.

In recent years, the push towards sustainable development and efficient resource management has become a central focus across various sectors within the European Union. Universities, as hubs of innovation and community engagement, are uniquely positioned to lead by example in implementing cutting-edge technologies and practices to reduce food waste and promote sustainability. This policy framework aims to transform the university canteen at Politecnico di Torino into a model of operational efficiency and environmental responsibility. By integrating EU policy directives and innovative technological solutions, the initiative not only addresses food waste at the university level but also sets the stage for city-wide adoption, aligning with the EU's broader sustainability goals.
This initiative is guided by the principles outlined in the EU's Circular Economy Action Plan, the Waste Framework Directive, the Digital Agenda, and the Farm to Fork Strategy.

Operational Efficiency-

Policy: Pre-booking & Portion control Technology can be partnered with local university to standardize these systems and can be encouraged through municipal grants or subsidies for necessary equipment.

EU's policy Reference: Aligns with EU's circular economy Action plan which encourages efficient resource use across all sectors including food services and supported by EU Waste framework directive (2008/98/EC) which emphasize waste prevention & reduction through innovative technology.

Inventory Management-

Policy: Develop a city-wide inventory management platform for institutional canteens facilitating bulk purchasing & reducing costs through collective bargaining.
Provide appropriate training to staffs supported by local government on using meal planning apps

EU's policy Reference: Aligns with EU's digital agenda promoting use of ICT (Information and communication Technology) to enhance efficiency and productivity and EU's farm to fork strategy to create a fair, healthy, environmental-friendly food system.

Sustainable food preparation practices-

Policy: Create a City-wide feedback platform for sharing best practices and recipes among canteens.
Establish composting labs/programs that collect Food waste from canteens to process the compost to city parks & gardens.

EU's policy Reference: In-line with EU's Horizon 2020 program which encourage innovative solution for societal challenge and supported by EU waste Framework Directive (2008/98/EC) targeting Waste Recycling & composting.

Food Redistribution -

Policy: Partnering with food delivery apps to redistribute surplus food to students and wider community at discounted rates with safety protocols to ensure the standards while adhering to existing regulation that we cannot donate condiments.

EU's policy Reference: Aligning with EU platform on Food losses and Food waste which promotes innovative solution for Redistributing Surplus food and general Food law Regulation (EC) 178/2002, which sets high Standards for food safety & Consumer protection in EU.

5.4 Impact of policies and alignment with stakeholders

Formulating and implementing policies for incremental changes can be achieved in cities will have very positive impact on the avoidance of resource wastage, cut on expenses and a more sustainable urban environment. In-line with the EU directives, guidelines and frameworks and diplomacy affects several actors including education, government, IT, food services and community services among others. Here is a list of the impact of each policy with an indication of the clustered stakeholder from chapter 3.5 that has been aligned with above policy.

- **Pre-booking & Portion Control Technology**

Policy Impact:

Operational Efficiency: Enhanced operational efficiency in canteens through reduced food waste and better resource management.

Cost Savings: Lower food costs due to more accurate portion control and reduced overproduction.

Environmental Impact: Decrease in food waste, contributing to lower greenhouse gas emissions and improved sustainability.

Stakeholders-


INSTITUTIONAL


POLITICAL & LEGAL


TECHNOLOGICAL

- **Inventory Management Platform**

Policy Impact:

Cost Reduction: Significant cost savings through bulk purchasing and collective bargaining.

Efficiency: Improved inventory management leading to reduced food wastage and more efficient resource use.

Training and Skill Development: Enhanced skills of canteen staff through training on meal planning apps.

Stakeholders:


POLITICAL & LEGAL


SOCIAL & VOLUNTARY


TECHNOLOGICAL


INSTITUTIONAL

• **Sustainable Food Preparation**
Policy Impact:

Knowledge Sharing: Increased dissemination of best practices and recipes through a city-wide feedback platform.

Waste Reduction: Enhanced recycling and composting efforts, leading to reduced food waste.

Community Engagement: Stronger community involvement in sustainable practices and composting programs.

Stakeholders-


POLITICAL & LEGAL


TECHNOLOGICAL

• **Food Redistribution**
Policy Impact:
Food Security: Improved access to affordable food for students and the wider community.

Waste Reduction: Effective redistribution of surplus food reduces overall food waste.

Public Health: Ensured food safety through adherence to safety protocols and existing regulations.


SOCIAL & VOLUNTARY


TECHNOLOGICAL


INSTITUTIONAL

5.5 Impact on Global scale accessed with SDG's.

To evaluate the strengths of the project and its global impact the United Nations' Sustainable Development Goals (SDGs) can be used as a framework for assessment. The SDGs are a blueprint to navigate pressing global challenges including poverty, inequality, climate change, environmental degradation, peace and justice (United Nations, n.d.). Although not necessarily to be used as the universal standard, the SDGs provide helpful and well-formulated targets and goals that offer direction. The proposed technologies and policies aim to achieve a global impact by aligning with specific SDGs. By implementing these solutions at the university canteen level and extending them to a city-wide scale, we contribute to several SDGs, ultimately fostering a more sustainable and equitable world.

To meet the goal of "zero hunger" is an urgent need in the modern world. However, further attempts can be made, using targets 3.9, 12.3 and 12.5, to:

1. prevent unnecessary food waste

2. mitigate further environmental destruction such as soil degradation.

To improve social inclusion and reduce food waste, especially amongst younger generations for longevity, targets 4.7, 12.8 and 13.3 are used to:

3. ensure that learners are provided with opportunities to complete high-quality education that also prepares them with the knowledge and skills needed to develop sustainable lifestyles
4. prompt communities to positively contribute to climate change mitigation
5. provide opportunities for communities to reconnect and harmoniously coexist with natural systems.

To prevent and reduce food waste, targets 9.1 and 9.B will be used to:

6. develop solutions for resilient and sustainable infrastructure.
7. increase inclusive innovation practices.
8. aid in the transition to more sustainable economic industries.

To prevent further social segregation by creating a sense of belonging and empowerment, the project will make use of targets 10.2, 11.3, 11.6, 11.7, and 11.B to:

9. facilitate inclusive and sustainable urbanization
10. develop solutions to allow for a reduction in food waste
11. improve access to green and public spaces for better social cohesion

06 CONCLUSION

6.1 Key takeaways

The research conducted on implementing technology in canteen services to reduce waste underscores the significant evolution of food preservation and disposal methods from the past to the present. This comprehensive study began with an in-depth historical analysis, tracing how ancient practices in food preservation prevailed before the advent of modern refrigeration and waste management techniques. This historical context provided a foundational understanding of how far food management practices have come and highlighted the persistent need for sustainable methods.

In the contemporary phase of the research, a detailed literature review was conducted across various universities. This review uncovered diverse methods for quantifying food waste, emphasizing the critical role of accurate data collection and analysis. The literature revealed that different institutions employ a variety of techniques, such as direct measurement, waste composition analysis, and statistical modelling, each tailored to their specific operational contexts. This variety in approaches provided a rich comparative framework for understanding the strengths and weaknesses of different quantification methods.

The proposal phase also delved into technological innovations currently employed to mitigate food waste. Technologies such as AI-driven waste tracking, smart refrigerators, and data analytics emerged as pivotal tools. These technologies enable real-time monitoring of food freshness and quantity, alerting staff when items approach expiration and thus preventing spoilage. AI algorithms analyse consumption patterns to optimize portion sizes and menu planning, significantly reducing overproduction. Data analytics provide actionable insights into waste trends, facilitating targeted interventions and continuous improvement. The integration of these technologies represents a paradigm shift in how food waste is managed, moving from reactive to proactive strategies.

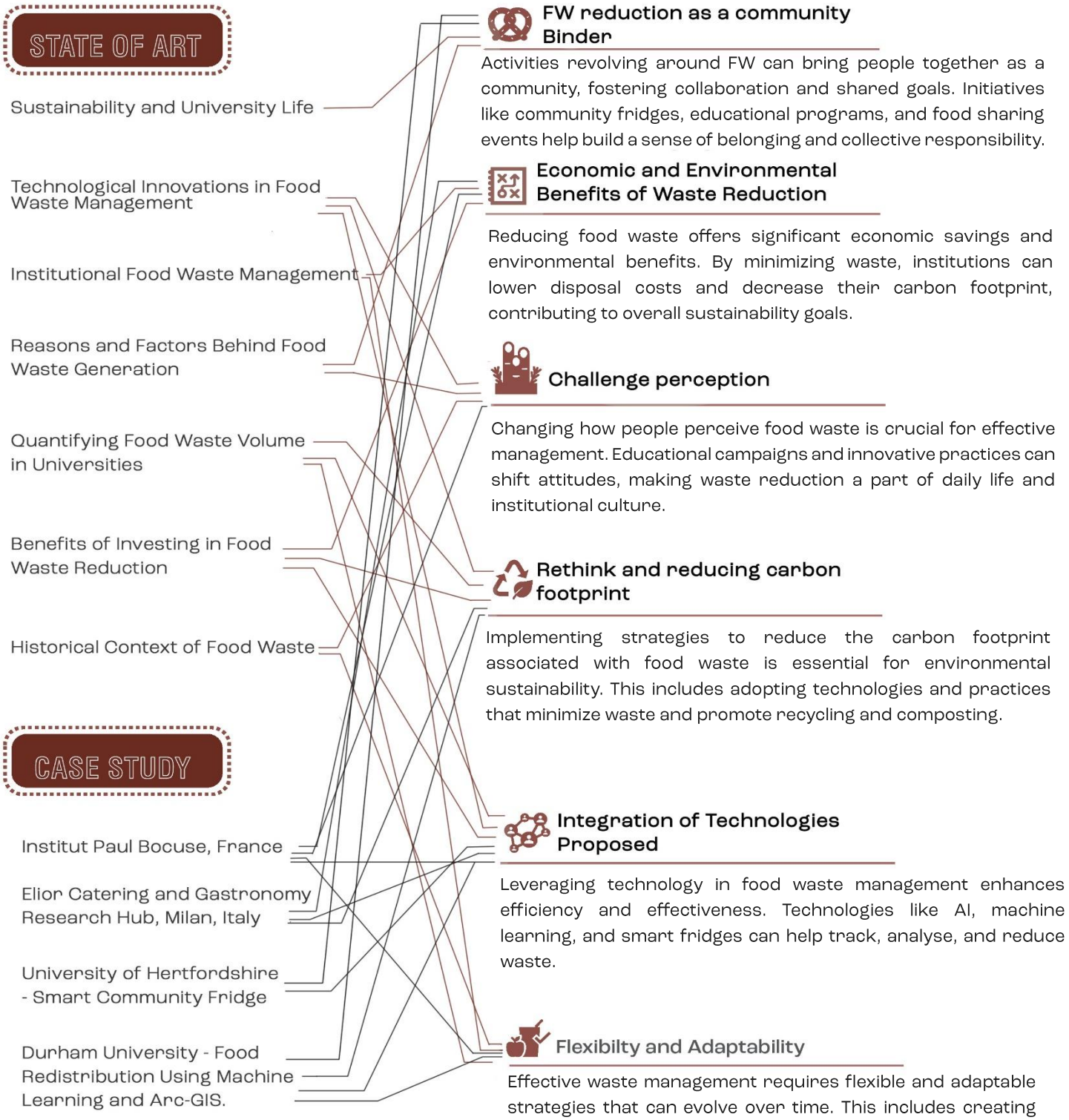
Surveys conducted at multiple institutions formed a critical component of the research. These surveys gathered data on stakeholders' perspectives, practices, and attitudes toward food waste management. The responses highlighted a consensus on the necessity of enhancing awareness and integrating digital solutions. Participants acknowledged that technological interventions are essential but stressed that these must be complemented by educational initiatives to foster a culture of sustainability. The surveys revealed that while technological tools are available and effective, their success depends significantly on the willingness of individuals and institutions to adopt and adapt to these innovations.

The lesson learned from this extensive research is that addressing food waste in canteen services requires a dual approach: technological and cultural transformation. Technological advancements alone are insufficient without a corresponding shift in behaviour and mindset. The transition to sustainable practices involves educating stakeholders, fostering a culture of awareness, and encouraging the adoption of new technologies. Each region's unique characteristics—morphology, demography, and socio-economic context—must be considered. Planning for future generations involves drawing inspiration from successful case studies globally, adapting these best practices to local contexts.

Ultimately, this research underscores the importance of a holistic approach to food waste management. It is not merely a technical challenge but a societal one that necessitates broad-based engagement and cultural change. By integrating technological capabilities with a shift in

cultural attitudes, we can make significant strides in reducing food waste, ensuring a sustainable future for generations to come. This approach guarantees that the solutions implemented are not only effective but also enduring, aligning with the planet's capacity to support human activities without further exacerbating environmental degradation.

6.1.1 Mapping Insights and references.



6.2 Limitations

The thesis presents significant findings regarding food waste patterns observed within surveyed population. However, it acknowledges several limitations that underscore the necessity for future research endeavours. Firstly, the narrow geographical scope of the study potentially limits the generalizability of its results. To ensure broader applicability, future research should encompass diverse cultural, socio-economic, and environmental contexts beyond the studied regions. Secondly, the reliance on self-reported and observational data introduces the possibility of response and observer biases, respectively, which may impact the accuracy of the findings. To mitigate this, integrating qualitative methods alongside quantitative measures would offer a more comprehensive understanding of food waste dynamics. Thirdly, while short-term interventions have demonstrated promise, the long-term sustainability of these strategies remains uncertain.

Future studies should adopt longitudinal approaches to evaluate the enduring effectiveness of food waste reduction strategies and identify potential implementation barriers.
Moreover, while the thesis highlights successful interventions, it overlooks certain crucial aspects necessary for a comprehensive understanding of food waste reduction. Particularly, there is a notable absence of extensive exploration into the economic implications of these strategies. Incorporating economic analyses would provide valuable insights into the cost-effectiveness and practical implementation of interventions. Additionally, the study fails to comprehensively address implementation challenges and barriers, such as budget constraints and administrative support, which are vital for successful adoption. Future research should delve deeper into these challenges to offer actionable recommendations for schools and policymakers alike.

Considering these limitations and opportunities for further investigation, future research directions should prioritize addressing these gaps and expanding knowledge in key areas. Longitudinal studies are imperative to assess the lasting impact of interventions and understand the factors influencing their effectiveness over time. Additionally, research efforts should aim to include a more diverse range of locations and participants to enhance the applicability and robustness of findings. Furthermore, exploring the economic implications and implementation challenges of food waste reduction strategies is essential for practical implementation.

6.3 Future Direction

In alignment with the research directions outlined in the thesis, I propose the establishment of a transformative initiative: a gastronomy research hub aimed at revolutionizing conventional Institutional canteens into smart, sustainable hubs of innovation. Leveraging cutting-edge technology and forward-thinking methodologies, these smart canteens would not only serve as centres for culinary excellence but also as pioneering platforms for research and practical implementation of sustainable food practices.

- The educational aspect is crucial for fostering a culture of sustainability and equipping future generations with the tools to tackle complex challenges.

- By piloting and scaling innovative solutions, it would demonstrate the feasibility and impact of sustainable food practices, influencing broader societal norms and behaviours. Thus, the gastronomy research hub has the potential to catalyse efforts towards creating more sustainable and efficient food systems, not only within universities but also within communities at large.

By integrating principles of sustainable design and urban planning, policymakers can create environments that facilitate healthy eating habits and minimize food waste (Hugh Barton, 2015).

References

Essential Tips for Seamless Barcode Integration in Your Applications. [Online]. - dynamsoft. - https://www.dynamsoft.com/blog/insights/essential-tips-for-barcode-integration/.

85 Official Journal of the European Union L 248/77- Commission Delegated Decision (EU) 2019/1597 of supplementing Directive 2008/98/EC of the European Parliament and of the Council as regards a common methodology and minimum quality requirements for the uniform measurement of levels of food waste [Report]. - 2019.

A. M. Favis C. K. Gotangco Gonzales, Ana Erika Lareza Addressing Rice Waste in University Cafeterias Using Material Flow Analysis and System Dynamics Modeling [Journal] // The Philippine journal of science. - 2022.

Absolon K., & Zapletal, K Moravia in Palaeolithic Times [Journal] // American Journal of Archaeology. - 1945. - Vol. 53. - pp. 19-28 .

Adams M.A., Bruening, M., Ohri-Vachaspati, P. and Hurley, J.C Location of School Lunch Salad Bars and Fruit and Vegetable Consumption in Middle Schools: A Cross-Sectional Plate Waste Study [Journal] // Journal of the academy of Nutrition and dietetics. - 2016. - 3 : Vol. 116. - pp. 407-416.

Afon Lateef Adeleke Adeniyi & Abel Omoniyi Seasonal quantification and characterization of solid waste generation in tertiary institution: a case study [Journal] // Journal of Material Cycles and Waste Management. - 2022. - Vol. 24. - pp. 1172-1181.

al. H. Charles J. Godfray et Food Security: The Challenge of Feeding 9 Billion People [Journal] // Science 327. - 2010. - Vol. 812.

Ali H. Abdelaal Gordon McKay, Hamish R. Mackey Food waste from a university campus in the Middle East: Drivers, composition, and resource recovery potential [Journal] // Waste management journal. - 2019. - Vol. 98. - pp. 14-20.

Amma Gamma by accenture ahead [Online]. - Amma Gamma by accenture, 2024. - https://ammagamma.com/en/soluzioni/ahead/.

Arroyo Paulina A new taxonomy for examining the multi-role of campus sustainability assessments in organizational change [Journal] // Journal of Cleaner Production. - 2017. - Vols. 140, Part 3. - pp. 1763-1774.

Australia/Pacific SDSN Getting started with the SDGs in universities: A guide for universities, higher education institutions, and the academic sector [Journal]. - 2017.

Baik J.Y. and Lee, H Habitual plate-waste of 6- to 9-year-olds may not be associated with lower nutritional needs or taste acuity, but undesirable dietary factors [Journal] // Nutrition Research. - 2009. - no.12 : Vol. 29.

Barioglio Caterina [et al.] Verso un'università della città: il caso studio del Masterplan per i campus del Politecnico di Torino [Online]. - Politecnico di Torino, 2018. - http://www.ecowebtown.it/n_17/pdf/17_05_1.pdf.

Bean M.K., Raynor, H.A., Thornton, L.M., Sova, A., Stewart, M.D. and Mazzeo, S.E. Reliability and validity of digital imagery methodology for measuring starting portions and plate waste from school salad bars [Journal] // Journal of the Academy of Nutrition and Dietetics. - 2018a. - No.8 : Vol. 118. - pp. 1482-1489.

Bean M.K., Spalding, B.B., Theriault, E., Dransfield, K.B., Sova, A. and Stewart, M.D. Salad bars increased selection and decreased consumption of fruits and vegetables 1 month after installation in title I elementary schools: a plate waste study [Journal] // Journal of Nutrition Education and Behavior. - 2018b. - no.6 : Vol. 50. - pp. 589-597.

Belén Derqui Vicenc Fernandez The opportunity of tracking food waste in school canteens: Guidelines for self-assessment [Journal] // Waste management. - 2017. - Vol. 69. - pp. 431-444.

Benoit Daviron Coline Perrin & Christophe-Toussaint Soulard Designing Urban Food Policies [Journal] // History of Urban Food Policy in Europe, from the Ancient City to the Industrial City. - 2019. - pp. 27–51.

Bhattacherjee Anol Social science research: Principles, methods, and practices. [Book Section].

Blondin S.A., Cash, S.B., Goldberg, J.P., Griffin, T.S. and Economos, C.D Nutritional, Economic, and Environmental Costs of Milk Waste in a Classroom School Breakfast Program [Journal] // American Journal of Public Health. - 2017. - 4 : Vol. 107. - pp. 590-592.

Boschini M., Falasconi, L., Cicatiello, C. and Franco, S. Why the waste? A large-scale study on the causes of food waste at school canteens [Journal] // Journal of Cleaner Production. - 2020. - Vol. 246. - p. p. 118994.

Boulton G What are universities for? [Journal] // University World News. - 69.

Burton K., Serrano, E., Cox, H., Budowle, R. and Dulys-Nusbaum, E Benefits, barriers, and challenges to university-level food waste tracking [Journal] // Journal of Hunger and Environmental Nutrition. - 2016. - no.3 : Vol. 11. - pp. 428-438.

Burton K., Serrano, E., Cox, H., Budowle, R. and Dulys-Nusbaum, E. Benefits, barriers, and challenges to university-level food waste tracking [Journal] // Journal of Hunger and Environmental nutrition. - no.3 : Vol. 11.

Byker C.J., Farris, A.R., Marcenelle, M., Davis, G.C. and Serrano, E.L. Food waste in a school nutrition program after implementation of new lunch program guidelines [Journal] // Journal of Nutrition education and behaviour. - 5 : Vol. 46. - pp. 406-411.

Canali M. [et al.] Food Waste Drivers in Europe, from Identification to Possible Interventions. [Journal]. - 2017. - Vol. 1:37.

Capps O., Jr, Ishdorj, A., Murano, P.S. and Storey, M. Examining vegetable plate waste in elementary schools by diversity and grade [Journal] // Health Behavior and Policy Review. - 2016. - No.5 : Vol. 3.

Carrero Federica EAT (in) THE CITY [Journal].

Cavazos RL Taylor K, Eary RB, Doty S. Institutional and Individual Effects of Greenwashing on Food Waste. [Journal] // Sustainability.. - 2023.

Celikcan Ufuk and Bülbül, Ahmed and Aslan, Cem and Buyuktuncer, Zehra and Isgin-Atici, Kubra and Ede, Gözde and Kanbur, Nuray The Virtual Cafeteria: An Immersive Environment for Interactive Food Portion-Size Education [Journal]. - 2018.

Chapman L.E., Richardson, S., McLeod, L., Rimm, E. and Cohen, J. Pilot evaluation of aggregate plate waste as a measure of students' school lunch consumption [Journal] // Journal of the Academy of Nutrition and Dietetics. - 2019. - no.12 : Vol. 119.

Charitonidou Marianna Revisiting Giancarlo De Carlo's Participatory Design Approach: From the Representation of Designers to the Representation of Users [Journal] // Heritage. - 2021. - Vol. 4. - pp. 985-1004.

Chiara Genta Silvia Favaro, Giulia Sonetti,Caterina Barioglio and Patrizia Lombardi Envisioning green solutions for reducing the ecological footprint of a university campus [Journal] // International Journal of Sustainability in Higher Education. - 2019.

Christopher Malefors Niina Sundin, Malou Tromp, Mattias Eriksson Testing interventions to reduce food waste in school catering [Journal] // Resources, Conservation and Recycling. - 2022. - Vol. 177.

Claudia Giordano Luca Falasconi, Clara Cicatiello, Barbara Pancino The role of food waste hierarchy in addressing policy and research: A comparative analysis. [Journal] // Journal of Cleaner Production. - 2020. - Vol. 252.

Cohn D.J., Pickering, R. and Chin, N.P. "Is lunch still gross? A qualitative evaluation of a new school lunch program [Journal] // Infant, Child, and Adolescent Nutrition. - no.6 : Vol. 5.

Companies Save investing in Reducing [Online] // WBSCD- World buisness council for Sustainable development. - 2017.

Costa Hofisi Miriam Hofisi and Stephen Mago Critiquing Interviewing as a Data Collection Method [Journal] // Mediterranean Journal of Social Sciences. - 2014.

Costantino Laura La problematica degli sprechi nella filiera agroalimentare. Profili introduttivi [Book Section]. - [s.l.] : Cacucci, 2018.

Costello C Birisci E, McGarvey RG. Food waste in campus dining operations: Inventory of pre- and post-consumer mass by food category, and estimation of embodied greenhouse gas emissions. [Journal] // Renewable Agriculture and Food Systems.. - 2016. - 3 : Vol. 31. - pp. 191-201.

CROW MICHAEL What is the role of universities in global development? [Online] // World bank blogs. - 2014. - https://blogs.worldbank.org/education/what-role-universities-global-development.

Davison N Young W, Ross A, Cockerill T, Rajput S. Investigating the Impacts of Behavioural-Change Interventions and COVID-19 on the Food-Waste-Generation Behaviours of Catered Students in the UK and India. [Journal] // Sustainability. - 2022.

Deliberador L. R., Batalha, M. O., Chung, M., & Cesar, A. D. S. Food waste: Evidence from a university dining hall in Brazil. Revista de Administração de Empresas, [Journal]. - 2021.

Derqui B., Fernandez, V. and Fayos, T "Towards more sustainable food systems. Addressing food waste at school canteens [Journal] // appetite. - 2018. - Vol. 129. - pp. 1-11.

Di Tullio P., La Torre M. and Rea M.A Social Media for Engaging and Educating: From Universities' Sustainability Reporting to Dialogic Communication [Journal] // Administrative Sciences. - 2021.

Dominika Alexa Teigiserova Lorie Hamelin, Marianne Thomsen Towards transparent valorization of food surplus, waste and loss: Clarifying definitions, food waste hierarchy, and role in the circular economy [Journal] // Science of The Total Environment. - 2020. - Vol. 706.

Dresler-Hawke E., Whitehead, D. and Coad, J What are New Zealand children eating at school? A content analysis of "consumed versus unconsumed " food groups in a lunch-box survey [Journal] // Health Education Journal. - 2009. - No.1 : Vol. 68. - pp. 3-13.

EDISU piemonte [Online]. - https://www.edisu.piemonte.it/en/sedi-e-contatti/ricerca-servizio-di-interesse field_tipologia_servizio_tassono_tid%5B%5D=49&title=&tid=All.

Egidio Dansero Franco Fassio, Eleonora Sirsi, Nadia Tecco LE UNIVERSITÀ E IL CIBO Buone pratiche verso un'alimentazione sostenibile negli atenei [Journal] // ATLANTE DEL CIBO. - [s.l.] : LEXIS Publishing Company, 2019.

Eisenhardt Kathleen M. Building Theories from Case Study Research [Journal] // The Academy of Management Review. - 1989.

Emmerson Allison LC Life and death in the Roman suburb. [Book]. - [s.l.] : Oxford University Press, 2020.

Eriksson M., Lindgren, S. and Persson Osowski, C. Mapping of food waste quantification methodologies in the food services of Swedish municipalities [Journal] // Resources, Conservation and Recycling. - 2018a. - Vol. 137. - pp. 191-199.

Eriksson M., Osowski, C.P., Björkman, J., Hansson, E., Malefors, C., Eriksson, E. and Ghosh, R The tree structure — A general framework for food waste quantification in food services [Journal] // Resources,conservation and recycling. - 2018. - Vol. 130. - pp. 140-151.

Eriksson M., Osowski, C.P., Malefors, C., Björkman, J. and Eriksson, E. Quantification of food waste in public catering services–a case study from a Swedish municipality [Journal] // Waste management. - 2017. - Vol. 61. - pp. 415-422.

EU Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 Amending Directive 2008/98/EC on waste [Journal] // Official Journal L150. - pp. 109-114.

EU. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives. [Journal] // Official Journal of the European Union. - Vols. L-312. - pp. 30-32.

European Commission Farm to Fork Strategy. For a Fair, Healthy and Environmentally-Friendly Food System [Journal] // The European Union: Brussels, Belgium. - 2020. - pp. 1-23.

Eurostat [Online]. - 2023. - https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230929-2.

Eurostat [Online]. - https://ec.europa.eu/eurostat/databrowser/view/env_wasfw/default/table?lang=en.

Falasconi L., Vittuari, M., Politano, A. and Segrè, A. Food waste in school catering: an Italian case study [Journal] // Sustainability. - 2015. - no.11 : Vol. 7. - pp. 14745-14760.

Federica Ciccullo Raffaella Cagliano, Giulia Bartezzaghi, Alessandro Perego, Implementing the circular economy paradigm in the agri-food supply chain: The role of food waste prevention technologies, [Journal] // Resources, Conservation and Recycling. - 2021. - Vol. 164.

Ferreira M., Liz Martins, M. and Rocha, A. Food waste as an index of foodservice quality [Journal] // British Food Journal. - 2013. - 11 : Vol. 115. - pp. 1628-1637.

Fighting Against Food Waste: Institut Paul Bocuse adopts Artificial Intelligence in the kitchen to train new generation of climate conscious chefs [Online]. - 2021. - https://blog.winnowsolutions.com/institut-paul-bocuse-adopts-artificial-intelligence-in-its-kitchen-to-train-new-generation-of-climate-conscious-chefs.

Filho Walter Leal Sustainability and University Life [Journal] // International Journal of Sustainability in Higher Education. - 2000. - 1 : Vol. 1.

Food is finally on the table': Cop28 addressed agriculture in a real way [Online]. - 2023. - https://www.theguardian.com/environment/2023/dec/17/cop28-sustainable-agriculture-food-greenhouse-gases.

Food wastage footprint & climate change [Report]. - 2015.

Fostercapital Understanding the Role of Technology in Food Waste Reduction Initiatives. - 2024.

Gase L.N., McCarthy, W.J., Robles, B. and Kuo, T Student receptivity to new school meal offerings: assessing fruit and vegetable waste among middle school students in the Los Angeles Unified School District [Journal] // Preventive Medicine. - 2014. - no.1 : Vol. 6. - pp. 28-33.

Gesyeana Bazlyn Zamri Nur Khaiyum Abizal Azizal, Shohei Nakamura, Koji Okada, Norul Hajar Nordin, NorÁzizi Othman, Fazrena Nadia MD Akhir, Azrina Sobian, Naoko Kaida, Hirofumi Hara Delivery, impact and approach of household food waste reduction campaigns. [Journal] // Journal of Cleaner Production. - 2020. - Vol. 246.

Getts K.M., Quinn, E.L., Johnson, D.B. and Otten, J.J. Validity and Interrater Reliability of the Visual Quarter-Waste Method for Assessing Food Waste in Middle School and High School Cafeteria Settings [Journal] // Journal of the Academy of Nutrition and Dietetics. - 2017. - 11 : Vol. 117. - pp. 1816-1821.

Ghinoi S., Silvestri F. and Steiner B. Toward the creation of novel food waste management systems: A network approach [Journal] // Journal of Cleaner Production. - 2020.

Gonzalez-Vaquè L. French and Italian Food Waste Legislation An Example for other EU Member States to Follow? [Journal] // EUropean food Feed law revised. - 2017. - Vol. 12. - pp. 224-233.

Greenbaum B.E., Graebner, M.E. (2018). Eisenhardt, Kathleen M.. In: Augier, M., Teece, D.J. The Palgrave Encyclopedia of Strategic Management. [Journal] // Palgrave Macmillan. - 2018.

Gudina Terefe Tucho Thuat Okoth Evaluation of neglected bio-wastes potential with food-energy-sanitation nexus [Journal] // Journal of Cleaner Production. - Vol. 242.

Hamish Forbes (WRAP) Tom Quested (WRAP), Clementine O'Connor (United UNEP Food Waste Index Report [Journal]. - Geneva : [s.n.], 2021.

Hanks A.S., Wansink, B. and Just, D.R. Reliability and accuracy of real-time visualization techniques for measuring school cafeteria tray waste: Validating The Quarter-waste method [Journal] // Journal of the Academy of Nutrition and Dietetics. - 2014. - no.3 : Vol. 114. - pp. 470-474.

HINDRIKS FRANK GUALA FRANCESCO Institutions, rules, and equilibria: a unified theory. [Journal] // Journal of Institutional Economics.. - 2015. - pp. 459-480.

History of food waste [Online] // Il Gelso - Cooperativa Sociale Onlus. - https://www.coopilgelso.com/storia_rifiuti.html.

Huang Z., Gao, R., Bawuerjiang, N., Zhang, Y., Huang, X. and Cai, M. Food and nutrients intake in the school lunch program among school children in shanghai, China [Journal] // Nutrients. - 2017. - no.6 : Vol. 9.

HUBBUB The Community Fridge Network [Report]. - [s.l.] : HUBBUB, 2022.

Hugh Barton Susan Thompson, Sarah Burgess, Marcus Grant The Routledge Handbook of Planning for Health and Well-Being [Book]. - london : [s.n.], 2015.

Hui Zhang a Shan Li a, Dingrui Wei a, Jiajun He b, Jinyi Chen a, Changhang Sun a, Arun K. Vuppaladadiyam c, Huabo Duan c Characteristics, environmental impact, and reduction strategies of food waste generated by young adults: Case study on university canteens in Wuhan, China [Journal] // Journal of Cleaner Production. - 2021. - Vol. 321.

J.Poore T.Nemecek Reducing food's environmental impacts through producers and consumers [Journal] // science 360. - 2018. - pp. 987-992.

jacobs Frank The Eggs of Price: An Ovo-Urban Analogy [Online] // Big think. - 2011. - https://bigthink.com/strange-maps/534-the-eggs-of-price-an-ovo-urban-analogy/.

Jagau H.L. and Vyrastekova, J Behavioral approach to food waste: an experiment [Journal] // British food journal. - 2017. - no.4 : Vol. 119. - pp. 882-894.

Jenny Gustavsson Christel Cederberg, Ulf Sonesson, Robert van Otterdijk, Alexandre Meybeck Global Food Losses and Food Waste – Extent, Causes and Prevention [Report]. - [s.l.] : Food and Agriculture Organization of the United Nations (FAO), 2011.

Joeri Rogelj Oliver Geden, Annette Cowie & Andy Reisinger Three ways to improve net-zero emissions targets [Journal] // Nature. - 2021. - 591. - pp. 365–368..

Jörissen Juliane, Carmen Priefer, and Klaus-Rainer Bräutigam. Food Waste Generation at Household Level: Results of a Survey among Employees of Two European Research Centers in Italy and Germany [Journal] // Sustainability 7. - 2015. - Vol. no.3. - pp. 2695-2715..

Joseph Langley Alaster Yoxall, Geoff Heppell, Elena Maria Rodriguez, Steve Bradbury, Roger Lewis, Joe Luxmoore, Alma Hodzic, and Jenny Rowson Food for Thought? — A UK pilot study testing a methodology for compositional domestic food waste analysis [Journal] // Waste Management & Research: The Journal for a Sustainable Circular Economy. - 2009. - 3 : Vol. 28.

Kasavan S., Ali, N. I. B. M., Ali, S. S. B. S., Masarudin, N. A. B., & Yusof, S. B. Quantification of food waste in school canteens: A mass flow analysis [Journal] // Resources, Conservation and Recycling. - Vol. 164.

Katare B., Wetzstein, M. and Jovanovic, N. Can economic incentive help in reducing food waste:experimental evidence from a university dining hall [Journal] // Applied Economics Letters. - 2019. - No.17 : Vol. 26. - pp. 1448-1451.

Kirti Kumar, V. Understanding Institutions and Revisiting the Theories of Institutional Change [Journal] // Dynamics of Institutional Change in Emerging Market Economies . Contributions to Economics. - 2021.

Knezevic B., Kurnoga, N. and Anic, I.D. Typology of university students regarding attitudes towards food waste [Journal] // British Food Journal. - 2019. - no.11 : Vol. 121. - pp. 2578-2591.

Lapini Gian Luca The waste collection network in Milan [Online]. - https://www.storiadimilano.it/citta/milanotecnica/rifiuti/rifiuti.htm.

lazell Jordon Consumer food waste behaviour in universities: Sharing as a means of prevention [Journal] // Journal of Consumer Behaviour. - 2016. - 15(5). - pp. 430-439.

Leal Filho W. [et al.] International Trends and Practices on Sustainability Reporting in Higher Education Institutions. [Journal] // Sustainability. - 2022.

Li J Li W, Wang L, Jin B Environmental and Cost Impacts of Food Waste in University Canteen from a Life Cycle Perspective [Journal] // Energies. - 2021.

Liz Martins M., Cunha, L.M., Rodrigues, S.S. and Rocha, A. Determination of plate waste in primary school lunches by weighing and visual estimation methods: a validation study [Journal] // Waste management. - 2014. - no.8 : Vol. 34. - pp. 1362-1368.

Lombardi M L’innovazione sociale nel settore agricolo del Mezzogiorno [Journal]. - 2017. - Vol. FrancoAngeli: Milano. - pp. 1-160.

Lombardi M. L’innovazione sociale nel settore agricolo del Mezzogiorno. [Journal] // FrancoAngeli: Milano. - 2017. - pp. 1-160.

Lombardi P. and Sonetti, G. News from the Front of Sustainable University Campuses [Book]. - Rome : Edizioni Nuova Cultura, 2017.

Long Qian a Feng Li a, Hongbo Liu b, Lingen Wang c, Breda McCarthy d, Shaosheng Jin e Rice vs. Wheat: Does staple food consumption pattern affect food waste in Chinese university canteens? [Journal] // Resources, Conservation and Recycling. - 2022. - Vol. 176.

LONG QIAN QINGLING RAO, HONGBO LIU, BREDA MCCARTHY, LI XIAN LIU, AND LINGEN WANG Food waste and associated carbon footprint: evidence from Chinese universities [Journal] // ECOSYSTEM HEALTH AND SUSTAINABILITY. - 2022. - 1 : Vol. 8.

M. Lombardi A. Lopolito, A.M. Andriano, M. Prosperi, A. Stasi, E. Iannuzzi NETWORK IMPACT OF SOCIAL INNOVATION INITIATIVES IN MARGINALISED RURAL COMMUNITIES [Journal] // Social Networks. - 2020. - Vol. 63. - pp. 11-20.

Mamaril Julius Cesar O. Mobile-Based Service Management Online Reservation Portal (Msmorp)Towards Continuous Quality Improvement [Journal] // Southeast asian journal of science and technology. - 2017. - 1 : Vol. 2.

Mangesh Gharfalkar Richard Court, Callum Campbell, Zulfiqur Ali, Graham Hillier Analysis of waste hierarchy in the European waste directive 2008/98/EC [Journal] // Waste management. - 2015. - Vol. 39.

Marais M.L., Smit, Y., Koen, N. and Lötze, E. Are the attitudes and practices of foodservice managers, catering personnel and students contributing to excessive food wastage at Stellenbosch university? [Journal] // South African Journal of Clinical Nutrition. - 2017. - No.03 : Vol. 30. - pp. 60-67.

Martinho N Cheng L, Bentes I, Teixeira CA, Sousa Silva S, Liz Martins M. Environmental, Economic, and Nutritional Impact of Food Waste in a Portuguese University Canteen. [Journal] // Sustainability.. - 2022.

Matteo Vittuari Paolo Azzurro, Sivia Gaiani, Manuela Gheoldus, Stephanie Burgos, Lusine Aramyan, Natalia Valeeva, David Rogers, Karin Östergren, Toine Timmermans, Hilke Bos-Brouwers Recommendations and guidelines for a common European food waste policy framework [Journal] // Report of the WP3.

news Leggi L'intelligenza artificiale in Cirfood: Ammagamma sviluppa una mappa per misurarne gli impatti [Online]. - 2023. - https://www.mediakey.tv/leggi-news/lintelligenza-artificiale-in-cirfood-ammagamma-sviluppa-una-mappa-per-misurarne-gli-impatti.

news shine High-tech dining debuts in university canteen. - [s.l.] : shine news.

Niaki S.F., Moore, C.E., Chen, T.A. and Cullen, K.W. Younger elementary school students waste more school lunch foods than older elementary school students [Journal] // Journal of the Academy of Nutrition and Dietetics. - no.1 : Vol. 117.

Nummer Brian A. Historical Origins of Food Preservation [Online] // National Center for Home Food Preservation. - May 2022. - https://nchfp.uga.edu/publications/nchfp/factsheets/food_pres_hist.html.

Opera universitaria,Trento [Online]. - https://www.operauni.tn.it/ristorazione.

Ostrom Sue E. S. Crawford and Elinor A Grammar of Institutions [Journal] // The American Political Science Review. - 1995. - no.3 : Vol. 89.

Pagliarino Elena Frontiers [Online]. - https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2024.1387100/full.

Painter K., Thondhlana, G. and Kua, H.W. Food waste generation and potential interventions at rhodes university, South Africa [Journal] // Waste Management. - Vol. 56.

Paola Garrone Marco Melacini, Alessandro Perego Surplus food recovery and donation in Italy: the upstream process [Journal] // British Food Journal. - 2014.

Perotto Eleonora RUS Resources and waste [Online]. - https://reterus.it/en/waste/.

Pinto R.S., dos Santos Pinto, R.M., Melo, F.F.S., Campos, S.S. and Cordovil, C.M.D.S. A simple awareness campaign to promote food waste reduction in a university canteen [Journal] // Waste management. - 2018. - Vol. 76. - pp. 28-38.

Platform EU Recommendations for Action in Food Waste Prevention. [Report]. - 2019.

Politecnico di torino-masterplan [Online]. - Politecnico di torino, 2017. - https://www.masterplan.polito.it/progettualita/campus_ingegneria_aule_r.

Prescott M.P., Herritt, C., Bunning, M. and Cunningham-Sabo, L. Resources, barriers, and tradeoffs: a mixed methods analysis of school Pre-Consumer food waste [Journal] // Journal of the Academy of Nutrition and Dietetics. - 2019a. - no.8 : Vol. 119. - pp. 1270-1283.e2.

programme UNEP - United nations environmental Reducing Consumer Food Waste Using Green and Digital Technologies [Report]. - 2022.

Puneet Kaur Amandeep Dhir, Shalini Talwar, Melfi Alrasheedy Systematic literature review of food waste in educational institutions: setting the research agenda [Journal] // International Journal of Contemporary Hospitality Management. - 2021. - 4 : Vol. 33.

Rada Elena Cristina, Elena Romenovna Magaril, Marco Schiavon, Anzhelika Karaeva, Maxim Chashchin, and Vincenzo Torretta. MSW Management in Universities: Sharing Best Practices [Journal] // sustainability 12. - 2020. - Vol. 12.

Ramos T.B., Caeiro, S., Van Hoof, B., Lozano, R., Huisingh, D. and Ceulemans, K Experiences from the implementation of sustainable development in higher education institutions: environmental management for sustainable universities [Journal] // Journal of cleaner production. - 2015. - Vol. 106. - pp. 3-10.

Repubblica. Camera dei Deputati e Senato della Disposizioni Concernenti la Donazione e la Distribuzione di Prodotti Alimentari e Farmaceutici a Fini di Solidarieta' Sociale e per la Limitazione Degli Sprechi. [Journal] // Gazzetta Ufficiale Serie Generale n. 202. - 2016.

Ritchie Hannah Our world in data [Online]. - 2020. - https://ourworldindata.org/food-waste-emissions#article-citation.

Robinson O. C. Sampling in interview-based qualitative research: A theoretical and practical guide. [Journal] // Qualitative Research in Psychology,. - 2014. - pp. 25-41.

Rodrigo Lozano Kim Ceulemans, Mar Alonso-Almeida, Donald Huisingh, Francisco J. Lozano, Tom Waas, Wim Lambrechts, Rebeka Lukman, Jean Hugé, A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey [Journal] // Journal of Cleaner Production,. - 2015. - Vols. Volume 108, Part A. - pp. 1-18.

RUS—Italian University Network for Sustainable Development. Goals and Objectives. The Partnership Agreement. 2022. [Online]. - https://reterus.it/en/goals-and-objectives.

RUS—Italian University Network for Sustainable Development. Universities for the regions in the year of climate ambition—2021 [Online] // RUS report. - 2021. - https://reterus.it/public/files/Documenti/Report_RUS/REPORT_RUS_2021_D_ENG.pdf.

Schupp C., Getts, K. and Otten, J. An evaluation of current lunchroom food waste and food rescue programs in a Washington state school district [Journal] // Journal of Agriculture, Food Systems,and Community Development. - 2018. - No.1 : Vol. 8.

Sénat Assemblée Nationale et Loi Relative à la Lutte Contre le Gaspillage Alimentaire [Journal]. - 2016.

Serebrennikov D., Katare, B., Kirkham, L. and Schmitt, S. Effect of classroom intervention on student food selection and plate waste: Evidence from a randomized control trial [Journal] // PLoS One. - 2020. - No.1 : Vol. 15.

Silvennoinen K., Heikkilä, L., Katajajuuri, J. and Reinikainen, A. Food waste volume and origin: case studies in the Finnish food service sector [Journal] // Waste management. - 2015. - no.1 : Vol. 46. - pp. 140-145.

Simkus Julia Stratified Random Sampling: Definition, Method & Examples [Journal]. - 2023.

Smaniotto C. [et al.] Insights and Next Challenges for the Italian Educational System to Teach Sustainability in a Global Context [Journal] // sustainability. - 2023.

Smith S.L. and Cunningham-Sabo, L. Food choice, plate waste and nutrient intake of elementary-and Middle-school students participating in the US national school lunch program [Journal] // Public Health Nutrition. - 2014. - no.6 : Vol. 17. - pp. 1255-1263.

Smith SL Cunningham-Sabo L Food choice, plate waste and nutrient intake of elementary- and middle-school students participating in the US National School Lunch Program. [Journal] // Public Health Nutrition. - 2014. - no.6 : Vol. 17. - pp. 1255-1263.

Snell Melissa Thought Co. [Online]. - 18 August 2019. - https://www.thoughtco.com/medieval-food-preservation-1788842.

Social Institutions (Definition + 7 Examples) [Online] // Practical Psychology. - 2023. - https://practicalpie.com/social-institutions/..

Sonetti G., Barioglio C. and Campobenedetto D. Education for Sustainability in Practice: A Review of Current Strategies within Italian Universities [Journal] // Sustainability. - 2020.

Sonetti G., Brown, M. and Naboni, E. About the triggering of UN sustainable development goals and regenerative sustainability in higher education [Journal] // Sustainability. - 2019. - no.1 : Vol. 11. - p. 254.

Steen H., Malefors, C., Röös, E. and Eriksson, M. Identification and modelling of risk factors for food waste generation in school and pre-school catering units [Journal] // Waste Management. - Vol. 77.

Stefan Hunziker Michael Blankenagel Single case research design [Journal] // Research Design in Business and Management. - 2021.

Stella Plazzotta Lara Manzocco, Maria Cristina Nicoli Fruit and vegetable waste management and the challenge of fresh-cut salad [Journal] // Trends in Food Science & Technology. - 2017. - Vol. 63. - pp. 51-59.

Templeton S.B., Marlette, M.A. and Panemangalore, M. Competitive foods increase the intake of energy and decrease the intake of certain nutrients by adolescents consuming school lunch [Journal] // Journal of the American Dietetic Association. - 2005. - no.2 : Vol. 105. - pp. 215-220.

The ancient value of waste [Online] // Regio 70 - Mirko Reggiani Official Website. - 17 March 2021. - https://www.regio70.it/2021/03/17/lantico-valore-del-rifiuto/.

The daily Princetonian Scraps to soil: How Princeton's food waste is recycled on and off campus [Report].

The role of universities in the process of decarbonization of urban areas [Online]. - 2023. - https://reterus.it/public/files/Eventi/2023/01_Lombardi-RUS-COP28.pdf.

Thiagarajah K. and Getty, V.M. Impact on Plate Waste of Switching from a Tray to a Trayless Delivery System in a University Dining Hall and Employee Response to the Switch [Journal] // Journal of the Academy of Nutrition and Dietetics. - 2013. - 1 : Vol. 113. - pp. 141-145.

Thorsen AV Lassen AD, Andersen EW, et al. Plate waste and intake of school lunch based on the new Nordic diet and on packed lunches: a randomised controlled trial in 8- to 11-year-old Danish children [Journal] // Journal of Nutritional Science. - 2015. - e20 : Vol. 4.

UNEP Food Waste Index Report 2021; United Nations Environment Programme: Nairobi, Kenya. [Report]. - 2021. - pp. 1-100.

United nations [Online]. - 22 11 2023. - https://sdgs.un.org/goals.

University of Pisa archives [Online]. - https://www.sba.unipi.it/it/risorse/archivio-fotografico/eventi-in-archivio/inaugurazione-della-mensa-universitaria-di-dei.

Valeria De Laurentiis D. V. L. Hunt, Chris David Foss Rogers Food Security Challenges: Influences of an Energy/Water/Food Nexus [Conference] // Proceedings of the 4th World Sustain.. - Swizterland : [s.n.], 2014. - Vol. 4.

Veronica Novelli Federico Nassivera, Marcela A. Martinez Pretelt 3. LE MENSE UNIVERSITARIE E LO SPRECO ALIMENTARE: ALCUNE RIFLESSIONI E POSSIBILI SOLUZIONI AL PROBLEMA [Book Section] // Università e cibo Buone pratiche per un'alimentazione sostenibile nelle università / ed. Egidio Dansero Franco Fassio, Eleonora Sirsi, Nadia Tecco. - Torino : Celid.it, 2019.

Visschers V.H.M., Gundlach, D. and Beretta, C. Smaller servings vs. information provision: Results of two interventions to reduce plate waste in two university canteens [Journal] // Waste management. - 2020. - Vol. 103.

Walter Leal Filho Amanda Lange Salvia , Brittany Davis , Markus Will & Sara Higher education and food waste: assessing current trends [Journal] // International Journal of Sustainable Development & World Ecology. - 2021. - 28(5). - pp. 440–450.

whear Lily The durham tab [Online]. - 2023. - https://thetab.com/uk/durham/2022/10/10/durham-university-launches-2-meals-on-too-good-to-go-50835.

Whitehair K.J., Shanklin, C.W. and Brannon, L.A. Written Messages Improve Edible Food Waste Behaviors in a University Dining Facility [Journal] // Journal of the Academy of Nutrition and Dietetics. - 2013. - 1 : Vol. 113. - pp. 63-69.

Wilkie A.C., Graunke, R.E. and Cornejo, C. Food waste auditing at three Florida schools [Journal] // sustainability. - No.2 : Vol. 7.

win Thin lei Reuters [Online]. - 2018. - https://www.reuters.com/article/us-italy-food-waste-idUSKBN1FR1UD/.

Winkler Astrid Torino city report [Journal]. - 2007.

Wood Adam Giancarlo De Carlo's Concept of Architecture – a Powerful and Inclusive Tool for Thinking about Educational Space [Journal] // Histories of Postwar Architecture. - 2019. - pp. 64-75.

World Environment Day: Elior's commitment to sustainability [Online]. - 2021. - https://www.elior.it/news/giornata-mondiale-ambiente-elior-sostenibilita.

Xingyi Zhao Louise Manning Food plate waste: factors influencing insinuated intention in a university food service setting [Journal] // British Food Journal. - 2019. - 7 : Vol. 121.

Yin Robert K Designing case studies [Journal] // Qualitative research methods. - 2003. - 3 : Vol. 15.

Yoder A.B.B., Foecke, L.L. and Schoeller, D.A. Factors affecting fruit and vegetable school lunch waste in Wisconsin elementary schools participating in farm to school programmes [Journal] // Public Health Nutrition. - 2015. - No.15 : Vol. 18.

Yoon B Lee J, Lim H. Campus Dining Sustainability: A Perspective from College Students [Journal] // Sustainability. - 2023. - 3 : Vol. 15.

Zhao X. and Manning, L. Food plate waste: factors influencing insinuated intention in a university food service setting [Journal] // British Food Journal. - 2019. - no.7 : Vol. 121. - pp. 1536-1549.

Zora Daniela From the few wastes of primitive people to the island of waste in the Pacific: man and waste throughout history [Report]. - [s.l.] : E habitat - the atmosphere is at home, 2018.

ANNEX -A

The full list of the questionnaire conducted to the students of Politecnico di Torino from 25-01-2024 to 22-02-2024 and the Answers received is demonstrated here.

WHY THIS SURVEY ?

Food waste refers to food that completes the food supply chain up to a final product, of good quality and fit for consumption, but still doesn't get consumed because it is discarded, whether after it is left to spoil or expire. Food waste is not merely a moral issue; it is an environmental, social, and economic problem of global proportions.

This survey is specifically designed for students to gather insights into food waste behaviors. Aim of this survey has been meticulously designed with four parts to delve into the preferences, attitudes, and expectations of students concerning food waste management in institutional settings. Hence, through the survey demographics obtained I would aim to convey the importance of technology in reducing food waste thereby creating a food circularity more effectively and as an urban planner propose policies to support this endeavor.

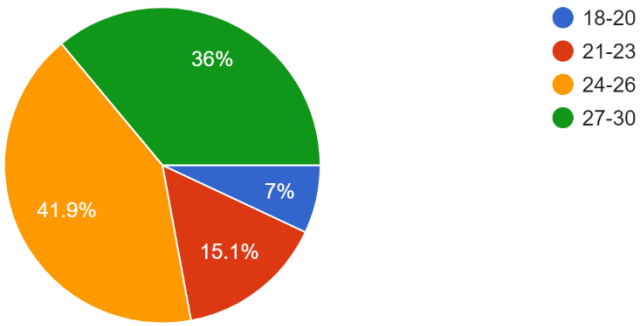
You represent a generation known for your active engagement in social and environmental issues, hence I have made you a valuable stakeholder in the fight against food waste.

Figure *65*:The Introduction to the survey

Part – I

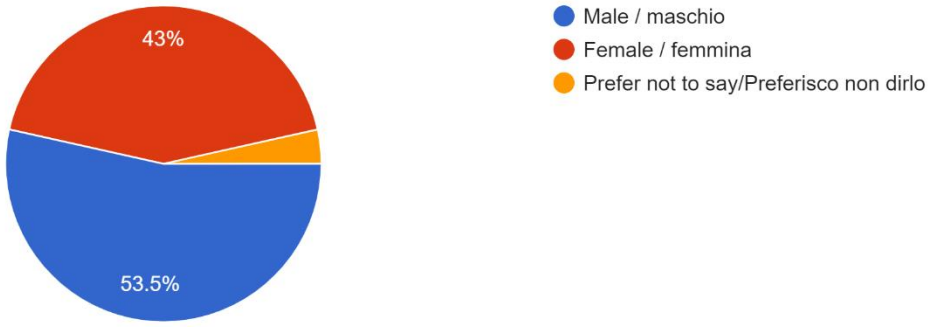
This part consists of general information to analyze and understand the characteristics of the surveyed population.
Questa parte è costituita da informazioni generali per analizzare e comprendere le caratteristiche della popolazione intervistata.

Information-01 What is your age range ? Qual è la vostra fascia d'età ?
86 responses



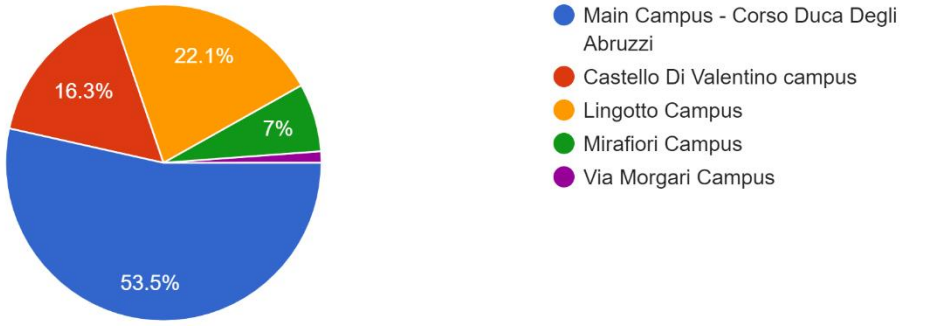
Information-02 What is your gender? qual è il tuo genere?

86 responses



Information-03 Which campus do you use often? Quale campus usi spesso?

86 responses



Information-04 What is your preferred method of dining at university? Qual è il tuo metodo preferito per pranzare all'università?

86 responses

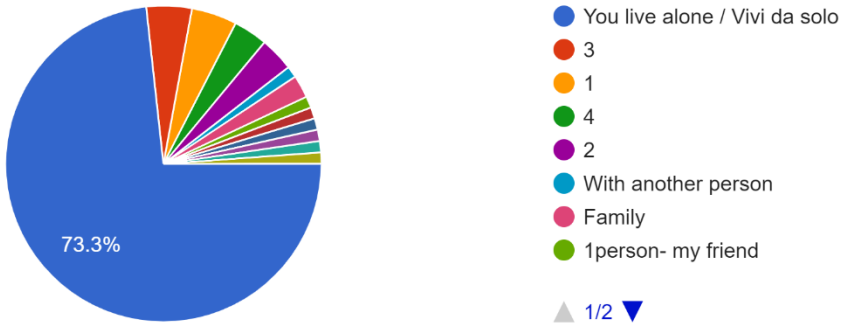
PART-II

This part aims to investigate how often do you spend/person for grocery and your habits of Food waste.

Questa parte ha lo scopo di indagare quanto spesso spendi/persona per la spesa e le tue abitudini in materia di sprechi alimentari.

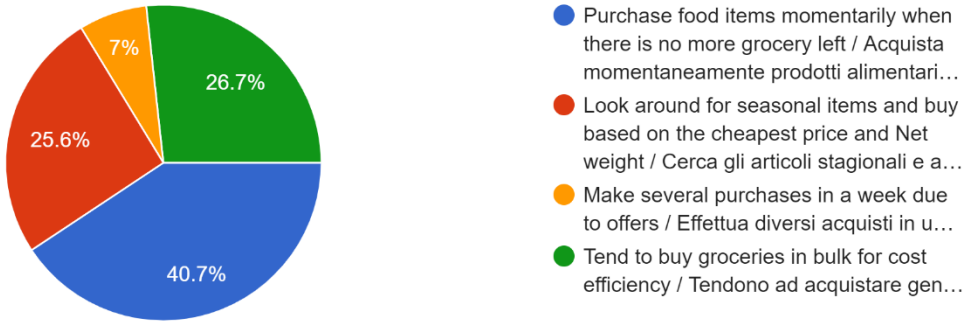
Question 01 - With how much people do you share your monthly Groceries and its Budget with? Con quante persone condividi la tua spesa mensile e il relativo budget?

86 responses



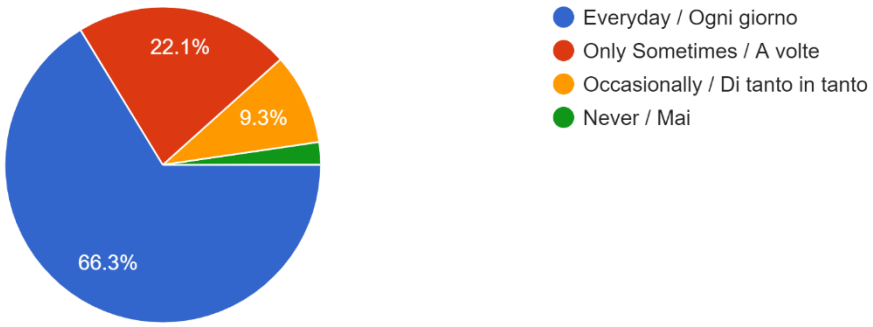
Question 02 - Which is your habits of purchasing grocery? Quali sono le tue abitudini nell'acquisto di generi alimentari?

86 responses



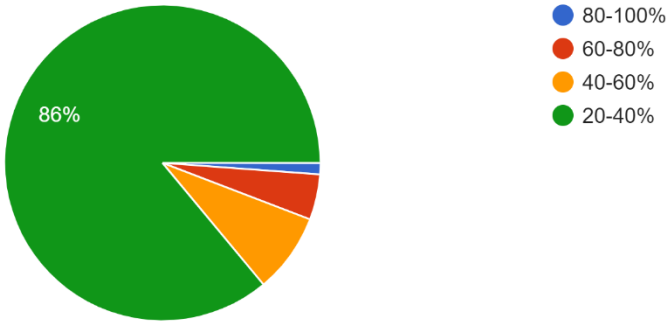
Question 05 - How often do you cook? Con quale frequenza cucini in una settimana per i prossimi giorni?

86 responses



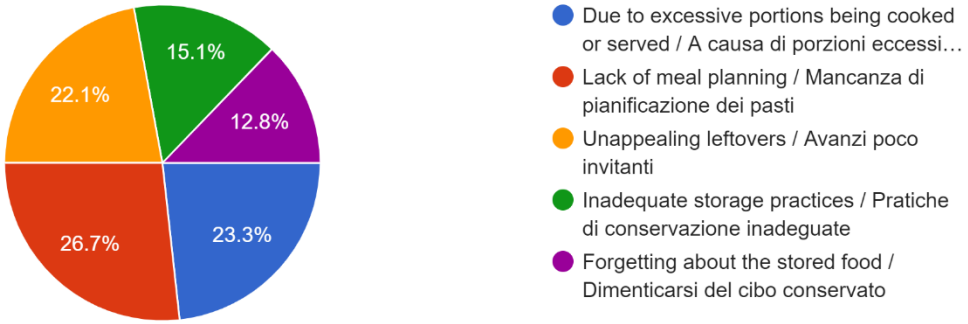
Question 06 - How much of food you cook goes to waste in general ? Quanto cibo che cucini andrà sprecato in generale?

86 responses



Question 07- In your personal opinion, Why does the cooked food go to waste? Secondo la tua opinione personale, perché il cibo cotto va sprecato?

86 responses



PART-III

This segment of the survey is helpful in learning about the strategies and practices you personally employ to minimize food waste in your own life and when You use University canteens.

Questa parte dell'indagine è utile per conoscere le strategie e le pratiche che utilizzi personalmente per ridurre al minimo lo spreco alimentare nella tua vita e quando utilizzi le mense universitarie.

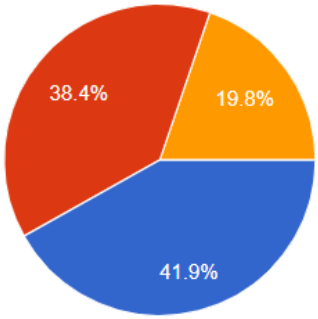
Question 08 -

Copy

How surprised are you by this statement - "If food waste were a country, it would be the third largest emitter of greenhouse gases in the world. Food waste is a huge contributor to climate change."

Quanto sei sorpreso da questa affermazione: "Se lo spreco alimentare fosse un paese, sarebbe il terzo più grande emettitore di gas serra nel mondo. Lo spreco alimentare contribuisce enormemente al cambiamento climatico".

86 responses



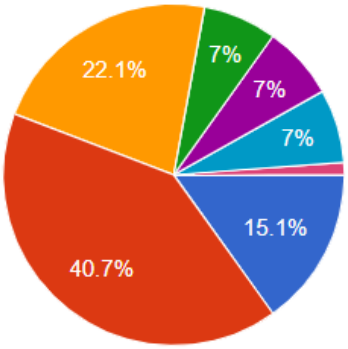
- Not surprised. I knew that food waste is a huge contributor to climate change / Non sorpreso. Sapevo che lo spreco alimentare contribuisce enormemente…
- Moderately surprised. I knew there was a link but didn't realize it was this significant / Moderatamente sorpreso. Sapevo che c'era un collegamento ma…
- Very surprised. I had no idea food waste non mi rendevo conto che fosse così significativo.
- Very surprised. I had no idea food waste contributed to climate change / Molto sorpreso. Non avevo idea che i rifiuti alimentari contribuissero al cambiamento climatico.

Question 09 -

Do you practice any food circularity or food waste reduction methods?

Pratichi metodi di circolarità alimentare o di riduzione degli sprechi alimentari?

86 responses



- Redistribute your food to family and friends / Ridistribuisci il tuo cibo a familiari e amici
- Check the shelf before buying groceries / Controlla lo scaffale prima di acquistare la spesa
- Check 'use by' and 'Best-before' dates and plan your menu accordingly/ Controlla le date di scadenza e di scadenza e pianifica il tuo menu di conseguenza
- Make dishes from food scraps that still can be used / Prepara piatti con gli avanzi di cibo che possono ancora essere utilizzati
- Consider portion size / Considera la dimensione della porzione
- Manage storing techniques / Gestire le tecniche di archiviazione
- Overconsume leftover food

PART IV-

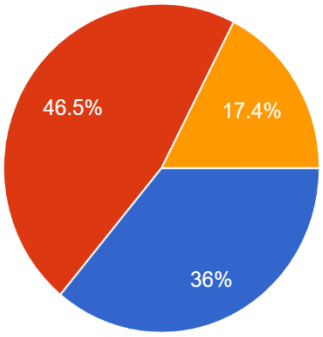
This part of the survey will help to understand how technology could be leveraged to mitigate food waste effectively.

Questa parte dell'indagine aiuterà a capire come sfruttare la tecnologia per mitigare efficacemente gli sprechi alimentari.

Question 14 -

To what extent do you agree that technology effectively reduces food waste, empowers food circularity, and contributes to building a better future world?

In che misura sei d'accordo sul fatto che la tecnologia riduce efficacemente gli sprechi alimentari, rafforza la circolarità alimentare e contribuisce a costruire un mondo futuro migliore?



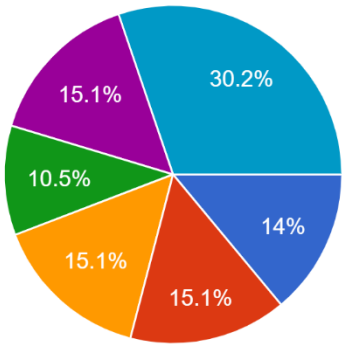
- Likely - For the ever-growing problem of food waste, technology is a solution / Probabile – Per il problema sempre crescente dello spreco alimentare, la tecnologia è una soluzione
- Neutral- I am afraid technology will replace manpower / Neutrale: temo che la tecnologia sostituirà la forza lavoro
- Not likely - While technology has benefits, it may not be the primary driver of change /Improbabile: sebbene la tecnologia presenti dei vantaggi, potrebbe non essere il principale motore del cambiamento.

Question 15 -

Are you familiar with any of the following technology solutions for food waste reduction?

Conosci qualcuna delle seguenti soluzioni tecnologiche per la riduzione degli sprechi alimentari?

86 responses

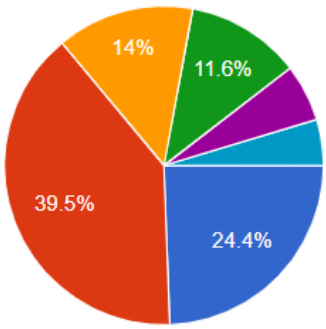


- Food tracking apps / App per monitorare il cibo
- Smart inventory management systems / Sistemi intelligenti di gestione dell'inventario
- Predictive analytics for meal planning / Analisi predittiva per la pianificazione dei pasti
- IoT (Internet of Things) devices for food quality monitoring / Dispositivi IoT (Internet of Things) per il monitoraggio della qualità degli alimenti
- Food rescue and redistribution platforms / Piattaforme di salvataggio e redistribuzione alimentare
- I'm not familiar with any of these technologies / Non ho familiarità con nessuna di queste

Question 16 -

Why do you think some people are afraid of using technology in food waste reduction?
Perché pensi che alcune persone abbiano paura di usare la tecnologia per ridurre gli sprechi alimentari?

86 responses



- Privacy and data security concerns / Problemi di privacy e sicurezza dei dati.
- Lack of understanding about how the technology works / Mancanza di comprensione su come funziona la tecnologia.
- Perceived high costs of technology implementation / Costi elevati percepiti di implementazione della tecnologia.
- Resistance to change in traditional food management practices / Resistenza al cambiamento nelle pratiche tradizionali di gestione alimentare.
- Concerns about the environmental impact of technology / Preoccupazioni per l'impatto ambientale della tecnologia.
- Lack of access to necessary technology or internet connectivity / Mancanza di accesso alla tecnologia necessaria o alla connettività Internet.