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# The True Cost of Food: A Preliminary Assessment

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## 1 Introduction

The vision of the UN Food Systems Summit was to "launch bold new actions, solutions and strategies to deliver progress on all 17 Sustainable Development Goals (SDGs), each of which relies on healthier, more sustainable and more equitable food systems" (UN 2021a, b). The Summit was seeking to transform the way in which the world produces, consumes and thinks about food and to build a just and resilient world where no one is left behind (UN 2021a, b). In various Summit platform discussions, questions have arisen relating to (a) the true cost of the food we eat,

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(b) what costs would be involved in shifting to more sustainable patterns of production and consumption, (c) who would bear the cost of these changes and (d) what the implications are for the poorest consumers. Addressing these hidden externalities would be a significant, bold action.

Ensuring sustainable food systems entails ensuring that food systems provide affordable and healthy food to all people while respecting planetary and social boundaries. Current food systems are not sustainable. They generate substantial environmental, social and health costs while failing to provide affordable food to all (FAO et al. 2020. For example:

- The emissions associated with pre- and post-production activities in the global food system are estimated to be 21–37% of total net anthropogenic GHG emissions (IPPC 2019),
- The majority of the global working poor work under difficult conditions in agriculture (World Bank 2016),
- 690 million people were undernourished in 2019 (FAO et al. 2020), and
- More than 10 million lives are lost annually due to unhealthy eating patterns (Afshin et al. 2019).

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A transition to sustainable food systems will reduce their environmental, social and health costs while making healthy food affordable to all. Researchers have only recently begun investigating what dietary changes will be necessary to keep food systems within planetary boundaries (Herrero et al. 2017; Rockström et al. 2009). Even more recently, the question has arisen as to how changes in the food system and their resultant impacts on environments in which consumers acquire foods (food environments) affect our health, particularly the incidence of obesity and non-communicable diseases (Willett et al. 2019). For example, the EAT-Lancet report estimated that a transformation to healthy diets by 2050 would require substantial dietary shifts. This will include reducing the consumption of:

- Foods with added sugars (including harmful non-nutritive sweeteners),
- Refined grains (that can cause diabetes),
- Added sodium (that can cause hypertension),
- Harmful fats (especially harmful trans fats, and, to a lesser degree, other solid fats linked to cardiovascular disease), and
- Processed meats (associated with cancer).

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Increasing the consumption of healthy, protective foods such as fruits and vegetables, legumes, nuts and seeds (Willett et al. 2019) will address multiple health-related issues. These protective foods are needed for their phytochemicals and fiber that may be absent from other foods. Often, unhealthy foods displace healthy alternatives (such as fruit, legumes, nuts, seeds and vegetables, along with beneficial forms of primary processing such as fermentation) that may be less convenient (Masters et al. 2021) and less marketed and, therefore, under-consumed.

Effective game-changing strategies[1] for achieving sustainable food systems should arguably not only treat the symptoms of the problem. Solutions should also address the root causes of why food systems impose environmental and health costs and fail to provide sufficient quantities of beneficial foods in the first place. One major root cause is that these costs and benefits of production and consumption are externalized, due to how markets are designed. These externalities are not reflected in market prices (Baker et al. 2020) and have no economic 'currency.' As a result, externalities are hidden effects of the choices of market players, and make sustainable and healthy food less affordable for consumers and less profitable for producers. Historically, business profits and the choices of all stakeholders have been based on market prices and recorded in economic statistics such as gross domestic product (GDP). External costs and benefits can also be documented in statistics on mortality and disease, climate change and pollution. However, the link between market activity and those social or environmental harms is not directly visible or reflected in the incentives that drive economic systems. As a result, the economic value of food, which drives economic choices by businesses, consumers and governments, is highly distorted. By providing distorted information and perverse (often unintended) incentives against affordable, sustainable and healthy food, externalities constitute a significant barrier to attaining sustainable food systems. Moreover, even with a full-cost approach, there are likely trade-offs across the health and sustainability considerations. There is considerable diversity in regional food systems and their externalities.

Internalizing the externalities of food systems requires redefining the value of food by measuring and pricing these externalities through 'true-cost accounting' (TCA) approaches. At the request of the Scientific Group of the UN Food Systems Summit, a working group set out to investigate the true costs of food and propose possible actions to address the problem.

[1]The UNFSS definition of a game changing and systemic solution' is a feasible action, based on evidence, best practice or a thorough conceptual framework that would shift operational models or underlying rules, incentives and structures that shape food systems, acting on multiple parts of – or across – the food system, to advance global goals that can be sustained over time. The key criteria that a 'game changing and systemic' solution must have are to (1) have impact potential at scale (including return on investment), (2) be actionable (taking into account politics, capacity, costs) and (3) be sustainable (i.e., the ability to keep delivering up to 2030 and beyond).

This chapter aims to inform food system stakeholders about how they can grasp an opportunity based on the most recent scientific insights in this young and emerging field of analysis. Section 2 summarizes the problem of externalities. Section 3 describes how TCA can be used to redefine the value of food. Section 4 provides an analysis of the current true environmental and health costs of food at the global level based on research from the working group. Section 5 outlines the potential benefits of dietary transitions. Section 6 outlines the study's limitations and future research avenues. Section 7 concludes and presents recommendations.

## 2 Externalities as Barriers to Sustainable Food Systems

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). Externalities can arise when people are affected by the market choices of others in which they have no say (Laffont 2008). For example, greenhouse gas (GHG) emissions from one person's actions affect people far away, as well as future generations who have no say in those decisions. Externalities can also be beneficial, such as disease prevention that lowers health care costs. There are other price-related market failures that lead to the inefficient allocation of resources. In addition to monopoly and monopsony, a lack of information or behavioral biases, for example, around health effects, can lead consumers to ignore the costs and benefits of their decisions (Gruber and Köszegi 2001; Wang and Sloan 2018). Due to missing markets, the well-being effects of affordable, healthy food on the poor will not translate to higher prices or drive the supply of more healthy food.

Externalities arise from several elements in the food system (see Table 1). The boundary between social and human capital is defined differently across frameworks, and health externalities can also be classified as human capital (TEEB 2018). There is considerable variation in costs between food products and regions. In some cases, traditional practices of animal husbandry can have positive effects on natural capital (Baltussen et al. 2019). Commodities involving production by smallholders in developing countries (such as cocoa or coffee) tend to have higher external social costs, including underearning for farmers.

Externalities create significant problems in food systems. The first problem is that externalities prevent societies from achieving their full potential by distorting the information about the value of food conveyed by market prices Gemmill-Herren et al. 2021. The market price of products does not reflect their true costs and benefits. Also, the value of companies and their decisions reflect expected future profits – the difference between the sum of the cost of outputs minus the sum of the cost of all

**Table 1** Summary of the key externalities in food systems

| Type of externality | Examples of externalities | Endpoint impact(s) |
|---|---|---|
| Environmental[1] (effects on natural capital) | Air, water and soil pollution<br>GHG emissions<br>Land use<br>Overuse of renewable resources<br>Soil depletion<br>Use of scarce materials<br>Water use | Contribution to climate change, health effects, depletion of abiotic resources, depletion of biotic resources, including ecosystem services and biodiversity |
| Social[2] (effects on social rights and human and social capital) | Animal welfare<br>Child and forced labor<br>Discrimination and harassment<br>High and variable prices<br>Training<br>Underpayment and underearning | Poverty, well-being, food security and human skills |
| Health[3] (effects on human health) | Antimicrobial resistance<br>Undernutrition<br>Unhealthy diet composition<br>Zoonoses | Human life (mortality and the quality of life), economic (medical costs, informal care, lost working days) |
| Economic[4] (effects on financial, manufactured and intellectual capital) | Food waste<br>Tax evasion | Increased food demand, and a decrease in public funds |

Sources
[1]FAO (2015), NCC (2015), Baltussen et al. (2016), Allen and Prosperi (2016), Nkonya et al. (2016), TEEB (2018, 2019), Dalin and Outhwaite (2019), FOLU (2019), and Galgani et al. (2021).
[2]Baltussen et al. (2016), Westhoek et al. (2016), IDH (2016), WBCSD (2018), Jaffee et al. (2019), and Galgani et al. (2021).
[3]Baltussen et al. (2016), FOLU (2019), TEEB (2018), Afshin et al. (2019), and FAO et al. (2020).
[4]FAO (2015), TEEB (2018, 2019), Impact Institute (2020), and FAO et al. (2020).

inputs, including labor (OECD 2002), all valued at market prices. If a company contributes to climate change, underpays workers or enables healthy and affordable food, this is not reflected in its profits (Serafeim et al. 2019). As the financial returns of companies are based on their (expected) profits, the financial value of investments does not reflect the actual value that these investments bestow upon society

(Serafeim et al. 2019). The economic value of the food sector is measured by its contribution to GDP, which is the sum of all companies' added value - the value of output minus the value of intermediate consumption measured at market prices (OECD 2001). Hence, the degree to which food systems contribute to climate change, deforestation or poor health is not factored into crucial economic indicators for policymakers (Stiglitz et al. 2018), and externalities, therefore, lead countries to have lower average living standards than would otherwise be possible.

A second problem with (negative) externalities is social injustice. The existing arrangement of property rights, institutions and infrastructure was constructed over time, reflecting the past choices of those in power who sometimes neglected or actively harmed marginalized groups, including women and girls, indigenous and minority populations, migrant workers, and other communities. Environmental harm such as air and water pollution is often concentrated in places inhabited by marginalized groups. Unhealthy products are often marketed most intensively to vulnerable populations such as children.

The result is a variety of involuntary harms that may include severe rights violations (forced labor, harassment of women or underpayment in the agricultural sector) and that breach the rights of the people who produce our food. A lack of affordable food is also a breach of the right to food for consumers. The erosion of natural capital breaches the rights of future generations to decent livelihoods (United Nations 1972).

The third problem with externalities is that they inadvertently reward unsustainable, unaffordable and unhealthy food production and consumption. As natural, health and social costs are externalized, it is more profitable to produce unsustainable and unhealthy food. Child labor, forced labor and underpaid workers represent cheap labor; consuming natural resources without replenishing them provides cheap inputs and the decision not to contain pollution saves costs. At the same time, adding calories, salt, poor quality fats, sugars and harmful sugar alternatives to food items, and promoting such foods, can increase sales, despite the negative effects on health (Stuckler et al. 2012). Food safety adds to the harmful effects on health, especially in developing countries (Devleesschauwer et al. 2018). One reason is that there is neurobehavioral evidence that some unhealthy foods elicit higher reward responses in the brain than healthy foods (Banerjee et al. 2020).

In the same way, encouraging high levels of food waste, e.g., through appealing packaging, can increase sales. Moreover, firms have no incentive to make healthy food affordable. Businesses set prices to optimize their business's profits (Laffont 2008), sometimes using inflated prices as signals of healthy food (Haws et al. 2017). As a result, sustainable and healthy food is more expensive to buy than unhealthy food (Stuckler et al. 2012).

Given that global markets allocate capital based on financial returns, most capital will flow to the companies most successful at externalizing costs to optimize profit (Serafeim et al. 2019). In an economy where consumers maximize purchasing power, businesses maximize profits. In addition, investors maximize returns, leading to the underproduction of food, which, in turn, leads to waste, overuse of natural resources and overconsumption of unhealthy food (Gemill-Herrero et al. 2021).

In summary, externalities form a significant barrier to the transition to sustainable food systems. It is difficult to imagine how policies aiming to foster sustainable food systems will be successful in an economic system where the erosion of natural capital, breaches of human rights, and unhealthy food are permissible and strongly incentivized.

## 3 True-Cost Accounting: Redefining the Value of Food

One first step to addressing externalities is to expose them and redefine the value of food. This can be realized through *TCA*, a tool for the systemic measurement and valuation of environmental, social, health and economic costs and benefits to facilitate sustainable choices by governments and food system stakeholders (Baker et al. 2020; Gemmill-Herren et al. 2021). TCA can serve different purposes, in which different actors have different applications (Baker et al. 2020):

- *Governments* can integrate TCA into local, national or regional policy and budgeting. For example, Brazil, China, Columbia, India, Indonesia, Kenya, Malaysia, Mexico, Tanzania, and Thailand have applied TCA through the TEEBAgriFood framework's participatory process to bring stakeholders together to identify agricultural land-use policies that would benefit from the valuation of ecosystem services (Baker et al. 2020). An interim TCA assessment in Indonesia contributed to agroforestry being included in the country's 2020 five-year development plan (Baker et al. 2020).
- *Businesses* can use these structured assessments to minimize negative impacts and enhance positive benefits across value chains (Serafeim et al. 2019; WBCSD 2021a). Companies can use TCA to produce impact statements or impact weighted accounts (monetized, multi-capital, multi-stakeholder accounts of all material business impacts, including true costs and benefits) (Baker et al. 2020) and manage their externalities (Impact Institute 2020).[2]
- *Financial institutions* use TCA for reporting, impact investment and risk assessment (WBCSD 2021a, b; Impact Institute 2020); and also to obtain assurance on their published impact statements (Schramade 2020).
- *Farmers* can use TCA as a means to account for the costs and benefits of their agricultural practices (Jones 2020). Various initiatives recognize farmers, peasants, indigenous peoples, pastoralists, and other food producers as important stewards of biocultural landscapes (Baker et al. 2020; Gemmill-Herren et al. 2021).

[2] A report by the Harvard Business School found that, by 2019, at least 56 companies worldwide had disclosed monetized information about their impact, five of which were in the food sector (Serafeim et al. 2019). By 2021, around ten food multinationals had become members of the Capitals Coalition (2021b)), and various leading multinational participate in WBCSDs True Value of Food project (WBCSD 2021b).

- *Consumers* can use TCA to become aware of the environmental and social externalities embedded in the food they buy (Lord 2020). Many labeling schemes incorporate TCA information to strengthen the transparency that they provide to consumers (Gemmill-Herren et al. 2021).

TCA recognizes that the economy's productive assets go beyond the assets currently accounted for, and include natural, social and human capital (TEEB 2018; Dasgupta 2021). A TCA assessment can be done at different levels: a food system, a policy, a region, an organization, an investment or a product (Baker et al. 2020). An overview of the approach and tools available is presented in Annex 1.

A TCA assessment typically starts by identifying the goal and scope of the assessment, establishing the unit of analysis and the system boundaries. Then, various externalities are assessed (qualitatively or quantitatively), valued and aggregated (TEEB 2018; Impact Institute 2019). It should be noted that the maturity of methods and data for measuring, valuing and attributing externalities varies greatly. The quantification of carbon emissions is relatively mature, whereas the quantification of health externalities is quite young and involves substantial uncertainty (Gemmill-Herren et al. 2021).

There is limited information available at this scale due to the young nature of TCA, the complexity of food chains and the large variety of disciplines and data required. Although TCA results will never be perfect or entirely objective, TCA provides actors in the food chain with much better information about the value of food than they currently have. However, given the ubiquity of externalities, the complexity of TCA, and the significant interests involved, actors in food systems need an abundant supply of affordable, comparable and reliable TCA information.

Available estimates (FOLU 2019) approximate the annual external costs of the global food system due to GHG emissions at 1.5 trillion (2018) USD, other 'natural capital costs' at 1.7 trillion USD and "Pollution, Pesticides & Anti-Microbial Resistance" at 2.1 trillion USD. The 2019 FOLU study estimated health costs due to obesity at 2.7 USD. An exploratory calculation by van Nieuwkoop (2019) estimated the annual external costs of the food system to be at least 6 trillion USD. A study by FAO (2015) estimated the natural capital costs of crop production at around 1.15 trillion USD.

## 4 Estimating the True Costs of Food Systems in the Context of the UNFSS Aspirations

A novel analysis was conducted by a working group of the UNFSS Scientific Group to estimate the true costs of the current food system and estimate the costs of changes towards a more sustainable system. The work brought together diverse sources of data and approaches. The core unit of analysis was the global food system, consisting of global food consumption and production, divided by country and food group. The environmental and health externalities (listed in Table 2) were

**Table 2** Data included in the study

| Type of externality | Externality | Endpoint impact(s) |
|---|---|---|
| Environmental | GHG-emissions | Contribution to climate change |
| | Nitrogen water pollution | Biodiversity loss |
| | Phosphorus water pollution | Biodiversity loss |
| | Scarce blue water use | Depletion of scarce water |
| | Land-use | Biodiversity, ecosystem services |
| | Air pollution (NH3) | Mortality and disability |
| Health (human life) | Contribution to cardiovascular diseases | Mortality |
| | Contribution to diabetes mellitus type 2 | Mortality |
| | Contribution to neoplasms (cancers) | Mortality |
| Health (economic costs) | Contribution to cardiovascular diseases | Medical costs, informal care, lost working days |
| | Contribution to diabetes mellitus type 2 | Medical costs, informal care, lost working days |
| | Contribution to neoplasms | Medical costs, informal care, lost working days |

estimated based on the externalities for which data were available at this scale and level of granularity. The current analysis excluded economic externalities, social externalities, some environmental externalities (soil degradation, depletion of non-renewable resources, land use other than cropland, overuse of renewable resources and other air pollutants than $NH_3$), and health costs such as antibiotic resistance, zoonoses and undernutrition, as well as productivity losses due to disease. Although these are important sources of externalities, time, data availability, data coverage and compatibility limited the inclusion of these costs. In particular, the requirement that data be available per food group excluded many externalities.

The value chain scope for environmental externalities was primary production, feed for animal products, and inputs such as nitrogen and phosphate. Transportation, processing and food preparation costs were not considered in the analysis. Previous studies have shown that the vast majority of environmental externalities are in the primary process (FAO 2015; Baltussen et al. 2016).

Many data sources and methods were used to quantify the externalities, including Afshin et al. (2019) and Springmann et al. (2018b) to quantify the health impacts and Pozzer et al. (2017), Schipper et al. (2020), Willett et al. (2019) and WWF (2020) to quantify the environmental impacts. The effects were modeled per food group, as set out in Willett et al. (2019) health reference diet. Consumption per food group was based on expenditure. Production was based on production data per country and food group, but is presented here as an aggregate for the world. The environmental effects of imports were based on a global average of the environmental effects of exports per food group.

The monetization of environmental externalities was based on country-level monetization factors for restoration and compensation costs. The methodology adopted has been described by Galgani et al. (2021). A single median global value was used to monetize the loss of human life, based on a meta-study by the OECD (2012) on the value of a statistical life. An average value was used to estimate the direct and indirect economic effects of health loss.

The true annual cost of food was estimated to be around 7 trillion USD (range 4–11) for environmental costs, 11 trillion USD (range 3–39) in costs to human life and 1 trillion USD (range 0.2–1.8) in economic costs (Fig. 1). the annual estimate is based on the most recently available data.

Figure 2 shows that the mean estimate for the total cost of food was 29 trillion USD per year. Given that the current cost of food at current market prices is 9 trillion USD, the results show that the true cost of food is disproportionally high. There is substantial uncertainty in the estimates, particularly for the health costs, as impact pathways have not been extensively studied. The counterfactual is not self-evident, and externalities relate more to diets than to products. In addition, it should be stressed that this is not a complete picture, as some relevant externalities are not yet included, as indicated above.

Among the highest environmental costs are GHG emissions that lead to climate change; land use and land-use change that lead to the loss of ecosystems and biodiversity; and air pollution that leads to, amongst other things, loss of biodiversity and degradation of human health (Fig. 3).

It should be noted that there is substantial uncertainty in these, as well as in other existing estimates of the external costs of food, due to (i) an incomplete coverage of impacts, (ii) major uncertainties in primary data, (iii) uncertainties in trade data, (iv) uncertainties in the modeling of impact pathways and (v) uncertainty in the monetization of external costs. An uncertainty range was created for the results based on footprint and valuation uncertainty. Given that not all uncertainties can be captured and not all sources quantify their uncertainty, the ranges should be interpreted comparatively.

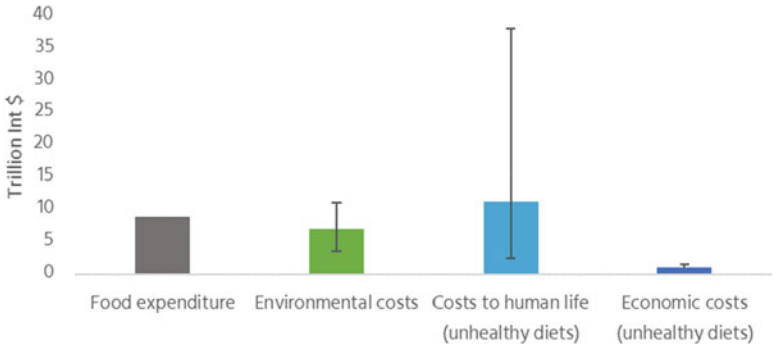


**Fig. 1** The annual true cost of food for the globe. Note: The bar represents the range of possible costs

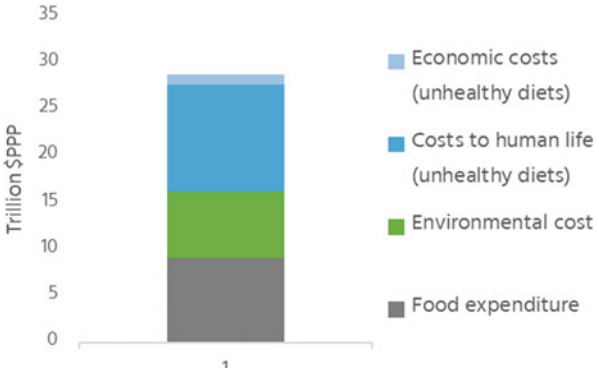


**Fig. 2** Mean estimate of the total annual true cost of food, including the external costs in the scope of the analysis. Note: This estimate excludes relevant externalities, and estimates of included externalities include uncertainty

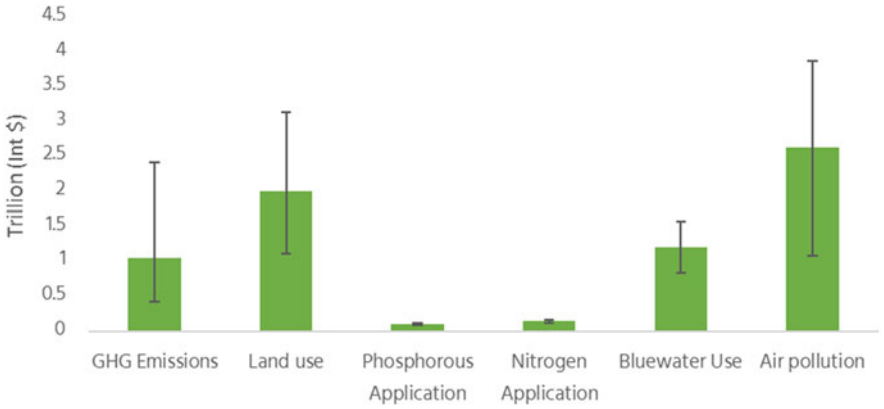


**Fig. 3** Breakdown of the annual environmental cost of food systems

Environmental impact pathways that have high uncertainty include biodiversity and pollution. Quantifying and valuing the health impacts of diets is a novel field, and methodological choices around attribution, the rationality of consumers, the reference scenario and the valuation of a statistical life affect the estimates. Currently, no quantified dietary guide is available to support the analysis of achieving the ambitions of the UNFSS. This is an area that requires more attention and quantification.

Further research is required to include relevant externalities related to undernutrition (which ultimately affects human productivity and incomes), zoonoses, antimicrobial resistance (AMR), productivity losses due to diseases, soil degradation, land use other than cropland, and depleted resources. In addition, it is important to add social costs such as underpayment of workers, underearning of farmers, child labor and harassment throughout the value chain.

## 5 Potential Benefits of a Transition to More Sustainable Diets

Effective policy interventions for redesigning the economics of food also require an understanding of the effects of possible transitions on environmental and health externalities, as well as affordability. Such interventions involve realizing multiple goals and making trade-offs, which can be managed by developing well-planned transition pathways, carefully monitoring key indicators, and implementing transparent science targets at the local level (Herrero et al. 2021).

Hence, in addition to estimating current global external environmental and health costs of food, the working group also explored the potential benefits on health and the environment of dietary shifts and their implications for affordability. Due to a lack of availability of recent international dietary guidelines, the analysis used the only available EAT-Lancet alternative diets (Springmann et al. 2018a). The working group in no way promotes these as recommended diets. The EAT-Lancet's recommended dietary patterns were based on the assumption that plant food production is more environmentally sustainable compared to animal food production, primarily based on considerations of land and water use, energy conversion and GHG emissions. However, these recommended diets do not consider differences in protein quality and nutrient bioavailability (Moughan 2021). Still, the EAT-Lancet pescatarian, vegetarian and vegan diets offer a comparison to a healthy reference diet.

For illustrative purposes, the analysis of shifting consumption patterns to align with these four dietary alternatives showed that significant gains could be achieved in reducing environmental and health costs (Fig. 4). However, these shifts do increase the average cost of food, albeit at a small fraction of the gains.

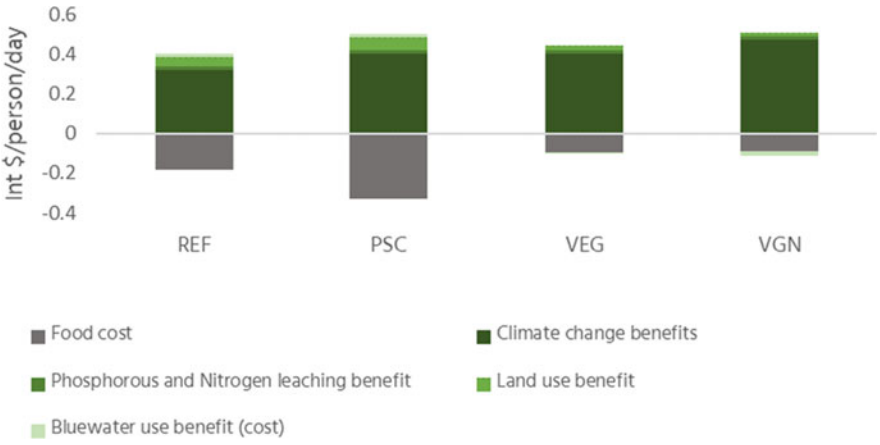


**Fig. 4** Costs and benefits of potential dietary shifts. *REF* Healthy Referencek diet, *PSC* pescatarian, *VEG* vegetarian, *VGN* vegan diets

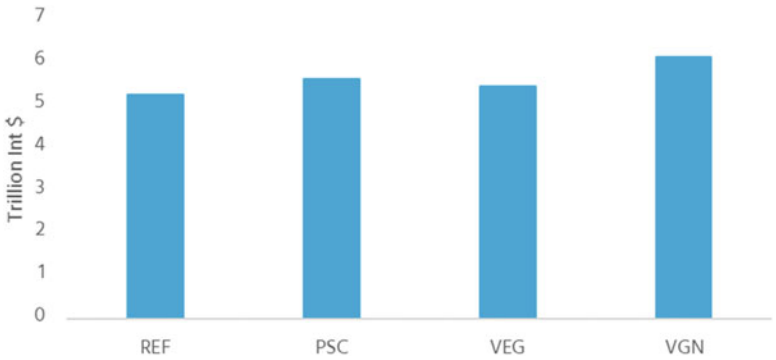


**Fig. 5** Health benefits of potential dietary shifts. *REF* Healthy Reference diet, *PSC* pescatarian, *VEG* vegetarian, *VGN* vegan diets

The health benefits of global dietary shifts are potentially substantial (Fig. 5). Ensuring the affordability of (healthy) food for all requires detailed analysis about how any interventions affect the poorest groups in society. The current analysis does not cover the distributional effects of dietary shifts. This represents a critical area for future research.

## 6 Study Limitations

The methodology applied to estimate the true costs of the global food system and alternative diets has the following limitations:

- The environmental cost of dietary shifts did not take household food waste into account. The results were based on dietary guidelines for consumption.
- All scenarios were based on the environmental footprints per kg of product in the current system. Potential reductions in footprints due to a change in cultivation techniques were not taken into account.
- For the land-use of animal products, pastureland was not included. The biomes used for growing the feed and the mean species abundance of the land used were determined from global averages of these data for products frequently used as feed (mainly cereal products). For processed food products such as vegetable oils and sugar, the biomes used and the mean species abundance were estimated by averages within the country.
- Air pollution emissions referred to the agricultural sector as a whole, and not only food production.
- The impact of food safety on human health and food waste has not been considered, but is a cause of significant disease and mortalities.
- The effect of food production on AMR was not covered in the analysis. According to the AMR review (O'Neill 2016), each year, at least 700,000 deaths

are caused by AMR, which corresponds to a cost of 2.3 trillion USD using the same valuation approach as for other health impacts in this study. A substantial part of this is likely due to food production, but it is currently not clear how much.
- The bioavailability and quality of protein and nutrients were not considered in the dietary shifts, but they are important considerations for future research.

## 7 Recommendations

Given the high costs to the environment and human health presented in these findings, it is essential that UNFSS stakeholders actively identify externalities that represent 'hidden costs' in the food system and those that ignore or incentivize unsustainable and unhealthy food systems. These costs need to be quantified through TCA practices and pathways identified to reduce or eliminate these externalities through policies that: (i) internalize externalities and (ii) sanction those food system stakeholders who do not take appropriate steps to reduce and internalize these costs and/or incentivize those who do. Estimating the full scope of these costs is a priority for determining if such an adjustment to the food system would increase food prices to a point where a reassessment of poverty lines is necessary to ensure access to healthy diets for the poorest.

In the short term, policymakers can remove the barriers for stakeholders to engage in TCA and use TCA data to redefine the value of food to reflect its true costs and benefits. In particular, governments and other UNFSS stakeholders can:

- **Foster internationally accepted harmonized TCA principles across all applications.** Together, experts, practitioners and stakeholders from all fields in food and agriculture can develop harmonized TCA principles to ensure validity and comparability of results and alignment among the various levels,
- **Educate and build capacity among professionals in business and government around TCA.** It is important that the new discipline of TCA be built. Harmonized principles are necessary to bring experts and practitioners from all fields together. In addition, TCA can be integrated into educational systems, and current food professionals in government, civil society and business can be educated in TCA.
- **Provide professionals in business and governments with concrete tools to facilitate TCA.** Lowering the entry barriers of professionals to the complex field of TCA can be facilitated by providing practical skills and approaches (toolboxes) for analysis.

In the medium and long term, governments can look at ways to integrate TCA into economic metrics at all levels systematically:

- **Integrate TCA into national accounts and GDP.** This can provide a standardized account of how much inclusive welfare (realized welfare and changes in wealth) was created. This would provide a much better view of how the food sector contributes to welfare.

- **Integrate TCA into business sustainability reporting and controls.** By adding TCA information into their internal and external financial reports, businesses can compile impact-weighted accounts and impact statements, enabling them to report and manage the value that they create to all stakeholders via all capitals.
- **Integrate TCA into product labeling**. Products themselves can educate their customers as to their true costs (in monetized terms), as well as their true value (in monetized terms or otherwise).

Finally, policymakers can start to explore first-best mechanisms for the medium term:

- **Generate a global agreement and create public-private partnerships around a roadmap to realize the SDGs by 2030 and reach fully sustainable food systems by 2050**, providing affordable and healthy food without environmental, social and health-related costs.

## Annex 1: How Does True-Cost Accounting Work?

A TCA assessment can be done at different levels: a food system, a policy, a region, an organization, an investment or a product (Baker et al. 2020). For each type of analysis, various frameworks exist. One major system-level framework is TEEB for Agriculture and Food (TEEB 2018). Recently, Lord (2020) also published a methodology for food systems analysis. These frameworks can be applied at other levels. At the regional level, the UN System of Environmental Economic Accounting provides a mature framework for natural capital valuation (UN 2021a, b). For other aspects, few well-accepted frameworks exist (Hoekstra 2019), although inclusive wealth is a promising approach (Dasgupta 2021 Various TCA frameworks are being developed for the organizational level, often focusing on corporate reporting (Natural Capital Coalition 2021; Impact Institute 2019). Also, frameworks have been developed specifically for products such as coffee and bananas (Serafeim and Trin 2020; Galgani et al. 2021) and investments (Addy et al. 2019; Olsen 2020; Impact Institute 2020).

A TCA assessment starts by defining the goal, scope and unit of analysis ('functional unit'). Consequently, the relevant externalities have to be identified. Once these externalities have been identified, they have to be assessed, qualitatively or quantitatively. Quantification starts with measuring or assessing inputs and outputs, the direct measurable effects of production and consumption (Impact Institute 2020). These inputs and outputs can be measured using primary data. In practice, inputs and outputs often have to be estimated with macro-level models through (environmentally) Extended Input-Output and Computable General Equilibrium models (Malik et al. 2018), micro-level models such as life-cycle accounting (LCA) (Hauschild et al. 2018) and social LCA (Huertas-Valdivia et al. 2020), or through hybrid approaches (Nakamura and Nansai 2016). Consequently, these outputs have to be translated into impacts via impact pathways (Impact Institute 2019).

For many environmental externalities, there are databases for such pathways, such as those based on Recipe (Huijbregts et al. 2016), although pathways for ecosystem and biodiversity are more complex (TEEB 2018; Dasgupta 2021). Impact pathways for social and, in particular, health externalities are less mature. If the functional unit is a product, investment or organization, the final quantification step is the attribution of impact to the functional unit (Capitals Coalition 2021a; Impact Institute 2020; VBA 2021). This process yields quantified impacts in *natural units*, such as $CO_2$-equivalents, liters of scarce blue water extraction or loss mean species abundance for environmental externalities, full-time equivalents (FTE) of child labor, FTE of forced labor and underpayment for social externalities, and disability adjusted life years (years of life lost + years lived with a disability) for health externalities.

After externalities have been quantified, they can be valued, in monetary terms or otherwise, so that they are expressed in a common unit. To capture value not reflected in market prices, a TCA assessment requires an (implicit or explicit) measure of welfare. Although terminology differs significantly in the literature, there is wide recognition that multiple dimensions exist (Stiglitz et al. 2018), and common welfare dimensions include:

- The preference satisfaction or well-being of people (Stiglitz et al. 2018; TEEB 2018; Dasgupta 2021; Impact Institute 2020).
- An equitable distribution of income and other resources (Stiglitz et al. 2018).
- Adherence to social limits such as a living wage, labor standards and the right to food security, which can be derived from human rights. (TEEB 2018).
- Adherence to environmental limits, such as the conservation of climate, abiotic resources and biodiversity. These limits can be derived from planetary boundaries for a livable planet (Rockström et al. 2009; Stiglitz et al. 2018), the intrinsic value of nature (TEEB 2018) and/or the rights of current and future generations.

The first dimension generally coincides with traditional measures of ordinal or cardinal utility that economists have used to measure collective welfare (Van Praag 1991; Galgani et al. 2021). The second dimension is linked to traditional measures of income inequality such as the GINI coefficient (Bowles and Carlin 2020). Nonetheless, these measures cannot accommodate central issues of sustainability, such as biophysical limits, human rights, social equity and intergenerational equity (Dore and Burton 2003; Gowdy and Erickson 2005). Hence, the valuation of environmental and social damages has met with resistance from non-economists, policymakers and civil society (McCauley 2006). As a result, in TCA, additional welfare dimensions emerged (Stiglitz et al. 2018; TEEB 2018; Impact Institute 2020). Depending on the welfare dimension, different valuation methods, such as cardinal utility, abatement costs, shadow pricing or remediation costs, are used (Galgani et al. 2021). A relevant discussion point is to which degree externalities can be summed and netted. Economists would traditionally sum all positive and negative externalities into one number, whereas some TCA frameworks hold that welfare dimensions ought to be considered separately (Stiglitz et al. 2018; Impact Institute 2019) and human rights violations or deforestation cannot be offset by an equal amount of profit, for example (Capitals Coalition 2021a).

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