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THE TRUE COST OF FOOD: TACKLING THE MANAGERIAL CHALLENGES OF THE FOOD SUPPLY CHAIN

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THE TRUE COST OF FOOD WASTE: TACKLING THE MANAGERIAL CHALLENGES OF THE FOOD SUPPLY CHAIN

ABSTRACT

Background: Increasing transparency and accountability in the current global food value chain is one of the biggest debates in food policy. Food waste generation and management is a global challenge that requires urgent prevention measures. Efforts are also required to develop significant conceptual frameworks and theoretical developments with a clear focus on a wide range of practical applications.

Scope and Approach: This commentary examines true cost accounting as a potential theoretical and methodological framework to evaluate the impact of food waste in relationship to cost-externalizing and the hidden costs of food systems.

Key Findings and Conclusions: The article opens up a discussion on true cost theory and its application to food waste. Additionally, it provides directions for future research in four specific areas: the broad food value chain, social policy, social sustainability aspects, and final consumers.

KEYWORDS: true cost, food, food waste, conceptual framework, metrics, research opportunities

1. Introduction

This commentary paper highlights one of the greatest societal challenges in the management of the food value chain, which concerns cost-externalizing and the hidden costs of food systems and, particularly food waste (Costa et al., 2022). Solving grand challenges requires robust action, one that systematically challenges existing assumptions and reorients attention and reasoning processes (Grimes & Vogus, 2021). The European Union has implemented legally binding targets to reduce food waste (reduction by at least 30% by 2025 and 50% by 2030) included in Directive 2018/851/EU. The U.S. has passed the first-ever domestic U.S. 2030 Food Loss and Waste Reduction Goal to halve food loss and waste by 2030. China has adopted the Law of the People's Republic of China on Food Waste in 2021 aiming at fostering food waste prevention. In parallel, companies must respond to disclosure requirements about greenhouse gas (GHG) emissions and waste management, for example, from ESG rating agencies or the Global Reporting Initiative (GRI) (Rajic et al., 2021).

Paradoxically, global indicators do not show progress in reducing their causal factors. Food waste is a global issue and a major challenge aggravated by its role in climate change, land, water, and biodiversity scarcity, groundwater pollution, and global deforestation. The US Environmental Protection Agency (EPA) has reported that food waste and packaging account for nearly 45 percent of the materials sent to landfills in the US (Gunders, 2012). At the EU level, food waste represents close to 16% of the food chain's carbon footprint (Scherhaufer et al., 2018). Food wastage largely goes to landfills, where it releases methane, a greenhouse gas at least 28 times as potent as carbon dioxide (IPCC, 2021). Recent research highlights a disconnect between the urgency of the challenge and the attention it receives from both professionals in the food sector and the general public (Martin-Rios et al., 2018; Papargyropoulou et al., 2019). Most of the environmental, social, and monetary costs of waste remains unaccounted at the organization, geographic or system level in part due to the lack of methodologies for quantification and monetization of food loss and waste practices.

This commentary paper sheds light on True Cost Accounting (TCA) for food as a novel theoretical and methodological approach with potential to bring new research and practical venues into the cross-disciplinary theme of waste in the food value chain. Current food prices fail to take into account short-

and long-term environmental, social, human health, and economic externalities, including food waste issues (FAO, 2014). TCA is accompanied by an additional corrective step, "true pricing", which seeks to incorporate externalities into prices in order to align market incentives with social values (Hendriks et al., 2021). Externalities refer to "situations when the effect of production or consumption of goods and services imposes costs or benefits on others which are not reflected in the prices charged for the goods and services being provided" (OECD, 2003). The advantage of TCA is its ability to account for the positive and negative costs/impacts, including true cost of food waste, on economic, social and natural capitals, using clear accounting standards and well-defined thresholds within financial balance sheets (de Adelhart Toorop et al., 2021; El-Hage Scialabba et al., 2021).

The intersection between sustainability and food value chain management is one of the most promising areas within the literature, having become a relevant topic for researchers and professionals. It focuses on the integration of sustainability principles into the concept of value chain management (Adams et al., 2021; Bebbington & Larrinaga, 2014; Martin-Rios et al., 2021; Mol, 2015). In its broadest sense, it refers to the integration of positive and negative impacts of food production systems by means of the systemic coordination of processes at all levels—product, organization, geography and sector—to improve the transparency and accountability of the costs and value provided by all stakeholders in the value chain. Given the importance and urgency of measuring sustainability externalities across the value chain, several frameworks and methodologies have been developed (Sandhu et al., 2021; Jerneck et al., 2011; Spangenberg, 2011). The relatively novel approach of TCA offers one possible methodology for measuring, valuing, and adopting sustainability.

There is an urgent need for more scientific research on the application of the TCA framework on the food value chain, particularly sustainability challenges such as food waste. This article aims to illustrate the state of the art and research venues for public policy, managerial implications of true cost accounting for companies alongside the food value chain, and applications for consumer behavior. In particular, the paper suggests that future research on the development of a set of indicators will serve as a great instrument in assessing the true value of food and the true cost of food waste and in redefining the food value chain.

2. True cost of food and food waste

One of the central problems of our current food system lies in its unsustainability, and even though this is not a new problem, the extent to which our food system is unfit for the 21st century has become more evident at the present moment. Moreover, incentives to change our unsustainable food system remain scarce, as the "true cost" of the food we consume remains an unknown topic for most (Michalke et al., 2022). The true cost paradigm addresses the true cost of food – including direct impacts and "hidden costs" on health, the environment, biodiversity, and social and economic inequity – and constitutes a necessary first step in achieving a transformative change in the global food system. By addressing externalities through TCA, a significant barrier to the transition to sustainable food systems is tackled, and governments and food system stakeholders are equipped with a tool that supports them in adopting sustainable choices (Baker et al., 2020; Gemmill-Herren et al., 2021).

The true cost paradigm materializes in the TCA methodology. The methodology expands beyond a single discipline and combines sustainability science, managerial, food science, and accounting literature to critically assess the TCA model for food cost estimation. It assesses the positive and negative externalities and impact of the food system on human health (e.g., high incidence of diet-related illnesses), environment (e.g., global warming, reduced biodiversity, water and air pollution, depletion of natural resources, food waste), and society (e.g., livable wages and working conditions of farmers, fishers, ranchers, and food workers who guarantee that goods get on the shelf). In other words, the price of foodstuff that a consumer sees reflects a mere fraction of the real cost of food. In some cases, costs are not included in market prices (e.g., for harmful foods), whereas in other cases they are not given the appreciation they deserve (e.g., healthy foods) (Hendriks et al., 2021).

TCA moves beyond looking at the typical financial values, and also calculates the impacts on natural and social capital (Nature & More, 2022). Generally, costs such as land costs, transportation and storage, and wages are fully or partially accounted for in food prices; however, other impacts such as health and illnesses, food safety, work conditions and wastage are not, which results in an 'untruthful' cost of food (de Adelhart Toorop et al., 2021; Rockefeller Foundation, 2021). For example, the U.S. spends close to $1.1 trillion a year on food; but if the food system's impact on health, the environment,

and society were factored in, the true cost of food would be three times as high or at least $3.2 trillion annually (Rockefeller Foundation, 2021). That extra cost comes primarily from two areas: human health and environmental impact. These two factors contribute most of the $2.1 trillion to the true cost of the U.S. food system (Rockefeller Foundation, 2021). For the hidden costs of the world food production, the UN Food and Agriculture Organization estimates that they total $2.1 trillion in 'hidden annual environmental costs', and $2.7 trillion in 'hidden social costs' (Nature & More, 2022).

Recent studies have attempted to take on the challenge of measuring the TCA of food. For example, de Adelhart Toorop et al., (2021) discuss opportunities and challenges in defining strategies for TCA harmonization for better comparison across frameworks. Baker et al., (2021) emphasizes the need to focus on social and environmental impacts. Michalke et al. (2022) assess the communication properties of TCA and conclude that consumers might be willing to pay the "true" price when this is backed by a legal framework. Sandhu et al. (2021) apply TCA to farm level metrics and calculate the social and sustainable impact of farming. Also, Gemmill-Herren et al. (2021) illustrate the role of public policy in incentivizing the transition to more sustainable food systems. Even though a variety of TCA tools and methods have emerged in the past few years, the presence of specific comparable metrics has been lacking (de Adelhart Toorop et al., 2021). Existing metrics focus on primary impacts of the food system or the classical impact assessment (Girotto et al., 2015). According to (El-Hage Scialabba & Obst, 2021), the well-known "environmental impact assessment" should be extended to a sustainability assessment, emcompassing environmental, social, and economic assessments. For example, Pieper et al., (2021) have applied LCA and TCA to calculate external climate costs of several food categories. To date no study has attempted to comprehensively assess the impact of social, financial and environmental dimensions together. Table 1 presents a synthesis of the main metrics that have been identified in recent studies.

--- Table 1 about here ---

Food waste is a specific area of study and action to which TCA can contribute. Unlike other more controversial aspects of monetizing unpriced externalities in the food value chain (Patel, 2021), there is wide agreement that food loss and waste is a major environmental, social and financial problem that

should be addressed by goverments, organizations, and consumers. Food waste remains true to the commonly held management adagio that what gets measured gets managed. Hence, how should the true cost of food waste be measured? Given the novelty of the conceptual framework, there is an absence of a unified methodology to quantify the true cost of food loss and food waste. Not only does this conceal the real cost of food, but it also fails to incentivize organizations, governments and consumers to reduce food waste (Pieper et al., 2020). Herein lies the importance of TCA as a principle providing the necessary tools to do so. TCA, as a type of bookkeeping, supports the redefinition of the negative externalities of food waste, by revealing its 'hidden costs' and by addressing externalities and other market failures.

Some of the main themes that have been identified throughout recent studies fall into the following categories: environment, biodiversity, human health, economy, and welfare. Secondary or indirect impacts are usually not included as metrics; however, they are significant factors in the true cost of food waste. These impacts include global and national food chains security, livelihood and educational outcomes due to nutrition and wastage unawareness, unsustainable production and consumption patterns where food scarcity coexists with excessive consumption, secondary impacts on the environment (e.g., increased landfill emissions due to demographic pressure, risks of increased deforestation due increase in agricultural production), or health and safety costs to farmers, fishermen, farm workers, restaurant service and kitchen staff.

Take the example of French fries (Varelis et al., 2018). When we eat some fries, we usually do not realize the story that lies behind those fries for us to be enjoying them, and we typically do not question what lies beneath the price we pay for them. Where do the potatoes come from? How far have the potatoes traveled to arrive at the restaurant where we ate the fries? What methods were used to grow those potatoes? Were those methods sustainable? Did the farmers who grew the potatoes and the kitchen staff who cooked and served meals receive a fair wage? French fries also illustrate the outsized role of waste in relationship to the true cost of bringing this food commodity to the table and dispose of it (Ooraikul, 2008). At every step from field to plate, there is loss and waste that is externalized from the final price of the product, thus making it hard for producers, manufacturing plants, foodservices, and

final consumers to truly disentangle the real cost of their wastage. As shown in Table 2, production and harvest, logistics, processing, and distribution phases generate food loss due, for example, to unpredictable weather patterns or a cold chain break during distribution. Waste can also occur in upstream activities, such as when potatoes are wasted due to an increase in trade tariffs making potatoes imports from certain countries less attractive. Potatoes also contribute to other forms of waste in terms of energy or water consumption. The average water footprint of potatoes is 290 liters/kg. Potato chips require over 1,000 liters of water per kilogram of potato chips[1] (Mekonnen & Hoekstra, 2011).

--- Table 2 about here ---

As it can be seen in Table 1, one of the greatest sustainability challenges is the calculation and management of scope 3 emissions (Poponi et al., 2022;). Food is often just thrown away during the harvest, when fruit/vegetables get damaged during the distribution or manufacturing process, or when edible food is not sold at the supermarket. At restaurants, excessively extensive menus, prepping too much food ahead of time, or serving large portions are some of the problems that cause food waste. These challenges are sometimes tackled independently by each player in the food chain (Martin-Rios et al., 2020). As explained by Papargyropoulou et al. (2014), throwing food away is at the bottom of the waste hierarchy, and creating standardized price metrics to reduce food waste could be the solution.

A true cost of food waste model can contribute - in a very concrete manner - to a sustainable use of resources, avoidance of waste, maximizing local resources and the promotion of the circular economy. TCA helps combine treatment, recycling, valorization of waste-by products, and recovery and reuse of high added-value food compounds or elimination of materials.

[1] This estimate includes the water involved in following steps: "potato seed production (fresh seed used every year); fertilizer and pesticide production; water loss from outgrade potatoes not meeting all quality specifications and thereby discarded from production lines (on farms: 10-20% and in the chip plants: 3-5%); storage from October to June where there is an ongoing water need to humidify and regulate temperature and ventilation; potato (and thereby water) losses when in long-term storage due to inadequate conditions (8-50% of crop); transporting, washing and processing potatoes during chip production; producing, processing and transporting vegetable oils including palm oil used in the final product; packaging materials manufacture; transportation from chip plant to distributors and on to retailers." (Yacoubou, 2015, based on Chapagain & Hoekstra, 2004)

3. Recommendations for future research

This section outlines research opportunities that need to be explored in order to move the field forward. Four main areas of research are taken into consideration: the food value chain, social policy, social sustainability aspects, and final consumers.

3.1 Pricing in the cost of food waste along the value chain

New research is needed to compare the metrics obtained from several TCA tools and methods developed in the past few years. Research on life cycle assessment (LCA) focused on food loss and waste provides a partial picture of the wastage problem and tends to overlook prevention measures (Omolayo et al., 2021). Applying TCA to food waste would help organizations, administrations, and consumers to determine – above and beyond the usual financial calculations – the impacts on the natural and social environments in which the food loss and waste takes place. As the impacts are calculated in monetary terms, the respective amounts can be incorporated in the TCA calculations, making visible and internalizing the "hidden costs" of waste generation which are otherwise commonly externalized (i.e., generated by producers but borne by society as a whole). For example, as it applies to downstream food activities, TCA may include the cost of waste externalities in the price of food products. For example, pricing wastage in buffets and banquets would result in price restructuring. Research should elucidate whether the true cost should be distributed among stakeholders in the value chain and not just final consumers. In the latter scenario, different TCA measurements need to be proposed and validated since food is wasted at every link of the food chain.

When discussing food waste, the debate usually focuses on waste quantification and mitigation rather than prevention (Beretta et al., 2017; Filimonau & De Coteau, 2019; Goossens et al., 2019; Hoehn et al., 2022) and revolves around specific upstream or downstream phases of the value chain (Eriksson et al., 2016; Stenmarck et al., 2016). To date, there are no standard criteria and methodology available to quantify food loss and waste. Most review studies provide an incomplete picture of the food value chain and may lead to systemic bias of the quantification methods (Hoehn et al., 2022). These caveats aside, there is extensive research on recycling or composting food but less so on how to avoid reaching that point (Magalhães et al., 2022; Messner et al., 2020). Only a few studies have addressed the true cost of

food waste. For example, the WRAP study by Lee et al., (2013) assesses the true cost of food waste by looking at the actual number of meals purchased and cost of food ingredients per meal in the hospitality and foodservice sector.

Hence, questions loom large around pricing. Is listing practices to avoid food waste the best solution? We suggest that other kinds of incentives, driven by TCA assessments should be considered as well. The main question here is, what can pricing do to incentivize these changes? TCA must take into consideration the impact of political, economic, socio-cultural, environmental, and other contingencies. Since indirect factors (i.e., externalities) should be calculated and then priced into the end cost of food this extra cost should be used to move towards a more sustainable way of producing and consuming food along global value chains. However, calculating the cost of positive and negative externalities is not that straightforward since, for starters, a uniform calculation method does not exist (D'Onza et al., 2016). There are exciting future research opportunities to quantify, assess, and valorize food losses and waste along the food supply chain. New research needs to evaluate how these metrics weight for and compensate for social disparities.

3.2 Social policy, taxes, and incentives

Government intervention is necessary to convert TCA for food into a reality. Policymakers are under pressure to impose measures to promote a more sustainable way of life. Social policies (e.g., taxes) need to be created and implemented, but the question continues to be what kind of taxes could make the change and how should this be implemented? In Switzerland, garbage bags are taxed, which aims to reduce the amount of waste produced and incentivize recycling. But are taxed garbage bags a success? Do people waste less because they are required to buy these bags? This example expresses the urgency of research into the kind of taxes that could encourage sustainable food production. As stated by Hendriks et al. (2021), TCA reveals the true value of food by making the benefits of affordable and healthy food visible and determining the costs of damage to the environment and human health. It can also contribute to better equipping governments, businesses, and citizens with sound metrics developed from a transformative and innovative paradigm. Methodologic research and pertinent data collection is

needed to establish systemic TCA as well as comprehensive geographic and organizational TCA of waste to support more informed policy decision making on prevention measures.

The "Farm to Fork Strategy" (Farm2Fork), an initiative from the European Commission, aims to create a more sustainable way of producing food. Considering the impact of food on the environment and health, they also reward food producers (e.g., farmers) who have already incorporated sustainable practices. In addition, the Farm2Fork strategy aims to motivate others by creating "common agriculture policies" (CAP) or other public and private initiatives. Furthermore, they seek to introduce an EU Code of Conduct to enhance retailers' environmental and social responsibility when promoting and selecting food products (European Commission, 2020). This initiative is just one example of the current state of the art; yet there are still uncertainties about how effective these policies will be in helping change consumer behavior. More specifically, are companies ready to shift to a more sustainable way of working? Is it possible to create policies applicable to all food sectors? How feasible is it to create/introduce new policies related to food waste mitigation and management? How can TCA contribute to shifts in waste management policy frameworks?

Along these lines, even if levying taxes is a possible solution, regulatory bodies would have to be set up along the food value chain to control and impose them. The commitment of regulatory bodies is essential for "identifying and highlighting strengths and weaknesses, costs and benefits of the different products and supply chains" (Bandel et al., 2021, p. 210). To date, there is a lack of comprehensive research on the role of regulatory bodies in preventing wastage and addressing existing food waste.

3.3 Social sustainability

Inequality in the global food system goes beyond having access to food. It also considers working conditions, exploitation of natural resources, or even unsanitary surroundings. Hence, TCA can serve to explore social challenges in current food systems, including to assess the need for better work conditions, more efficient manufacturing practices, new food packaging, or more professionalized food manipulation, cooking, and service. The TCA for food could aid these problems by creating measurements used to uniformly calculate the externalities of products. The True Price Organization, founded in 2012, is a salient example of an initiative to determine the actual price of products, not only

food, and sell them at that price in their "True Price Stores" (True Price Foundation, 2012). Their central tenet is to show consumers the difference between the retail and foodservice price and the actual price in their stores and food outlets. The true price is explained in detail. For example, a banana has hidden costs such as the CO2 produced by transportation (environmental impact), underpayment of farmers (social impact), and fruit and vegetables discarded by farmers (Ribeiro et al., 2018). This explanation helps to create awareness of what is being consumed.

However, these measures need to take into account also the social costs of waste (Filimonau & Gherbin, 2017). There is urgent need for research to adopt TCA frameworks to strengthening transparency at work conditions, global inequalities in food production and consumption, discrimination of minority groups, food and nutrition education, and related social costs of landfills and incinerators where food is loss or wasted. Therefore, research on the best way to show the true price to close the food requirement gap in economically developing countries, calculate externalities, and tax the hidden costs associated to social costs in the value chain should be conducted.

One major issue common to all sustainability assessment frameworks is data availability. Research evidence not only on the environmental impacts but also the negative social aspects of food loss and waste are scattered in niche journals. There is need for interdisciplinary research to measure, appraise, and price waste from a multi-stakeholder perspective. This paper calls for more rigorous research on food and specifically food waste by means of applying TCA all along the food value chain.

3.4 Final consumers

Research needs to explore whether consumers should pay the "true price" of food and if this "price gap" should be used to restore the harm caused by the production of food with the final objective being to transform "worst" practices into best practices. As de Groot Ruiz (2021) points out, the true price could be implemented by following the 5Ts: Transparency about the true price of products, transformation for the prevention of externalities in the cost, transaction when consumers pay for externalities, taxation of these hidden costs while subsidizing sustainable methods, and taking out the externalities by regulations. However, guidelines for succeeding in implementing each of the 5Ts are necessary.

The TCA of food paradigm opens up exciting research opportunities around end-users and consumption decisions, effective communication of fair price/value of food, or to prompt change in consumer behavior. Eventually less sustainable food should become more expensive. On the flip side, products that factor in sustainable consumption and economic, social, and environmental concerns might come down in price. Alongside these questions, what happens with consumers from economically developing countries? How can institutional and private actors manage inequalities resulting from higher food prices? What measurements should institutional players and governments implement to avoid resulting social differences? More research on the implications of the potential paradigm shift in consumer behavior is required. These studies may lead to novel discoveries that allow industry stakeholders to challenge the current paradigm

To be successful, a big part of the TCA for food depends on the support of all links in the chain (e.g., production, distribution, consumers), making compromises, and changing behavior when necessary. In a hypothetical scenario where all stakeholders involved in producing and selling food products are willing or obliged to, for example, include the price gap into their prices, one question remains: Would customers be willing to pay a fair price for food products? Would adding the price gap be enough to change their behavior? Would they trust the process? And would they want to be part of this change?

Consumers play an essential role in food waste (Schanes et al., 2018; Stöckli, Dorn, et al., 2018). Food production might become more sustainable if consumers willingly change their behavior and incentives exist to reach the goal. Yet, industrial and service activities often criticize consumers for their inaction, whilst consumers blame both producers and retailers for the lack of alternative food products (Stöckli, Niklaus, et al., 2018). Environmental change behavior from the consumers' perspective has been the subject of many research papers. Yet, there are few studies on how behavioral change may be triggered by considerations about food waste in the TCA framework.

4. Conclusion

By thoroughly assessing what the food system costs both in actual and unrealized potential, the true cost of food paradigm has the potential to contribute to enhancing the sustainability of food systems, reducing environmental, societal, and health costs, and guiding decision-makers to adopt sustainable practices. This paper calls for more rigorous research on food externalities and specifically food waste by means of applying TCA in a food value chain. TCA offers important research venues to address food waste management along the value chain. In turn, it has the potential to transform food loss and waste into an environmental, social, and economic opportunity.

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TABLES AND FIGURES

Table 1. Summary of existing TCA metrics developed by main institutions

Environment	GHG emissions	1,2,3,4,5,6,7,8,9,10
	Water use	3,8,9,10
	Soil degradation	6,7,10
	Air pollution	6,7,10
	Eutrophication	5,9
	Water scarcity /depletion	2,7
	Air and water pollution	4
	Water pollution	7
	Acidification	5
	Deforestation	1
	Fertilizer use	8
Biodiversity	Biodiversity loss	2,3,4,7,9
	Land use	5,10
	Animal welfare	10
	Soil use	3
Social livelihood	Salaries and benefits	8,10
	Worker rights	4
	Child labor	10
	Under-payment	10
	Health and safety issues	10
	Discrimination	5
	Rural welfare	2
	Water costs	6
Human health	Obesity	2,3,10
	Food security	1,10
	Non-communicable diseases	3,6,10
	Healthcare costs	4
	Antibiotic resistance	6,10
	Premature mortality	9
Financial	Subsidies	10
	Resilience	10

Source: extracted from de Adelhart Toorop et al. (2021); Gemmill-Herren et al. (2020); Rockefeller Foundation (2021)

LEGEND

1 The Economics of Ecosystems and Biodiversity for Agriculture and Food (TEEBAGRIFOOD)
2 Food and Land Use Coalition
3 World Business Council for Sustainable Development
4 Food Tank
5 True Price
6 Sustainable Food Trust
7 The Prince's Charities
8 Capitals Coalition
9 World Wide Fund for Nature
10 The Rockefeller Foundation

Table 2. Illustration of reasons behind food loss and waste related to production and consumption of French fries

Upstream losses and waste		Downstream waste and wastage			
Agricultural production	Logistics	Processing	Distribution	Retail and Foodservice	Consumption
- Overproduction - Harvest and post-harvest handling - Varieties - Weather - Pricing - Work practices - Work conditions - Qualifications and skills	- Storage - Geopolitical issues - Trade tariffs - Equipment - Work practices (trip routing, shipment, data entry)	- Yield and steam peeling - Production line management - Inventory	- Operating costs - Delivery issues - Break cold chain - Packaging damage	- Seasonal anomalies - Storage and stock management - Date marking - Tracking technology - Work practices (cooking and serving) - Menu design	- Plate portion - Health and nutrition - Purchasing and planning - Food management skills