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Assessing Food Loss and Waste in Chile: Insights for Policy and Sustainable Development Goals

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Abstract: The Food and Agriculture Organization (FAO) reports that Latin America and the Caribbean experienced the most rapid rise in food insecurity, with approximately 47.7 million individuals in the region affected by hunger in 2022. In Chile, almost three million people, 15.6% of the country's population, do not have regular access to sufficient nutritious food and suffer from some form of food insecurity. Moreover, Chile is particularly susceptible to the impacts of climate change and contends with the depletion of several critical natural resources, notably water, stemming from severe and prolonged drought conditions. This article aims to comprehensively evaluate food loss and waste (FLW) in Chile and analyzes the implications of FLW on the sustainable development goal (SDG). This will be achieved by utilizing a top-down mass balance methodology that integrates various data sources and an in-depth analysis of the main food categories at different stages of the food supply chain (FSC). In 2021, Chile generated 5.18 million tons of FLW, with fruit being the largest contributor at 2.5 million tons (48% of total FLW). Vegetables accounted for 0.8 million tons (16%). Other food groups each contributed 1% to 10% of the total FLW. Per capita FLW was 295 kg. FLW varied by food group and FSC stage. Fruits, vegetables, starchy roots, and pulses had the most FLW early in the FSC, while cereals had it later. Comparing FLW with the domestic supply quantity of food, it is observed that 68% of the fruit available for the population was discarded. Vegetables and starchy roots also showed significant volumes of discarded food, with 48% and 29% of the availability of these products in Chile. Furthermore, we explore the implications of FLW on realizing SDG 2—zero hunger, particularly emphasizing its correlation with target 12.3. The research underscores the potential of its findings to significantly shape public policies and strategies concerning FLW and their alignment with the associated SDGs, making a tangible impact on the lives of millions.

Keywords: food loss and waste; food supply chain; sustainable development goal (SDG); food security; environment; Chile

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1. Introduction

Food loss and waste (FLW) is a current topic of concern in the academic and political spheres due to its economic, social, and environmental consequences. Food production needs a lot of water and land during the entire FSC, and many greenhouse-gas emissions are emitted [1,2]. Conversely, FLW results in adverse environmental externalities due to the utilization of water and land resources in food production that ultimately go unconsumed [3–5]. In the long-term, when natural resources are wasted now, the availability of these resources is reduced in the future.

Factors contributing to FLW vary among nations. In developing countries, FLW is primarily attributed to inadequate infrastructure, insufficient investment in storage technologies, and limited knowledge [6,7]. For developed countries, the primary sources

of FLW are often found within the retail, food service, and household sectors of the FSC, which is influenced by many reasons [8], such as burning, food not used in time, leftover waste, personal preferences, or spoilage [9,10].

In 2015, global leaders endorsed a universal agenda for 2030, embracing the 17 SDGs. The SDG 2 of zero hunger states that humanity must end hunger, ensure food security, enhance nutrition, and promote sustainable agriculture [11]. This goal connects to target 12.3, which establishes that, by 2030, it should cut per capita global food waste in half at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses [11]. Despite these objectives, by 2021, an estimated 768 million people globally were undernourished, and 2.3 billion people were experiencing moderate-to-severe food insecurity [12]. Furthermore, 14% of food is not consumed globally and is wasted from harvest to distribution, and 17% is in retail [13]. In Latin America and the Caribbean, 220 million tons of food per year are wasted when 40.6% of the people suffer from hunger [12]. These data give an idea of the relevance and importance of these issues.

Chile has progressed in reducing child undernourishment in the last three decades. For instance, the prevalence of undernourishment (average of three years) fell from 4.7% to 2.5% between 1999–2001 and 2020–2022. Therefore, Chile is almost reaching the level of Northern America and Europe, where the rate is less than 2.5%. Nevertheless, from 2020 to 2022, a total of 500,000 people persisted in a state of undernourishment [14]. Furthermore, adhering to a food basket in Chile that is aligned with the dietary guidelines would cost approximately 36.1% more than a basic food basket [15]. This disparity suggests that as many as 27% of the population may face challenges accessing these recommended dietary options. Moreover, according to [16], food insecurity levels increased significantly during the COVID-19 pandemic, from 30% (2017) to 49% (2020). According to [17], the prevalence of severe food insecurity in the period 2020–2022 was 4.1%. When considering both moderate and severe food insecurity, the prevalence was 18.1% in the same period. The rise in food insecurity has impacted every household in Chile, with particular strain felt by those supporting economically dependent individuals, such as children, adolescents, and older adults.

More studies are needed to examine Chile's patterns and the extent of FLW. However, they are urgent due to FLW's importance for food security, the environment, and the Chilean agriculture industry. The results of a survey led by [18], with a sample of 311 people in the metropolitan region, showed that 95% of the respondents acknowledged throwing food away from the fridge as normal behavior. Ref. [19] directed a study about FLW in the hake and jibia value chains in the Region of Valparaiso. The research stated that 1851 and 24,824 tons of hake and jibia per year are wasted, respectively. Another study of ten farmers in the Metropolitan Region of Chile concluded a loss of 12,000–25,000 heads of lettuce per hectare [20]. Ref. [21] conducted a case study in a rice mill, estimating a waste of 104.4 tons per year, equivalent to 0.5% of the rice traded by the mill [22]. Based on a study of eight farmers in the Municipality of Melipilla, a waste of between 1.08 and 1.7 tons per hectare of potatoes was concluded for harvest and storage, respectively.

On the other hand, ref. [22] also pointed out a waste of 63.3 kg of bread per household per year in Chile, which is equivalent to 16.7% of the national population's average consumption. In 2019, a project was initiated to collect data on food loss within Chile's fruit and vegetable supply chains, specifically focusing on potatoes, tomatoes, lettuces, and raspberries, which are pertinent to the domestic market [23]. Ref. [24] investigated the family eating behavior regarding food waste for a sample of fifteen households in the metropolitan region. The findings revealed that homes, on average, discarded 3.65 kg of fruits and vegetables per week. Ref. [25] conducted a study of household waste and found that 92% of people stated that they waste food in Chile. Finally, ref. [26] conducted a pilot study in a fresh-food market in Estación Central (n = 9), finding that planning and storage represented the leading causes explaining surplus and FW.

While prior research has provided valuable insights into FLW, it has primarily focused on specific product categories, stakeholders, and stages of the FSC. Moreover, most of these

studies are from the grey literature with limited datasets. Significantly, no studies have yet explored the potential of FLW to advance the SDGs, particularly in the context of Chile. This underscores the need for our research to fill this gap by providing a comprehensive assessment of FLW in Chile across various FSC stages and food products. Our study will offer a robust understanding of the amount of FLW, its causes, and the benefits of reducing it.

Our article is a significant step towards addressing these constraints. We provide a comprehensive assessment of FLW in Chile, expanding the range of food products studied and considering all aspects of the FSC. We, then, analyze the implications of FLW on the SDGs, highlighting the challenges that public policies and other initiatives must overcome to effectively mitigate FLW. The structure of our article is as follows: a theoretical background on FLW and food security, its relationship with the SDGs, and the patterns and scale of FLW in Chile; a methodology for estimating FLW across different products and stages of the FSC, along with empirical findings and a discussion based on available data; and a section outlining the challenges public policies must address to enhance food security through FLW reduction efforts.

2. Research Background and Literature Review

2.1. Food Loss and Waste

The commonly accepted definition of FLW refers to the decrease in mass or quality characteristics of food intended for human consumption, occurring across the entire FSC, from initial production to final domestic consumption [27]. However, there is no universally agreed-upon definition of FLW. Various definitions and approaches exist, leading to a proliferation of terms that can complicate understanding, measurement, and addressing the issue [28,29]. Following [30], variations in the description of FLW may include differences in scope (whether intended for human consumption or not), timing (pre-harvest, harvest ready, post-harvest), criteria (use, edibility, nutritional value), perspective (environmental, social, food security), and type (qualitative, quantitative). It is important to distinguish between the terms' food loss' and 'food waste'. The former refers to the reduction in the mass of edible food from the production to processing stages within the FSC [31,32]. The latter, on the other hand, refers to food of adequate quality for human consumption that remains uneaten and is discarded after the FSC, including the distribution, retail, and consumption stages [32,33].

Various terms have been explored in FLW, including food loss and waste rate (FLWR), allocation, and conversion factors. The FLWR represents the food loss and waste ratio to the total food production. Conversion factors specify the percentage of edible food, while allocation factors determine the proportion of food intended for human consumption.

2.2. SDG2 Zero Hunger and Food Security

Ref. [34] defined food security as when everyone always has access to adequate, safe, and nourishing food that aligns with their dietary requirements and preferences, encompassing physical, social, and economic dimensions, to support an active and healthy lifestyle. This universally embraced definition underscores the multifaceted character of food security, encompassing its four dimensions: availability, affordability, quality and safety, and stability [35]. According to [36], availability measures the production of agricultural commodities and the on-farm operational capacities, along with the susceptibility to supply interruptions, the national ability to distribute food, and the initiatives in research to enhance agricultural production. Affordability involves consumers' capacity to acquire food, their susceptibility to fluctuations in prices, and the existence of initiatives and regulations to assist consumers during such fluctuations. Quality and safety involve the diversity and nutritional value of typical dietary patterns, along with the food safety aspect. Finally, stability is defined as the situation when a population, household, or person has access to adequate food at all times. Despite these four dimensions of food security, it is noteworthy to highlight the significance of conducting new analyses considering the continuous evolu-

tion of the understanding of food security. Currently, a phase of updating is in progress, characterized by the expansion of the traditional four-dimensional framework. For example, the agency dimension was proposed recently and underscores the importance of people and groups having control over their production and consumption systems; another emergent dimension of food security is the sustainability and adaptation dimension that examines the vulnerability of a nation to the consequences of climate change, its proneness to risks related to natural resources, and its strategies for mitigating these risks [37].

The FSC has evolved into a more globalized, specialized, and intricate system, facilitated by advancements in technology and transportation and diminished trade barriers [38]. In globalized food systems, there are actors connected horizontally and vertically. Transitioning from conventional to globalized agriculture has resulted in greater distances separating food production and consumption locations [39]. This scenario may heighten the likelihood of FLW owing to the extended duration between post-harvest and consumption and the numerous transactions among various actors within the FSC. Nonetheless, it also holds the potential to enhance food security by enabling the linkage of food producers with populations experiencing food insecurity.

SDG 2 zero hunger aims to achieve food security, counting it with eight goals. SDG targets 2.1. and 2.2. address issues related to micro- and macronutrient deficiencies but do not specifically address concerns regarding excessive consumption or the prevalence of fundamental salt, fat, and sugar levels in certain foods and their resultant health implications. SDG targets 2.3 and 2.4 are about food production, focusing on enhancing the productivity and incomes of small-scale food producers and promoting sustainable food-production practices. The subsequent four targets address the implementation challenges essential for attaining the initial objectives, including genetic diversity, infrastructure and technology enhancement, and the development of agricultural trade and markets.

Achieving food security and SDG2 hinges on sustainable food production and conscientious consumption. Hence, tracking FLW can directly aid in advancing the SDGs through various means. Managing FLW enhances food availability [40], potentially bolstering food security. Additionally, implementing sustainable food systems with reduced FLW could decrease food costs. As outlined in [7], considering the significant scale of FLW, investments aimed at its reduction could alleviate the food expense. As exemplified by [40], minimizing FLW or facilitating food donation before it reaches the FLW stage can decrease food costs, mainly if the associated expenses are lower than those incurred by disposing of FLW. By reducing FLW and the expenses related to food production, there is an expansion in food availability within the market, leading to price reductions and, subsequently, an enhancement of food access for vulnerable populations [41]. Moreover, mitigating FLW during the FSC consumption stage enhances consumers' purchasing power for food, thereby improving access to nourishment. Indeed, according to [42], the primary motivation for minimizing FLW at the household level is financial savings rather than environmental considerations. Nevertheless, further research is required to explore the connections between FLW and food prices, mainly through quantitative analysis [41]. Third, managing FLW entails enhancing the availability of high-nutritional-quality food, addressing hunger issues through increased food availability, and ensuring access to nutritionally superior food options [41]. Fourth, sustainable food systems with diminished FLW can mitigate business investment risks. Consequently, this risk reduction can stabilize food prices, enhancing the reliability of the food supply. Presently, markets are characterized by limited transparency and erratic fluctuations in food prices that often marginalize vulnerable populations within food systems [27].

The adverse environmental impacts of FLW are equally significant, including the squandering of water and land resources and CO_2, N_2O, and CH_4 emissions, contributing to climate change and biodiversity loss [43,44]. As documented by [45,46], food waste contributes to a significant loss of agricultural water, accounting for a quarter of total usage, and results in an estimated global economic loss of approximately USD 940 billion annually. Furthermore, the intensive exploitation of land leads to acidification and soil degradation,

ultimately diminishing agricultural yields. Environmental degradation negatively impacts agriculture in a reciprocal relationship, perpetuating a vicious cycle [47]. Climate change, for instance, heightens the susceptibility of food insecurity by exerting biophysical pressures on crops, livestock, and agricultural productivity [48].

The following Figure 1 summarizes the impact of FLW on food security, the environment, and SDGs through various transmission channels. It highlights two main categories of effects: environmental and food-security dimensions. Ecological impacts include the waste of water, land degradation, CO_2 emissions, and habitat alterations, affecting water, land, climate change, and biodiversity. On food security, it emphasizes reduced food availability, higher food prices, nutritional quality loss, and long-term unsustainability in food systems, impacting the four dimensions of food security: availability, access, use, and stability, ultimately hindering the achievement of the SDGs.

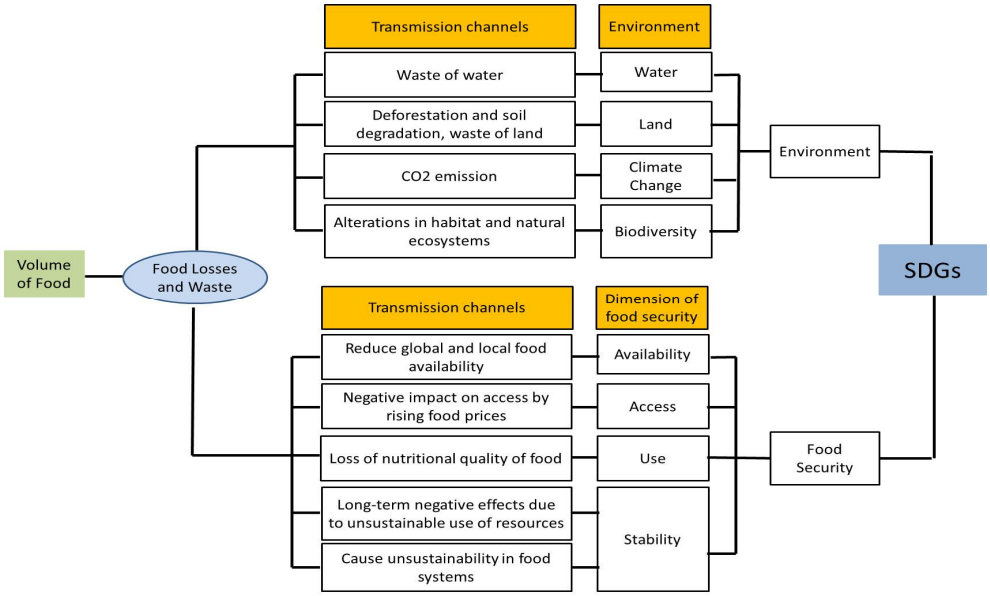

Figure 1. FLW effects on food security and SDGs. Source: own elaboration.

2.3. Food Loss and Waste Patterns in Chile

Ref. [49] constructed an SDG Global Rank by assessing the performance of SDG indicators across countries, revealing Chile's position as 31 among 162 nations. However, the SDGs related to food security have adverse effects. Still, none of them were achieved. Two represent a major challenge, four were assessed as significant, and the challenge remains in three. In addition, at least two conditions may hinder the achievement of the SDGs. In Chile, a disparity persists in the nutritional quality of food consumed across various socioeconomic groups. Ref. [15] reported that following the recommendations of food guides would result in a 36.1% increase in the cost of a food basket in Chile compared to a basic food basket. It implies that as much as 27% of the population may be unable to access them.

On the other hand, in the last decade, Chile has been facing the worst drought in Chilean history [50]. This situation has had substantial adverse effects on the Chilean agriculture industry and the availability of natural resources. Therefore, reducing FLW will play a pivotal role in securing future food supplies [51], enhancing environmental quality, and preserving the availability of natural resources. Table 1 shows the status and trends of food security and environmental SDGs in Chile.

Table 1. Evaluating the status and trends of food security and environmental SDGs in Chile.

SDG	Assessment	Trends
No Poverty	Significant challenges	Stagnating
Zero Hunger	Major challenges	Stagnating
Clean Water and Sanitization	Challenge remains	On track or maintaining SDG achievement
Affordable and Clean Energy	Challenge remains	Moderately improving
Sustainable Cities and Communities	Significant challenge	Moderately improving
Responsible consumption and production	Significant challenge	Stagnating
Climate Action	Major challenges	Stagnating
Life Below Water	Significant challenges	Stagnating
Life on Land	Major challenges	Stagnating

Source: [49].

Regrettably, more research is needed to delve into the core factors driving FLW in Chile. Four undergraduate theses were conducted under an FAO project by the Universidad de Santiago de Chile. However, by considering the research conducted in other countries in Latin America or other developing countries, it is possible to get clues about the causes of FLW in Chile. Ref. [52] pointed out general drivers to explain FLW in China that might also apply to Chile. First is the economic growth and the increase in income and purchasing power. Second is the development of agriculture in the last few decades.

In 2022, Chile ranked second among South American countries in GDP per capita after Uruguay. Moreover, between 1985 and 2022, the annual average growth rate of GDP per capita stood at 3.4%, resulting in an income increase surge from USD 4257 in 1985 to USD 14,355 in 2022 [53].

Access to credit is another factor that has increased the consumption capacity in Chile in the last decade. According to the [54], household debt from 2010 to 2019 has continuously increased from 36% to 49% of GDP. Economic growth corresponds with enhanced living standards, encompassing increased food consumption. The available data suggest that household per capita food waste rises with per capita GDP growth [55]. The increase in economic growth contributes to a rise in FLW, as higher income availability typically results in a lower percentage of household budgets allocated toward food purchases. Therefore, it could lead to negligent behaviors among individuals regarding FLW.

Over the past few decades, Chile's agricultural sector has significantly developed. Between 1990 and 2021, the production of fruits increased from 2.6 to 7.9 million tons [14]. An increase in food production will inevitably result in higher FLW levels, if the underlying causes remain unchanged. For example, if a nation boots grain production without improving inefficient storage technology, FLW will rise accordingly.

Specific reasons also provoke FLW at every stage of the FSC. In Chile, 67% of the FLW of fruits occurred during agricultural production and post-harvest and storage, representing 30% of the total FLW. This aligns with the fact that fruits account for 30% of Chile's food-production volume. Also, the FLW of vegetables and starchy roots are generated in the first two stages of the FSC. The international literature and national studies suggest the following reasons. To begin with, specific attributes inherent in producing fruits, vegetables, and starchy roots diminish the ability to forecast supply and demand volumes. This circumstance impedes the adaptability of FSC operators to evolving markets, thereby resulting in FLW [56]. For example, during the agricultural production stage, uncertainties such as weather conditions, frosts, droughts, pests, or diseases can contribute to FLW in fruits, vegetables, and starchy roots. This circumstance induces farmers to overplant as a precaution against the risks of not meeting contractual obligations. Consequently,

surplus products that remain unsold or unharvested are produced [57]. Second, the delicate nature of numerous fruits and vegetables makes them vulnerable to damage during automated or manual harvest and handling processes [56]. Third, various factors, including bird damage, frosts, droughts, and adverse weather conditions, contribute to the FLW of these products [22]. Additionally, these conditions often result in fruits, vegetables, and starchy roots failing to meet market standards regarding appearance, shape, and weight. Consequently, farmers discard them to mitigate harvesting costs [58].

In the first stage of the FSC, around 48% of fish and seafood were discarded. The main reason for this was catching fish and returning them to the sea, either injured or deceased. As stated by [19], this situation happens due to a need to recognize what FLW is and its importance in the daily work of fishers, fisheries officers, fish cleaners, and intermediaries.

The living standards of the Chilean population have improved due to economic growth in recent decades, allowing part of the population to access a broader range of higher-quality foods. Thus, Chile has seen a rapid decline in poverty, with the population falling by one-tenth between 1990 and 2022, from 68% [59] to 6.5% [60]. This situation involved an equally accelerated reduction in malnutrition rates, creating a favorable economic expectation. Therefore, it resulted in a societal perception of no longer being poor. The way to demonstrate this new socioeconomic status was through the increase in the purchase of goods and food, even if they were not needed, leading to a rise in the volume of discarded food. According to [18], throwing food away in 94.9% of Chilean households is widespread. Prepared foods comprise the most significant portion of household food waste, accounting for 44% of total waste, followed by vegetables (24.4%) and bread (12.9%). The most cited reason (57.6% of the interviewed people) for this behavior was forgetting that the food was in the refrigerator. Moreover, the domestic supply of animal products quadrupled, rising from 0.5 million tons in 1990 to 2 million tons in 2021 [14]. Animal products inherently yield unavoidable waste, including bones and organs. The increase in the population's prosperity and accompanying consumption patterns may have contributed to a rise in FLW at the consumption stage within Chile's FSC.

3. Materials and Methods

3.1. Method and Calculation of Food Loss and Waste

The studies mentioned offer insightful data concerning the magnitude and trends of FLW but are constrained to specific product categories and stages within the FSC. This article broadens the scope to encompass a more comprehensive array of products and food types, including all FSC stages, while also updating the data to estimate FLW. Using the mass balance method [7,61], it examines the impact of FLW on the SDGs and highlights the challenges that public policies must confront in mitigating FLW and its adverse effects.

The mass balance approach entails deducing the quantity of FLW by examining the disparities between inputs and outputs of food, stock fluctuations, and weight alterations throughout the process [62]. This methodology offers the benefit of quantifying solid and liquid food loss and waste across each FSC stage at a national or company-specific level. The data necessary for its implementation are often readily available and easily accessible from national statistics [63]. These advantages make this method well-suited for the objective of this study, as the estimation herein encompasses FSC stages at the national level in Chile and spans a diverse array of food products.

It is important to note that certain food groups, such as cereals, oil crops, and legumes, may serve alternative purposes, such as animal feed or biofuel production. Hence, allocation factors are considered. For the rest of the food groups, all production is assumed to be designated for human consumption. Edibility is determined using conversion factors, which were applied to cereals, fish and seafood, fruits, starchy roots, and vegetables, as certain parts of these foods, such as banana skin, may not be edible. Conversely, it is assumed that other food groups are edible. Figure 2 shows the FLW accountability approach used in this research. The figure illustrates how food-waste flows were calculated at each stage of the FSC based on various indicators. As mentioned, it used a mass balance approach to

determine the flows of FLW by-products, considering the amounts of food entering an FSC stage as inputs and as outputs of the quantities of food leaving an FSC stage, adhering to the principle of mass conservation. For example, the total volume of food in the agricultural production and the postharvest and storage stages are multiplied by the FLWR, CF, and AF to estimate the volume of FLW of each stage, respectively. In the subsequent FSC stages, the volume of food in each stage minus the food intended for other purposes and previous estimates of FLW provides the input volume of food for this stage, which will be multiplied by FLWR, CF, and AF to calculate the volume of FLW at each stage.

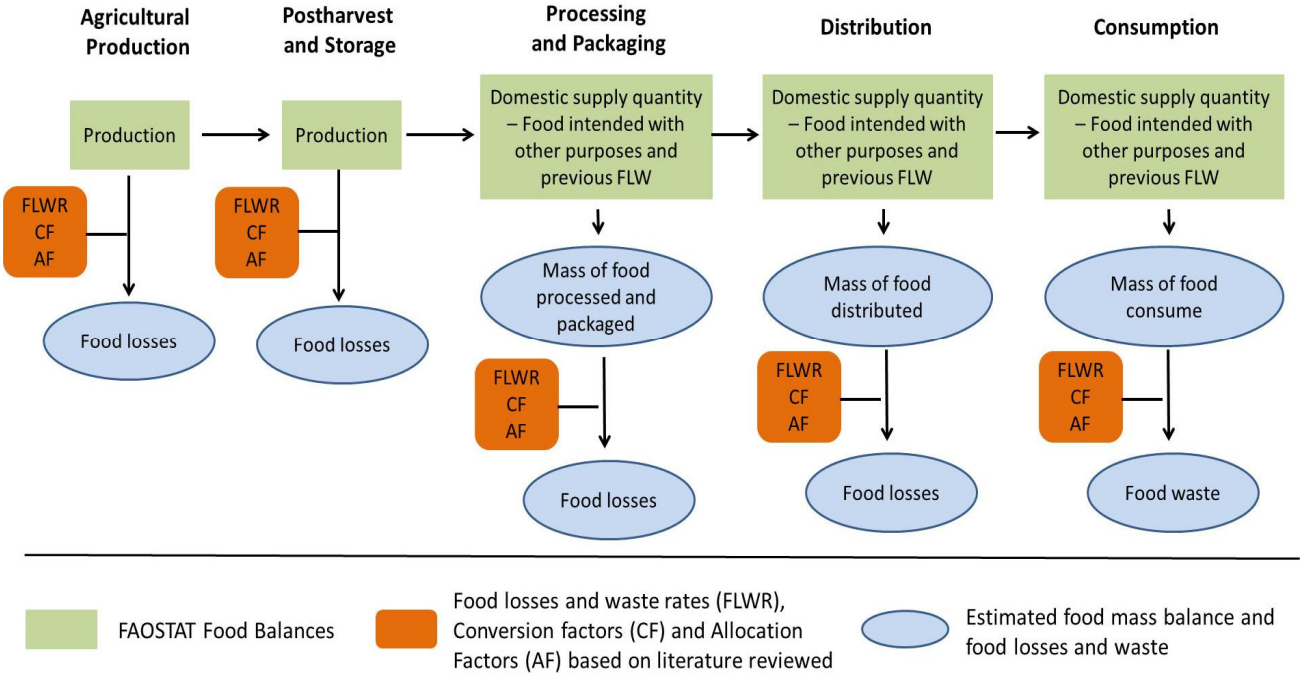

Figure 2. FLW estimation accounting methodology. Source: own elaboration.

The subsequent overarching equation outlines the calculation of FLW.

$$FLW = \sum_{i=1}^{n} QA_{ij} * \alpha_{ij} * \beta_{ij} * \gamma_{ij} \quad (1)$$

where

i = categories of food, including cereals, fish and seafood, fruits, meats, dairy, eggs, oilseeds, legumes, starchy roots, and vegetables.
j = Stages within the FSC, encompassing agricultural production, post-harvest handling and storage, processing and packaging, distribution, and consumption.
QA_{ij} = the amount of food within food group i at stage j of the FSC.
α_{ij} = the food loss and waste rate (FLWR) at stage j of the FSC, calculated as the proportion of FLW to the total food production.
β_{ij} = the allocation factor at stage j of the FSC establishes the percentage of food allocated for human consumption.
γ_{ij} = the conversion factor at stage j of the FSC determines the percentage of edible food.

The quantity of edible food mass diminishes throughout the FSC due to various factors, each with its distinct causes [4]. Food loss occurs during agricultural production, post-harvest, processing and packaging, and distribution, whereas food waste arises during consumption [33].

Hence, the FLW was determined by multiplying the quantity of food available at each stage of the food chain by FLWR, along with the allocation and conversion factors.

The per capita FLW is calculated using the following equation.

$$FLW_{PC} = \frac{FLW}{P_n} \quad (2)$$

where

FLW_{PC} = per capita food loss and waste.
P_n = population.

3.2. Data

The scope of this study encompasses Chile as its geographical area. Production and yield data for the year 2021 were sourced from FAOSTAT. Population data from the National Statistical Institute of Chile were used for the per capita analysis. FLWR, conversion, and allocation factors were obtained from [7] and contrasted with [55]. Table 2 shows FLWR by each stage of the FSC, conversion factors, and allocation factors.

Table 2. FLWR by each stage of the FSC, conversion factors, and allocation factors.

Food Losses and Waste Rate							
Food Groups	**Agricultural Production**	**Postharvest and Storage**	**Processing and Packaging**	**Distribution**	**Consumption**	**Allocation Factor**	**Conversion Factor**
Cereals	6.0%	4.0%	4.5%	4.0%	10.0%	40.0%	78.0%
Fish, Seafood	5.7%	5.0%	9.0%	10.0%	4.0%		50.0%
Fruits	20.0%	10.0%	20.0%	12.0%	10.0%		78.0%
Meat	5.3%	1.1%	5.0%	5.0%	6.0%		
Milk and Eggs	3.5%	6.0%	2.0%	8.0%	4.0%		
Oilcrops and Pulses	6.0%	3.0%	8.0%	2.0%	2.0%	12.0%	
Starchy Roots	14.0%	14.0%	12.0%	3.0%	4.0%		82.0%
Vegetables	20.0%	10.0	20.0%	12.0%	10.0%		78.0%

Source: [7].

The methodology and data used in this article possess inherent limitations, necessitating further exploration in future research to achieve a more comprehensive and robust FLW accounting. The subsequent list outlines these limitations:

(i) The mass balance method yields broader data, particularly nationally. Nevertheless, these data tend to be less precise than the information generated by other methods, such as the direct weighing method;
(ii) The FAOSTAT data for a wide range of food groups and FSC stages were used to conduct this research. In this sense, not all food groups in the FAOSTAT data are equally accurate and reliable;
(iii) FLWR, conversion factors, and the allocation factors employed in estimating FLW were sourced from [7,61], which synthesized data from scientific journals, online sources, statistical databases, national agencies, international organizations, and NGOs from 1997 to 2011. For more comprehensive information regarding data sources and methodologies used in estimating FLWR, conversion, and allocation factors by [7], see Annex 1 to Annex 3 of [61]. Moreover, in this FLWR investigation, the conversion and allocation factors were contrasted with data from [55] from 1943 to 2015. The studies cited above aggregated these factors from various regional studies across Latin America. Consequently, they do not pertain specifically to Chile and may need to be updated. This introduces a potential bias in the estimation process. Nonetheless, these limitations can be mitigated by comparing the outcomes with studies based on primary food-waste data [62,63]. Although using factors designed for Latin America as a proxy variable for Chile presents certain drawbacks, it remains crucial to conduct

research employing these factors and the mass balance method. The argument above is because the mass balance method offers a broader perspective of FLW composition within a country [62,63]. This larger picture helps focus future research resources on the nation's FLW hotspot. Therefore, future research could focus on collecting primary data on Chile's food waste to improve the accuracy of FLWR, conversion, and allocation factors.

4. Results and Discussion

In 2021, Chile's domestic food supply reached 21 million tons, with cereals and fruits collectively accounting for 52%, equivalent to 11 million tons. Oil crops and pulses constituted only 3% of the domestic supply, totaling a mere 0.7 million tons, marking them as the categories with the smallest share. In 2021, the per capita domestic food supply was 1192 kg, while the findings revealed that Chile's total FLW amounted to 5.18 million tons. Without accounting for conversion factors, the total rises to 6.5 million tons. Most of this waste, 2.5 million tons, or 48% of the total FLW, was attributed to fruit. With lower volume than the previous group were vegetables, which were 16% of the total FLW and equivalent to 0.8 million tons. The other food groups individually represented a small percentage of the total FLW, 1% to 10% each. The per capita FLW was 295 kg. Table 3 shows the domestic supply quantity and FLW calculated for each food group and FSC stage, with conversion factors, in Chile in 2021.

Table 3. Domestic supply quantity and FLW calculated for each food group and FSC stage, with conversion factors, in Chile in 2021.

Food Groups	Domestic Supply Quantity (1000t)	Food Losses and Waste (1000t)						Food Waste/Domestic Supply Quantity
		Agricultural Production	Postharvest and Storage	Processing and Packaging	Distribution	Consume	Total FLW by Product	
Cereals	7270	58	39	8	90	217	411	6%
Fish, Seafood	1174	95	83	5	13	5	200	17%
Fruits	3698	1075	538	435	268	192	2508	68%
Meat	1911	84	17	0	95	109	306	16%
Milk and Eggs	3207	90	154	12	182	84	522	16%
Oilcrops and Pulses	692	4	2	29	0	0	36	5%
Starchy Roots	1263	116	116	78	22	29	361	29%
Vegetables	1737	360	180	103	114	82	840	48%
Total FLW by FSC stage	20,952	1882	1129	670	785	717	5183	25%

Source: own elaboration.

Findings about the stages of the FSC indicated that the first two stages, namely, agricultural production and post-harvest and storage, accounted for 58% (3 million tons) of the total FLW. The remaining three stages contribute approximately 14% of total FLW. The results indicated that fruit contributed to FLW at the early stages of the FSC, 1.1 (43%) and 0.5 (21%) million tons in agricultural production and post-harvest and storage, respectively. The situation was similar to that of the vegetables, starchy roots, and pulses group, where around 63% was lost in the first two stages of the FSC. Cereals showed a different situation because FLW occurred in distribution and consumption, 0.3 million tons, equivalent to 75% of the FLW of this group of products. FLW in meat was distributed equally among agricultural production, distribution, and consumption, around 30% at each stage. The following Figure 3 shows the FLW calculated for each food group and FSC stage in Chile in 2021.

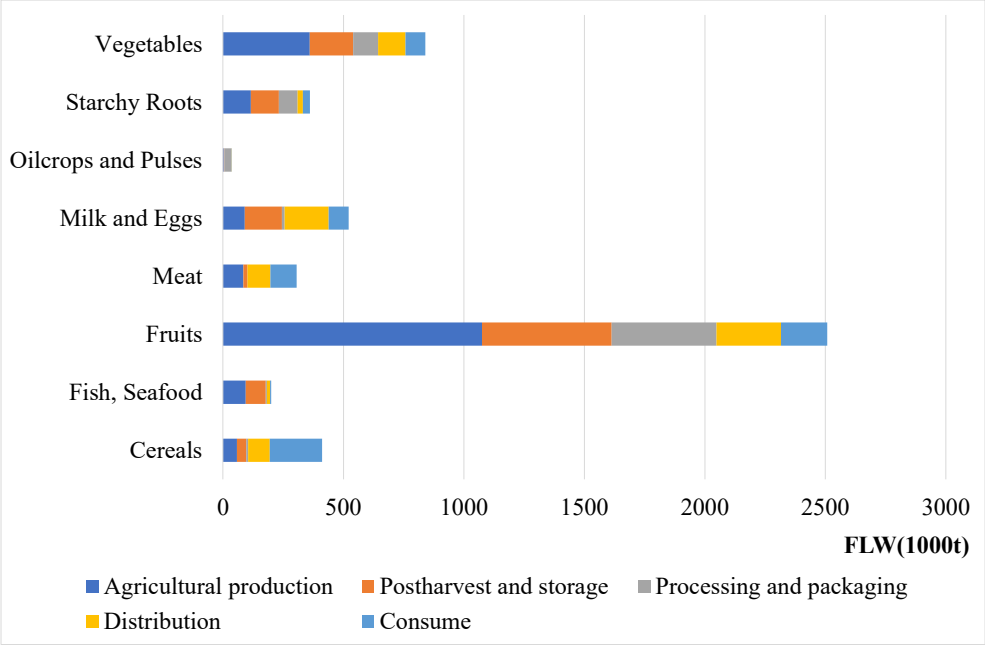

Figure 3. FLW was calculated for each food group and FSC stage in Chile in 2021. Source: own elaboration.

Comparing FLW with the domestic supply quantity of food, it was observed that 68% of the fruit available for a person in Chile is discarded. Vegetables and starchy roots also showed significant volumes of discarded food, 48% and 29% of the availability of these products in Chile. Dairy products, eggs, meat and fish, and seafood exhibited a notable level of FLW relative to the domestic supply quantity, accounting for approximately 16%. Although Chile ranks 25 out of 113 countries in the Global Food Security Index (GFSI), there are still aspects where the mitigation of FLW could contribute to improving food-security levels. The groups of food with the highest FLW in Chile are fruit and vegetables; both types of food are rich in vitamins, minerals, and antioxidants. For example, leafy greens, such as spinach, kale, and chard, as well as fruits such as berries, citrus, and kiwi, are particularly rich in vitamins and minerals. The GFSI pointed out that Chile is under the world average in terms of the availability of micronutrients, such as vitamin A, iron, and zinc; therefore, reducing FLW in these groups could improve the availability dimension of food security. Furthermore, the prevalence of obesity in Chile in 2016 was 28% [17]; in this sense, a diet rich in fruits and vegetables can be part of an effective strategy to control weight and prevent obesity due to their low-calorie content and high fiber and water content and because fruits are healthy substitutes for high process unhealthy snacks [64]. Looking for mechanisms to mitigate FLW and transforming this food into consumption could contribute to improving the dietary diversity of the Chilean population, another aspect of the GFSI where Chile is below the world average.

The GFSI pointed out that Chilean marine biodiversity performance is also below the world average. This indicator measures the health of aquatic life represented by a country's total catch from overexploited or collapsed stocks, considering all fish stocks within a country's exclusive economic zone. Even though 17% of fish and seafood available for food consumption in Chile has been discarded, the opportunity to improve this situation is provided by reducing fish and seafood FLW.

When comparing estimates across countries and regions, it becomes evident that Chile's per capita FLW, equivalent to 295 kg in 2021, surpassed the global FLW per capita, which is estimated at 240 kg per year [65]. It was at the level of North America and Europe. Ref. [7] estimated 280 kg per year per capita in North America, while several estimations based on primary and secondary data suggested that, in Europe, FLW per capita ranges

from 158 to 298 kg per year [61,65–73]. Ref. [72] estimates the total EU consumer food waste averages 123 (min 55–max 190) kg/capita annually. The estimations of [69] were 173 for EU-28 in 2012; ref. [71] estimates that in 2006 EU-27 generated 179 kg per capita. Ref. [73] pointed out an FLW per capita of 257 in 2011 for the EU-28; ref. [67] estimates that, in 2006, the EU-27 generated 288 kg per capita. Ref. [70] pointed out an FLW per capita of 290 kg in 2012 for 2011; the estimations of [65] were 298 kg for Europe in 2011. Variations in the reported estimations stem from disparities in study scopes, system boundaries, objectives, methodologies, adopted definitions, and the inherent challenges in accounting problems [74]. Another cause of discrepancies is the different years of estimation. FLW in Chile is higher than in Sub-Saharan Africa and South and South-East Asia, where the estimated FLW ranges between 120 and 170 kg per year [7].

Regarding the absolute volume, the Chilean FLW of 5.18 million tons represents a small percentage of the global and Latin American FLW. The reason is Chile's small domestic supply quantity compared with the world's total domestic supply quantity [14]. According to [65], in 2011, the global FLW was 1629 million tons. Latin America produced 126 million tons of FLW [61]. When comparing FLWR, the global average was found to be higher (33%) than that of Chile (26%) [7]. When examining by region, Chile frequently demonstrated a lower FLWR than the other areas. For instance, as noted by [61], developed regions, such as Europe, North America, Oceania, and industrialized Asia, typically exhibit an FLWR of approximately 35% across the entire FSC.

Examining the breakdown by group of food and stage of the FSC, Chile's FLW for fruit during the agricultural production stage significantly exceeded that of developed nations like Italy, with 61 kg per capita compared to 18.76 kg per capita, respectively [57]. The reason is the large amount of fruit produced in Chile, of which 54% is exported. In the agricultural production stage, the Chilean FLW of vegetables per capita, equivalent to 21 kg in 2021, was also higher than the Italian FLW for vegetables in the same stage, which is equivalent to 8.1 kg per capita in 2010 [75]. This reinforces the assertion that there is a substantial disparity in the amount of discarded fruits and vegetables between developing and developed countries. This variation can be explained by the fact that developed countries use more advanced and modern technologies than developing countries [55]. Acknowledging that the preceding comparisons may lack robustness due to variations in estimations methodologies, data sources, and data years is crucial. Therefore, researchers and policymakers should approach them with careful consideration.

5. Policy Implications

At a political level, Chile began to address the problem of FLW in 2014, when a regional alliance for the prevention and reduction of FLW was established by 13 Latin American and Caribbean countries [76]. This alliance aims to design a regional strategy to reduce FLW. The first step of the alliance was to create a regional network of experts and national committees to reduce FLW. In 2017, the Chilean committee included different stakeholders, including national governmental organizations, civil society organizations, universities, and FAO. The main objectives of this committee are to facilitate and coordinate strategies with other stakeholders; enhance the competitiveness and sustainability of agricultural production systems; provide a practical framework for the development of laws, public policies, and actions with the private sector; and promote academic research and teaching in this area [77]. In this sense, in recent years, diverse initiatives related to FLW have been implemented in Chile (see Appendix A).

Despite this, there are still several challenges to be addressed. First, the initiatives to tackle the FLW are still highly fragmented and uncoordinated because actors have different objectives and tools for addressing the problem. In this respect, The National Committee for the Prevention and Reduction of Food Loss and Waste might fill this gap. Second, the issue of FLW persists across various food products, including meat and dairy items, yet initiatives targeting this problem remain predominantly focused on fruits and vegetables. Finally, there is a deficiency in statistical data concerning FLW, particularly in terms of primary and

secondary data-based studies, to better inform public policies aimed at reducing FLW and mitigating its environmental impact.

Nevertheless, avoiding FLW is not an environmental and economic issue but, most importantly, an ethical and nutritional issue. At the international level, the circular economy initiatives developed also emphasize this issue. This is the case of the European Union, which is developing a substantial number of initiatives to reduce FLW that could be a reference framework for Chilean policy, as pointed out by several authors [76–78]. The circular economy contributes to sustainable production and consumption along the value chain of the agrifood sector, ensuring responsible use of resources and waste reduction. This is the path to follow for reinforcing Chilean policy along with the collaboration of all stakeholders in which the consumers have a relevant role.

6. Conclusions

The objective of this work was to assess the extent of FLW in Chile, analyze its implications for achieving the SDGs related to food security, and examine the remaining challenges that public policies and other initiatives must address to effectively diminish FLW. In this research, FLW in Chile was estimated using a top-down mass balance methodology, which integrated diverse information sources and categorized the FLW's major food groups at different stages of the FSC. This work is the first to attempt to estimate the FLW for diverse food groups in the entire FSC in Chile and to link it with the SDGs.

The quantity of FLW in Chile reached 5.18 million tons in 2021. The greatest discard was in fruit, at 2.5 million tons, which is equivalent to 48% of total FLW. With a lower volume than the previous group were vegetables, 16% of total FLW and equivalent to 0.8 million tons. The other food groups individually represented a small percentage of the total FLW, 1% to 10% each. The per capita FLW was 295 kg. FLW was concentrated at various stages depending on the group of food. The FLW for fruit, vegetables, starchy roots, and pulses was in the first two stages of the FSC, while the FLW of cereals occurred in the last two stages of the FSC. Comparing FLW with the domestic supply quantity of food, it is observed that 68% of the fruit available for the population was discarded. Vegetables and starchy roots also showed significant volumes of discarded food, at 48% and 29% of the availability of these products in Chile.

Considering the quantity of FLW in Chile, it becomes evident that effective management of FLW has the potential to directly facilitate the achievement of SDGs related to food security and environment conservation. Management of FLW enhances food availability, decreases food costs, facilitates better access to food for vulnerable people, boosts the availability of superior quality food, and increases the stability of the food supply. Moreover, reducing FLW can reduce the food industry's negative environmental impact, especially in water, land, climate change, and biodiversity.

Over the last eight years, FLW has gradually become an essential political and social issue in the world and Chile. This increase in concern for FLW, along with the SDGs, has led to the creation of The Latin American Alliance for the Prevention and Reduction of Food Losses and Waste and The Chilean National Committee for the Prevention and Reduction of Food Losses and Waste. However, challenges persist, including the need for coordinated public policies that address all the adverse effects of FLW and the scarcity of dependable statistical data. The economic, social, and environmental impact of FLW is profound. Chile is a country that has recently been facing environmental issues that should be addressed, such as, for example, the scarcity of water due to intense and prolonged droughts. Also, the agriculture industry, especially fruit exports, is vital for the Chilean economy. Therefore, reducing FLW represents a potential pathway to enhance food security and achieve the long-term sustainable development that the world needs.

Despite the comprehensive analysis provided in this study, several limitations need to be acknowledged. The accuracy of the FLW estimates is constrained by the reliance on a top-down mass balance methodology, which may not capture precise primary data, and challenges in conversion and allocation factors can affect data accuracy across different

food groups and FSC stages. Integrating diverse information sources poses additional challenges in terms of data consistency, reliability, and comparability. The geographic focus on Chile means the findings may not be directly applicable to other regions with differing agricultural practices and socio-economic contexts, which makes it difficult to compare the results with other countries and regions. Furthermore, the study covers major food groups but may omit smaller yet significant contributors to FLW. Finally, effective public policy coordination and stakeholder engagement remain critical challenges, as current efforts are often fragmented and insufficiently integrated.

In this sense, future research should prioritize acquiring more precise primary data through advanced data-collection technologies and conducting longitudinal studies to understand trends over time. Refining methodologies for better conversion and allocation factors, and conducting comparative studies across different regions, can enhance the accuracy and applicability of FLW estimates. Detailed analyses linking FLW with specific SDGs, interdisciplinary approaches, and the exploration of technological innovations, like IoT, AI, and blockchain, in FLW management are essential as future research topics. Evaluating the effectiveness of existing policies, developing robust regulatory mechanisms, and designing and evaluating awareness campaigns for stakeholder engagement are crucial steps forward. Economic and environmental assessments, including cost–benefit analyses and studies on the environmental impacts of FLW, will further support the development of effective strategies for reducing FLW, thereby promoting food security and sustainable development.

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Appendix A. Initiatives Implemented Related to FLW in Chile

Year	Initiative	Type	Description	Stage of FSC	Organization	FAO Classification
1998	Creation of the Sustainability and Climate Change Agency	Programs and projects	The objective is to encourage sustainable production practices and support mitigation and adaptation to climate change within companies, with a particular focus on SMEs and specific regions, including, among them, agricultural companies.	All stages	Ministry of Environment	Meso-solution
2009	Circular N° 54 on "Punishment of food whose trade has become unfeasible"	Laws and regulatory changes	State unique logging that indicates and creates a model of certificate of accreditation for the donation of food whose trade is unfeasible. Through this circular food, companies have tax exemption in food donations.	All stages	Internal Tax Service of Chile	Meso-solution
2010 2019	Food Banks	Programs and projects	A project that collects food that is suitable for human consumption and distributes it to vulnerable populations to enhance food security and avoid FLW.	All stages	Red de alimentos Chile and Mercado Lo Valledor	Macro-solution
2011 2015	Quantification of FLW	Quantification	One survey and one university thesis estimated the amount of FLW in households and the consumption of bread, respectively.	Consumption	Universidad de Santiago de Chile	Support action
2014	Disco Sopa	Programs and projects	It is an international movement that collects food that producers, merchants, and consumers will discard because of its appearance, but they are still edible. Activities include organizing festivals and community meetings, where volunteers collect fruits and vegetables in markets to prepare dishes and distribute them for free during the event.	Distribution and consumption	Disco Sopa Chile and Retroalimenta	Macro-solution
2015	Project of law N° 10.198-11	Laws and regulatory changes	This law project proposes to amend the Health Code on the provision of food to avoid waste.	All stages	Ministry of Health	Meso-solution
2015	Mercado Lo Valledor	Programs and projects	The project aims to mitigate FLW and reduce the amount of waste disposal in the landfill.	Distribution	Mercado Lo Valledor	Macro-solution
2015	Quantification of FLW	Quantification	Three undergraduate university theses estimated the amount of FLW in the production of potatoes, rice, and heads of lettuce.	Production	Universidad de Santiago de Chile	Support action

Year	Initiative	Type	Description	Stage of FSC	Organization	FAO Classification
2016	Article N° 4, law 20.920	Laws and regulatory changes	Framework for Waste Management, Extended Producer Responsibility, and Promotion of Recycling. This law confers authority on The Ministry of Environment to generate mechanisms to prevent waste generation, including measures to prevent products suitable for human consumption.	All stages	Ministry of Environment	Meso-solution
2016	Project of law N° 10.841-11	Laws and regulatory changes	This project of law proposes to amend the Health Code to regulate food management suitable for human consumption that is not traded to prevent waste.	All stages	Ministry of Health	Meso-solution
2017	Reduction of FLW in fruits and vegetables	Research	This research aims to study the physiological problems that affect the conservation of fruits and vegetables and spread the technological solutions that prolong their postharvest consumption quality.	Packing, storage, and distribution	Institute for Agricultural Research (INIA)	Support action
2017	Zero loss of raw material in the food industry	Quantification	A public–private program that seeks to quantify the loss of raw material in agribusiness from harvest to processing and storage.	Harvest, processing, and storage	CORFO	Support action
2017–2022	Reciclo Orgánicos	Programs and projects	The program aims to accelerate actions that help Chile reduce the emission of harmful gases into the atmosphere in the solid waste sector, specifically those from the decomposition of organic matter in landfills.	Garbage dumps	Ministry of the Environment of Chile and Ministry of Environment and Climate Change of Canada.	Macro-solution
2018	Circular N° 60/2018	Laws and regulatory changes	The circular regulates the calculation and application of income taxes, VAT, and taxes on sales for cases in which the products are not fit for sale but for human consumption.	Distribution and consumption	Internal Tax Service of Chile	Meso-solution
2018	Resolución 151/2018	Laws and regulatory changes	The resolution regulates registration procedures of non-profit institutions, which function as food distributors for social purposes.	Distribution and consumption	Internal Tax Service of Chile	Meso-solution

Year	Initiative	Type	Description	Stage of FSC	Organization	FAO Classification
2019	Quantification and management of FLW in vegetables and fruits at the agricultural production stage in Chile	Quantification	Methodology for quantifying FLW fruit and vegetables at the agricultural production stage.	Production	United Nations Environment Programme, ODEPA, USACH, Cadenas de Valor Sustentables, and FAO.	Support action
2020–2040	National strategy of organic waste Chile 2040	Programs and projects	The aim is to optimize the processes of collecting and managing organic waste, preventing it from being deposited in dumps, thus reducing the uncontrolled emission of greenhouse gases. Organic matter can be treated separately to produce compost, fertilizers, and biogas.	Garbage dumps	Ministry of the Environment of Chile and Ministry of Environment and Climate Change of Canada.	Macro-solution
2020	Creation of the National Commission to Reduce and Prevent FLW	Programs and projects	Propose actions that promote the prevention and reduction of food loss and waste and contribute to the sustainable development of Chile.	All stages	Department of Agriculture	Meso-solution
2020	Tax reform (Law 21.210/2020)	Laws and regulatory changes	As in the case of Circular N° 60/2018, the tax reform allows companies to discount the cost of food donated to the companies when calculating their taxes. In addition, the Tax Reform aligns with Law 20,920 on the management framework of residues. It specifies that food not donated but disposed of as waste cannot be considered a loss to the company.	All stages	Internal Tax Service of Chile	Meso-solution
2021	Roadmap for a Circular Chile 2040	Laws and regulatory changes	The Roadmap for a Circular Chile to 2040 is the public policy instrument that guides the country's transition towards this development model that emphasizes the efficient and sustainable use of resources and is one of the pillars of sustainable development.	All stages	Ministry of Environment. Ministry of Economy, Development and Tourism. Production Promotion Corporation. Sustainability and Climate Change Agency.	Macro-solution
2023	Project of law that promotes the recycling of organic waste in homes and commerce	Laws and regulatory changes	The project of law does not seek to reduce FLW directly but creates incentives for its reduction, since it gradually prohibits the final disposal of organic waste and promotes its recovery, which aims to divert the organic fraction of municipal solid waste from landfills.	Consumption and distribution	Ministry of Environment.	Meso-solution

References

1. Bennetzen, E.; Smith, P.; Porter, J. Agricultural production and greenhouse gas emission from world regions—The major trends over 40 years. *Glob. Environ. Change* **2016**, *37*, 43–55. [CrossRef]
2. Shafiee-Jood, M.; Cai, X. Reducing food loss and waste to enhance food security and environmental sustainability. *Environ. Sci. Technol.* **2016**, *50*, 8432–8443. [CrossRef]
3. FAO. *Food Wastage Footprint Impacts on Natural Resources*; Summary Report; FAO: Rome, Italy, 2013.
4. Liu, J.; Lundqvist, J.; Weinberg, J.; Gustafsson, J. Food losses and waste in China and their implication for water and land. *Environ. Sci. Technol.* **2013**, *47*, 10137–10144. [CrossRef]
5. Sun, S.; Lu, Y.; Gao, H.; Jiang, T.; Du, X.; Shen, T.; Wu, P.; Wang, Y. Impacts of food wastage on water resources and environment in China. *J. Clean. Prod.* **2018**, *185*, 732–739. [CrossRef]
6. Krzywoszynska, A. Spotlight On. . . 'Waste: Uncovering the global food scandal'. *Geography* **2011**, *96*, 101–104. [CrossRef]
7. FAO. *Global Food Losses and Food Waste—Extent, Causes, and Prevention*; FAO: Rome, Italy, 2011.
8. Godfray, H.; Beddington, J.; Crute, I.; Haddad, L.; Lawrence, D.; Muir, J.; Pretty, J.; Robinson, S.; Thomas, S.; Toulmin, C. Food security: The challenge of feeding 9 billion people. *Science* **2010**, *327*, 812. [CrossRef]
9. Jellil, A.; Woolley, E.; Rahimifard, S. Towards integrating production and consumption to reduce consumer food waste in developed countries. *Int. J. Sustain. Eng.* **2018**, *11*, 294–306. [CrossRef]
10. Cicatiello, C.; Franco, S.; Pancino, B.; Blasi, E. The Value of Food Waste: An Exploratory Study on Retailing. *J. Retail. Consum. Serv.* **2016**, *30*, 96–104. [CrossRef]
11. UN United Nations. *Transforming Our World: The 2030 Agenda for Sustainable Development*; A/RES/70/1; UN United Nations: New York, NY, USA, 2015.
12. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2022. Repurposing Food and Agricultural Policies to Make Healthy Diets More Affordable*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2022. [CrossRef]
13. FAO. *The State of Food and Agriculture: Moving Forward on Food Loss and Waste Reduction*; FAO: Rome, Italy, 2019.
14. FAOSTAT. Food and Agriculture Organization of the United Nations Data. 2024. Available online: www.fao.org/faostat/en/#home (accessed on 4 June 2024).
15. Cuadrado, C.; García, J. *Estudio Sobre el Cálculo de Indicadores Para el Monitoreo del Impacto Socioeconómico de las Enfermedades no Transmisibles en Chile*; Ministerio de Saludo del Gobierno de Chile, CEPAL, OPS, OMS: Santiago, Chile, 2015.
16. Giacoman, C.; Herrera, M.S.; Ayala-Arancibia, P. Household food insecurity before and during the COVID-19 pandemic in Chile. *Public Health* **2021**, *198*, 332–339. [CrossRef]
17. FAO, FIDA, OPS, PMA y UNICEF. *América Latina y el Caribe—Panorama Regional de la Seguridad Alimentaria y la Nutrición 2023*; Estadísticas y Tendencias: Santiago, Chile, 2023. [CrossRef]
18. Castro, M. *Cuánto Alimento Desperdician los Chilenos*; Centro de Estudios de Opinión Avanzados, Universidad de Talca: Talca, Chile, 2011.
19. Lango, V. *Estimación de las Pérdidas y Desperdicio de Alimentos en la Cadena de valor de las Pesquerías Artesanales de Merluza Merluccius gayi y jibia Dosidicus gigas en Chile, Save Food*; FAO: Santiago, Chile, 2013.
20. Gutiérrez, F. Análisis de las Pérdidas de Lechugas Escarola en Productores de la Región Metropolitana. Undergraduate Thesis, Universidad de Santiago de Chile, Santiago, Chile, 2015.
21. Lopez, Y. Cuantificación de Pérdidas en la Cadena de valor de Arroz en Molino en la Provincia de Santiago. Undergraduate Thesis, Universidad de Santiago de Chile, Santiago, Chile, 2015.
22. FAO. *Pérdida y Desperdicio de Alimentos en América Latina y el Caribe*; Boletin N° 2; FAO: Rome, Italy, 2015.
23. One Planet. Measurement and Management of Fruit and Vegetable Losses in the Production Stage at the National Level in Chile. 2018. Available online: https://www.oneplanetnetwork.org/knowledge-centre/projects/measurement-and-management-fruit-and-vegetable-losses-production-stage (accessed on 23 January 2024).
24. Cáceres, P.; Morales, M.; Nercasseau, M.; Sanhueza, C.; Vargas, C.; Solis, Y. Encuesta sobre comportamiento familiar frente al desperdicio de alimentos y determinación del costo nutricional de este, en una muestra de hogares en Chile. *Rev. Esp. Nutr. Humana Diet.* **2021**, *25*, 279–293. [CrossRef]
25. Maggi-Ipsos. *Primer Estudio Nacional Maggi-Ipsos Sobre Desperdicio de Alimentos en Chile*; Maggi-Ipsos: Santiago, Chile, 2023.
26. Fredes, C.; Pérez, M.I.; Jimenez, M.; Reutter, B.; Fernández-Verdejo, R. Tailored Informational Interventions for Reducing Surplus and Waste of Fruits and Vegetables in a Food Market: A Pilot Study. *Foods* **2023**, *12*, 2313. [CrossRef]
27. FAO. *Reflexiones Sobre el Sistema Alimentario y Perspectivas para Alcanzar su Sostenibilidad en América Latina y el Caribe*; FAO: Rome, Italy, 2017.
28. Scherhaufer, S.; Moates, G.; Hartikainen, H.; Waldron, K.; Obersteiner, G. Environmental impacts of food waste in Europe. *Waste Manag.* **2018**, *77*, 98–113. [CrossRef] [PubMed]
29. Boiteau, J.M.; Pingali, P. Can We Agree on a Food Loss and Waste Definition? An Assessment of Definitional Elements for a Globally Applicable Framework. *Glob. Food Secur.* **2023**, *37*, 100677. [CrossRef]
30. Chaboud, G.; Daviron, B. Food losses and waste: Navigating the inconsistencies. *Glob. Food Secur.* **2017**, *12*, 1–7. [CrossRef]
31. Vilariño, M.V.; Franco, C.; Quarrington, C. Food loss and Waste Reduction as an Integral Part of a Circular Economy. *Front. Environ. Sci.* **2017**, *5*, 21. [CrossRef]

32. Huang, G.; Hoekstra, A.Y.; Krol, M.S.; Jägermeyr, J.; Galindo, A.; Yu, C.; Wang, R. Water-saving agriculture can deliver deep water cuts for China. *Resour. Conserv. Recycl.* **2020**, *154*, 104578. [CrossRef]
33. Parfitt, J.; Barthel, M.; Macnaughton, S. Food waste within food supply chains: Quantification and potential for change to 2050. *Philos. Trans. R. Soc. B Biol. Sci.* **2010**, *365*, 3065–3081. [CrossRef]
34. World Food Summit. Report of the World Food Summit. Roma. 13–17 November 1996. Available online: https://www.fao.org/3/w3548e/w3548e00.htm (accessed on 16 January 2024).
35. FAO. *El estado de la Inseguridad Alimentaria en el Mundo 2006*; Organización de las Naciones Unidas para la Agricultura y la Alimentación: Rome, Italy, 2006.
36. Economist Impact. *Global Food Security Index 2022*; Economist Impact: London, UK, 2022.
37. Clapp, J.; Moseley, W.G.; Burlingame, B.; Termine, P. Viewpoint: The case for a six-dimensional food security framework. *Food Policy* **2022**, *106*, 102164. [CrossRef]
38. Veldhuizen, L.J.; Giller, K.E.; Oosterveer, P.; Brouwer, I.D.; Janssen, S.; van Zanten, H.H.; Slingerland, M. The Missing Middle: Connected action on agriculture and nutrition across global, national and local levels to achieve Sustainable Development Goal 2. *Glob. Food Secur.* **2020**, *24*, 100336. [CrossRef]
39. Princen, T.; Maniates, M.; Conca, K. *Confronting Consumption*; The MIT Press: Cambridge, MA, USA, 2002.
40. Lemaire, A.; Limbourg, S. How can food loss and waste management achieve sustainable development goals? *J. Clean. Prod.* **2019**, *234*, 1221–1234. [CrossRef]
41. HLPE. *Food Losses and Waste in the Context of Sustainable Food Systems, A Report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*; HLPE: Rome, Italy, 2014.
42. Schanes, K.; Dobernig, K.; Gözet, B. Food waste matters—A systematic review of household food waste practices and their policy implications. *J. Clean. Prod.* **2018**, *182*, 978–991. [CrossRef]
43. Candy, S.; Turner, G.; Larsen, K.; Wingrove, K.; Steenkamp, J.; Friel, S.; Lawrence, M. Modelling the Food Availability and Environmental Impacts of a Shift Towards Consumption of Healthy Dietary Patterns in Australia. *Sustainability* **2019**, *11*, 7124. [CrossRef]
44. Marston, H.R.; Musselwhite, C.B.A. Improving Older People's Lives Through Digital Technology and Practices. *Gerontol. Geriatr. Med.* **2021**, *7*, 23337214211036255. [CrossRef] [PubMed]
45. Kummu, M.; de Moel, H.; Porkka, M.; Siebert, S.; Varis, O.; Ward, P. Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *Sci. Total. Environ.* **2012**, *438*, 477–489. [CrossRef] [PubMed]
46. Adelodun, B.; Yusuff, K.; Kumar, P.; Kumar, V.; Sook, K.; Kumar, K.; Yadav, A.; El-Denglawey, A.; Cabral, M.; Truong, C.; et al. Understanding the impacts of the Covid-19 pandemic on sustainable agri-food system and agroecosystem decarbonization nexus: A review. *J. Clean. Prod.* **2021**, *318*, 128451. [CrossRef]
47. IFPRI. *2019 Global Food Policy Report*; International Food Policy Research Institute: Washington, DC, USA, 2019.
48. HLPE. *Food Security and Climate Change, A Report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*; HLPE: Rome, Italy, 2012.
49. Sachs, J.D.; Lafortune, G.; Fuller, G.; Drumm, E. Implementing the SDG Stimulus. In *Sustainable Development Report 2023*; SDSN: Paris, France; Dublin University Press: Dublin, Ireland, 2023. [CrossRef]
50. CR, Centro de Ciencia del Clima y la Resiliencia. *Informe a la Nación, La Megasequía 2010–2015: Una Lección para el Futuro*; CR, Centro de Ciencia del Clima y la Resiliencia: Santiago, Chile, 2015.
51. Garnett, T. *Cooking Up a Storm: Food, Greenhouse Gas Emissions, and Our Changing Climate*; Food Climate Research Network, Center for Environmental Strategy: Surrey, UK, 2008.
52. Ma, L.; Qin, W.; Garnett, T.; Zhang, F. Review on drivers, trends, and emerging issues of the food wastage in China. *Front. Agric. Sci. Eng.* **2015**, *2*, 159–167. [CrossRef]
53. World Bank. 2024. Available online: https://data.worldbank.org/ (accessed on 20 January 2024).
54. Central Bank of Chile. *Informe de Estabilidad Financiera, Segundo Semestre 2019*; Central Bank of Chile: Santiago, Chile, 2019.
55. Xue, L.; Liu, G.; Parfitt, J.; Liu, X.; Van Herpen, E.; Stenmarck, Å.; O'Connor, C.; Ostergren, K.; Cheng, S. Missing food, missing data? A critical review of global food losses and food waste data. *Environ. Sci. Technol.* **2017**, *51*, 6618–6633. [CrossRef] [PubMed]
56. Canali, M.; Amani, P.; Aramyan, L.; Gheoldus, M.; Moates, G.; Östergren, K.; Silvennoinen, K.; Waldron, K.; Vittuari, M. Food waste drivers in Europe, from identification to possible interventions. *Sustainability* **2016**, *9*, 37. [CrossRef]
57. Buchner, B.; Fischler, C.; Gustafson, E.; Reilly, J.; Riccardi, G.; Ricordi, C.; Veronesi, U. *Food Waste: Causes, Impacts, and Proposals*; Barilla Center for Food & Nutrition: Parma, Italy, 2012.
58. Mena, C.; Adenso-Diaz, B.; Yurt, O. The causes of food waste in the supplier-retailer interface: Evidence from the UK and Spain. *Resour. Conserv. Recycl.* **2011**, *55*, 648–658. [CrossRef]
59. Larrañaga, O.; Rodríguez, M. *Desigualdad de Ingresos y Pobreza en Chile 1990 a 2013*; United Nations Development Programme: New York, NY, USA, 2014.
60. Ministerio de Desarrollo Social. *Encuesta Casen 2022*; Ministerio de Desarrollo Social: Santiago, Chile, 2022.
61. Gustavsson, J.; Cederberg, C.; Sonesson, U.; Emanuelsson, A. *The Methodology of the FAO Study: "Global Food Losses and Food Waste—Extent, Causes, and Prevention"—FAO 2011*; The Swedish Institute for Food and Biotechnology: Gothenburg, Sweden, 2013.

62. Hanson, C.; Lipinski, B.; Robertson, K.; Días, D.; Gavilan, I.; Gréverath, P.; Ritter, S.; Fonseca, J.; Van Otterdijk, R.; Timmermans, T.; et al. *Food Loss and Waste Accounting and Reporting Standard*; CID: 20.500.12592/sr9c5m; WRI: World Resources Institute: Washington, DC, USA, 2016. Available online: https://policycommons.net/artifacts/1360255/food-loss-and-waste-accounting-and-reporting-standard/1973602/ (accessed on 9 March 2023).
63. Tostivint, C.; Östergren, K.; Quested, T.; Soethoudt, J.M.; Stenmarck, A.; Svanes, E.; O'Connor, C. *Food Waste Quantification Manual to Monitor Food Waste Amounts and Progression*; FUSIONS Report; EU FUSIONS: Neuilly-sur-Seine, France, 2016.
64. Peña-Jorquera, H.; Cid-Jofré, V.; Landaeta-Díaz, L.; Petermann-Rocha, F.; Martorell, M.; Zbinden-Foncea, H.; Ferrari, G.; Jorquera-Aguilera, C.; Cristi-Montero, C. Plant-Based Nutrition: Exploring Health Benefits for Atherosclerosis, Chronic Diseases, and Metabolic Syndrome—A Comprehensive Review. *Nutrients* **2023**, *15*, 3244. [CrossRef]
65. Porter, S.; Reay, D.; Higgins, P.; Bomberg, E. A half-century of production-phase greenhouse gas emissions from food loss and waste in the global food supply chain. *Sci. Total Environ.* **2016**, *571*, 721–729. [CrossRef]
66. Bräutigam, K.; Jorissen, J.; Priefer, C. The extent of food waste generation across EU-27: Different calculation methods and the reliability of their results. *Waste Manag. Res.* **2014**, *32*, 683–694. [CrossRef] [PubMed]
67. FUSIONS. EU FUSIONS. 2020. Available online: www.eu-fusions.org (accessed on 10 December 2023).
68. Kemna, R.; van Holsteijn, F.; Lee, P.; Sims, E. *Complementary Research on Household Refrigeration—Optimal Food Storage Conditions in Refrigeration Appliances, VHK in Collaboration with Oakdene Hollins for the European Commission*; European Commission: Brussels, Belgium, 2017.
69. Monier, V.; Mudgal, S.; Escalon, V.; O'Connor, C.; Gibon, T.; Anderson, G.; Morton, G. *Preparatory Study on Food Waste across EU 27*; Report for the European Commission. Technical Report, 054; European Commission: Brussels, Belgium, 2010.
70. Vanham, D.; Bouraoui, F.; Leip, A.; Grizzetti, B.; Bidoglio, G. Lost water and nitrogen resources due to EU consumer food waste. *Environ. Res. Lett.* **2015**, *10*, 084008. [CrossRef]
71. Caldeira, C.; De Laurentiisa, V.; Corrado, S.; van Holsteijnb, F.; Sala, S. Quantification of food waste per product group along the food supply chain in the European Union: A mass flow analysis. *Resour. Conserv. Recycl.* **2019**, *149*, 479–488. [CrossRef]
72. Corrado, S.; Sala, S. Food waste accounting along global and European food supply chains: State of the art and outlook. *Waste Manag.* **2018**, *79*, 120–131. [CrossRef] [PubMed]
73. Segrè, A.; Falasconi, L.; Politano, A.; Vittuari, M. *Background Paper on the Economics of Food Loss and Waste*; FAO: Rome, Italy, 2014.
74. FAO. *Pérdida y desperdicio de alimentos en América Latina y el Caribe*; Boletin N° 3; FAO: Rome, Italy, 2016.
75. Acuña, D.; Domper, A.; Eguillor, P.; González, C.; Zacarías, I. *Manual de Pérdida y Desperdicio de Alimentos. 5 al día Chile*; INTA Universidad de Chile and Ministerio de Agricultura de Chile: Santiago, Chile, 2018.
76. Salazar, M. La economía circular como respuesta alternativa a los desafíos de la alimentación: Análisis de caso para la situación de Chile. *Rev. Chil. Relac. Int.* **2018**, *2*, 94–104.
77. Cañoles, M.; Valdés, O.; Rojas, L.; Galáz, J.C.; Coz, F.; Díaz, N.; Giraldo, C.; Bañados, N.; Leiva, F.; Carrasco, C. *Estudio de Economía Circular en el Sector Agroalimentario Chileno*; Oficina de Estudios y Políticas Agrarias del Ministerio de Agricultura, Gobierno de Chile: Santiago, Chile, 2018.
78. Aparcana, S. *Economía Circular en el Sector de la Producción y Distribución de Alimentos de Chile*; UNEP DTU Partnership: Santiago, Chile, 2022.